Association Romande Alerte aux ondes électromagnétiques

Documents réglementaires et scientifiques

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Association Romande Alerte aux ondes électromagnétiques

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Statuts

https://www.alerte.ch/images/stories/documents/ara/statuts_ara_2011_07_25.pdf

Nous y lisons :

Art. 2 - *Buts*

a) L'ARA a pour but de sauvegarder la santé publique, de faire reconnaître les nuisances de la téléphonie mobile ainsi que d'autres technologies de propagation d'ondes électromagnétiques et toutes technologies similaires potentiellement nuisibles à la santé.

b) L'ARA a aussi pour objectif de réunir toutes les personnes intéressées.

c) L'ARA entreprendra toute action utile pour informer le public et défendre l'intérêt de la santé publique, en rapport avec ses moyens financiers. L'ARA informe notamment à propos des affirmations et prescriptions officielles relatives à la problématique des ondes électromagnétiques.

d) L'ARA n'a pas de but lucratif et n'a aucun caractère politique ou confessionnel.

Résumé exécutif

L'Association Romande Alerte aux ondes électromagnétiques demande aux autorités cantonales et fédérales :

- de considérer et de mettre en pratique les recommandations formulées par l'Assemblée parlementaire dans sa Résolution 1815 aux états membres du Conseil de l'Europe, dont la Suisse est signataire
  (http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-FR.asp?fileid=17994)

- d'appliquer le principe de précaution, notamment en ce qui concerne la 5G, tel que ratifié en août 2003 par la Suisse
  (https://www.who.int/ifcs/documents/forums/forum5/synthesepaper_precaution_ch_fr.pdf)

- de faire appliquer un moratoire concernant la 5G

- de créer des zones dites « blanches », comme demandé au niveau fédéral via la "Pétition Hadlikon" du 9 février 2018

- de contrôler, en temps réel, les émissions actuelles et futures de la 5G, en des endroits choisis

- d'appliquer l'article 35 de la Loi sur la santé publique (LSP 800.01) du 29 mai 1985 pour les ondes de la téléphonie mobile et de la 5G

- de considérer le "syndrome d'intolérance aux champs électromagnétiques" comme une réalité médicale et biologique établie sur des bases scientifiques

- de prendre en compte les effets athermiques, ou non thermiques, des ondes de la téléphonie mobile et de la 5G sur les êtres vivants

- de soutenir l'appel international pour stopper la 5G sur Terre et dans l'Espace
  (https://www.5gspaceappeal.org/the-appeal)
  et de soutenir l'appel international pour un moratoire de la 5G
  (http://www.5gappeal.eu/)

L' analyse du Dr Martin L. Pall sur les causes et conséquences des rayonnements électromagnétiques de la téléphonie mobile

Dr Martin L. Pall, Professeur émérite de biochimie et de sciences médicales fondamentales à l'université de l'État de Washington, a sorti au printemps dernier un livre sur les risques sur la santé que nous encourrons avec le développement de la 5G.

Vous pouvez le consulter en téléchargeant le lien ci-dessous.

Les effets non thermiques des champs électromagnétiques (CEM)

Selon Dr Martin Pall, ils seraient susceptibles *« d'attaquer nos **systèmes nerveux**, (…) entraînant des **effets neuropsychiatriques »***; *« d'attaquer nos **systèmes endocriniens** » ; « de produire le **stress oxydatif** et des dommages causés par les radicaux libres » ; « d'attaquer l'**ADN** de nos cellules »* pouvant conduire à leur tour à *« des **cancers** et des **mutations** dans les cellules reproductrices » ; « de produire des niveaux élevés d'**apoptose** (mort cellulaire programmée) »; « d'entraîner **baisse de fertilité** masculine et féminine, diminution des **hormones sexuelles**, **baisse de la libido**, augmentation des taux d'**avortement spontané** et, des attaques sur l'ADN dans les spermatozoïdes »; « de produire un **excès de calcium** [Ca2+] intracellulaire ».* Enfin, ils pourraient *« agir dans les cellules de notre corps via 15 mécanismes différents pour provoquer le cancer ».*

Des effets cumulatifs et irréversibles des champs électromagnétiques (CEM)

D'après Dr M. Pall, *« les études sur les rongeurs et les humains apportent un argument solide montrant à la fois la nature cumulative et l'irréversibilité des effets neurologiques et neuropsychiatriques, et montrent des effets cumulatifs similaires avec les effets cardiaques ».*

Des effets cardiaques chez les électrohypersensibles (EHS)

« Lorsque des personnes EHS apparentes sont exposées à une connexion Wi-Fi, à un téléphone cellulaire, à une antenne relais de téléphonie cellulaire ou au rayonnement de systèmes de mesure intelligents, elles auraient des palpitations cardiaques » d'après Dr M. Pall.

La nocivité des CEM, incluant le Wifi, chez les jeunes

Dr Martin L. Pall l'explique, entre autres, par *« l'épaisseur du crâne beaucoup plus petits chez les jeunes enfants, augmentant l'exposition de leur cerveau aux CEM ».* C'est pourquoi *« le placement du Wi-Fi dans les écoles du pays et la présence assez fréquente d'antennes relais de téléphonie cellulaire dans les écoles pourraient constituer des menaces de haut niveau pour la santé de nos enfants et pour les enseignants ».*

Les dangers de la 5G

Dr M. Pall soulève 4 points pour lesquels la 5G se montre dangereuse:

« Le ***nombre*** *extraordinairement élevé d'****antennes prévues****; les* ***très hautes doses énergétiques*** *qui seront utilisées pour assurer la pénétration; les* ***niveaux d'impulsions*** *extraordinairement élevés et les* ***interactions*** *apparentes de haut niveau de la fréquence 5G* ***sur les éléments de cellules chargés*** *incluant vraisemblablement les VGCC ».* (canaux calciques voltage-dépendants ou CCDV).

http://www.asef-asso.fr/actualite/l-analyse-du-dr-martin-l-pall-sur-les-causes-et-consequences-des-rayonnements-electromagnetiques-de-la-telephonie-mobile/

Le Dr Martin Pall, un éminent professeur de biochimie met en garde : La 5G est « l'idée la plus stupide de l'histoire du monde »

Un éminent professeur de biochimie met en garde : La 5G est « l'idée la plus stupide de l'histoire du monde »

par Terence Newton, reseauinternational.net, 01 mars 2019
https://mieuxprevenir2.blogspot.com/2019/03/le-dr-martin-pall-un-eminent-professeur.html

Le déploiement international de la technologie sans fil de cinquième génération (5G) est en cours malgré l'opposition de plus en plus vive des scientifiques et des professionnels de la santé, qui tentent désespérément de nous avertir des dangers bien documentés de la 5G. Le gouvernement et les industries impliquées dans le déploiement de la 5G n'ont aucune préoccupation pour la sécurité publique car cette technologie promet d'être exceptionnellement rentable, tout en précipitant tout le monde dans cette technocratie émergente.

S'ajoute à la dissidence, Martin L. Pall, docteur et professeur émérite de biochimie et de sciences médicales de base à la Washington State University. Dans une étude et une présentation, il examine de plus près la technologie 5G et lance un avertissement majeur pour nous tous.

« Installer des dizaines de millions d'antennes 5G sans un seul test biologique de sécurité doit correspondre à l'idée la plus stupide que quelqu'un ait jamais eu dans l'histoire du monde. » – Martin L. Pall, PhD.

Le rapport propose 4 explications pour lesquelles la 5G est nettement plus dangereuse que les générations précédentes de technologie sans fil, signalant :

« La 5G devrait être particulièrement dangereuse pour chacune des quatre raisons suivantes :

- Le nombre extraordinairement élevé d'antennes prévues.
- La très grande quantité d'énergie qui sera utilisée pour assurer la pénétration.
- Les niveaux de pulsation extraordinairement élevés.
- Les apparentes interactions de haut niveau de la fréquence 5G sur des groupes chargés comprenant probablement les groupes chargés du capteur de tension. »

Il commence par parler des directives de sécurité actuelles pour les technologies 2g / 3g / 4g, en soulignant à juste titre que les directives approuvées par le gouvernement ignorent les effets indésirables qui se produisent à des doses ou expositions inférieures auxdites directives. En d'autres termes, comme le souligne Pall, elles sont aberrantes en matière de sécurité.

Il discute ensuite de huit façons dont cette technologie nuit à la santé humaine, en s'appuyant sur une documentation scientifique exhaustive :

- Fertilité réduite
- Effets neurologiques / neuropsychiatriques
- Dommages à l'ADN cellulaire
- Apoptose – Mort cellulaire programmée
- Stress oxydant et dommages des radicaux libres
- Effets endocriniens (hormonaux)
- Excès de calcium intracellulaire
- Cancer

Dans sa conclusion, Pall n'a pas mâché ses mots pour décrire la 5G : « Le déploiement de la 5G est absolument insensé. » La présentation qui suit est particulièrement utile pour quiconque souhaite mieux comprendre de quoi il s'agit et comment le combattre.

Pall n'est qu'un des nombreux professionnels émettant le même avertissement, mais le déploiement progresse sans retard. Martin Blank, du Département de physiologie et de biophysique cellulaire de l'Université de Columbia, résume ici son évaluation.

« Nous avons créé quelque chose qui nous fait du mal et cela nous échappe. Avant l'ampoule de Edison, il y avait très peu de rayonnement électromagnétique dans notre environnement. Les niveaux actuels sont plusieurs fois supérieurs aux niveaux de base naturels et augmentent rapidement en raison de tous les nouveaux appareils émettant ce rayonnement. En termes clairs, ils endommagent les cellules vivantes de notre corps et tuent beaucoup d'entre nous prématurément. » – Dr. Marin Blank.

La docteure Sharon Goldberg, médecin et professeure, commente la 5G en s'adressant au Sénat américain.

« Le rayonnement sans fil a des effets biologiques. Point final. Ce n'est plus un sujet de débat lorsque vous consultez PubMed et la littérature examinée par des pairs. Ces effets sont visibles dans toutes les formes de vie ; plantes, animaux, insectes, microbes. Chez l'homme, nous avons maintenant des preuves évidentes du cancer : il n'y a pas de doute que nous avons des preuves de dommages à l'ADN, de la cardiomyopathie, précurseur de l'insuffisance cardiaque congestive, des effets neuropsychiatriques… La 5G est une application non testée d'une technologie que nous savons nuisible ; nous le savons de la science. Dans les universités, on appelle cela la recherche sur des sujets humains. » – Dr. Sharon Goldberg.

Enfin, Claire Edwards, membre du personnel de l'ONU, a lancé cet avertissement fort aux membres de haut rang des Nations Unies, qualifiant la 5G de « guerre contre l'humanité »

Original : Prominent Biochemistry Professor Warns – 5G is the 'Stupidest Idea In The History of The World'

Source : https://www.sante-nutrition.org/un-important-professeur-de-biochimie-met-en-garde-la-5g-est-lidee-la-plus-stupide-de-lhistoire-du-monde/

https://reseauinternational.net/un-eminent-professeur-de-biochimie-met-en-garde-la-5g-est-lidee-la-plus-stupide-de-lhistoire-du-monde/

L'exposition aux champs électromagnétiques agit via l'activation des canaux calciques voltage-dépendants de type L. Comment cela conduit à l'hypersensibilité électromagnétique (EHS) et à d'autres effets sur la santé.

Martin L. Pall

Professeur émérite de biochimie et de sciences médicales fondamentales

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La majeure partie de mon exposé portera sur la façon dont les champs micro-ondes et autres champs électromagnétiques (CEM) agissent sur les cellules de notre corps ainsi que sur la manière dont l'exposition aux micro-ondes provoque une hypersensibilité électromagnétique (EHS - electromagnetic hypersensitivity).

Je discuterai aussi brièvement de la façon dont ce groupe de «maladies émergentes», à savoir le syndrome de fatigue chronique, la fibromyalgie, la sensibilité chimique multiple et l'EHS, sont toutes initialisées par un mécanisme commun.

Comment les champs électromagnétiques (CEM) peuvent-ils impacter notre biologie et notre médecine ?

Il existe un grand mystère sur la façon dont les champs électromagnétiques (CEM) peuvent influencer notre biologie, pour le meilleur ou pour le pire. Ces CEM sont constitués de photons de basse énergie, avec une énergie par photon trop faible pour influencer la chimie du corps ! Comment peuvent-ils influencer notre biologie par des effets non thermiques ?

Les normes de sécurité américaines et internationales reposent sur l'hypothèse qu'ils ne le peuvent pas, que seuls les effets thermiques doivent être pris en considération, de telle sorte que les expositions qui produisent des effets thermiques infimes ne puissent pas produire d’effets biologiques.

Et pourtant, il existe des milliers d'articles dans la littérature scientifique qui rapportent des effets biologiques dus à des expositions qui restent conformes aux normes de sécurité !

Il existe un 2em type de preuve qui a son importance ici. On sait depuis plus de 30 ans que les champs électromagnétiques pulsés sont souvent beaucoup plus actifs biologiquement que les champs non-pulsés. Comme je le disais, c'est incompatible avec le paradigme thermie/chaleur puisque les champs pulsés produisent soit moins de chaleur, soit la même quantité de chaleur selon la façon dont l'expérience est menée. Nous sommes donc confrontés à une énigme importante concernant la façon dont ces champs électromagnétiques basse fréquence peuvent influencer notre biologie, pour le meilleur ou pour le pire. Ces champs électromagnétiques sont constitués de photons de basse énergie, avec une énergie par photon trop faible pour influencer la chimie du corps ! Comment peuvent-ils influencer notre biologie par des effets non thermiques ? Et pourtant, les études sont nombreuses à montrer qu'ils le font.

J'ai récemment résolu cette importante énigme. Les CEM activent les canaux calciques voltage-dépendants. Et ce sont les effets en aval de l'augmentation du Ca2+ intracellulaire qui conduisent aux effets biologiques de l’exposition aux CEM. La preuve principale est que toute une série d'études montrent que dans les études sur l’exposition à divers champs électromagnétiques de basse fréquence, tous les effets produits peuvent être bloqués par des inhibiteurs des canaux calciques, c’est-à-dire des médicaments qui inhibent les canaux calciques voltage-dépendants.

Je discuterai tout d’abord d’une partie des preuves à l'appui de ce mécanisme et j’expliquerai ensuite comment cela peut conduire à diverses maladies.

Table 1: EMF Responses Blocked or Lowered by Calcium Channel Blockers

Ref #	EMF type	Calcium channel	Cell type or organism	Response measured
2	Pulsed magnetic fields	L-type	Human lymphocytes	Cell proliferation; cytokine production
3	Static magnetic field (0.1 T)	L-type	Human polymorphonuclear leukocytes	Cell migration; degranulation
5	ELF	L-type	Rat chromaffin cells	Differentiation; catecholamine release
6	Electric field	L-type	Rat and mouse bone cells	Increased Ca2+, phospholipase A2, PGE2
7	50 Hz	L-type	Mytilus (mussel) immunocytes	Reduced shape change, cytotoxicity
8	50 Hz	L-type	AtT20 D16V, mouse pituitary corticotrope-derived	Ca2+ increase; cell morphology, premature differentiation
9	50 Hz	L-type	Neural stem/ progenitor cells	In vitro differentiation, neurogenesis
10	Static magnetic field	L-type	Rat	Reduction in edema formation
11	NMR	L-type	Tumor cells	Synergistic

11	NMR	L-type	Tumor cells	Synergistic effect of EMF on anti-tumor drug toxicity
12	Static magnetic field	L-type	Myelomonocytic U937 cells	Ca^{2+} influx into cells and antiapoptotic effects
13	60 Hz	L-type	Mouse	Hyperalgesic response to exposure
14	Single nanosecond electric pulse	L-type	Bovine chromaffin cells	Very rapid increase in intracellular Ca^{2+}
15	Biphasic electric current	L-type	Human mesenchymal stromal cells	Osteoblast differentiation and cytokine production
16	DC & AC magnetic fields	L-type	β-cells of pancreas, patch clamped	Ca^{2+} flux into cells
17	50 Hz	L-type	Rat pituitary cells	Ca^{2+} flux into cells
18	50 Hz	L-type,N-type	Human neuroblastoma IMR32 and rat pituitary GH3 cells	Anti-apoptotic activity
19	Nanosecond pulse	L-type, N-type, P/Q-type	Bovine chromaffin cells	Ca^{2+} dynamics of cells
20	50 Hz	Not determined	Rat dorsal root ganglion cells	Firing frequency of

22	Very weak electrical fields	T-type	Sharks	Detection of very weak magnetic fields in the ocean
23	Short electric pulses	L-type	Human eye	Effect on electro-oculogram
24	Weak static magnetic field	L-type	Rabbit	Baroreflex sensitivity
25	Weak electric fields	T-type	Neutrophils	Electrical and ion dynamics

La conclusion que ces champs électromagnétiques agissent sur le plan biologique en activant les canaux calciques voltage-dépendants (CCVD) est en outre soutenue par des centaines d'études qui montrent que l'exposition aux champs électromagnétiques micro-ondes est suivie par de grandes augmentations du calcium intracellulaire et/ou par des modifications de la signalisation calcique.

En outre, cette conclusion est également étayée par les études de modélisation biophysiques de Panagopoulos et al, qui montrent que les CEM peuvent agir par le biais de leurs interactions avec les résidus d'acides aminés chargés qui régulent l'ouverture et la fermeture du canal, pour ouvrir les canaux ioniques voltage-dépendants. Ainsi l'activation les CCVD par les CEM est biophysiquement plausible et a été prédite à partir de la modélisation biophysique !

Ajouter les references scientifiques :

(BBRC 2000 Jun 16;272(3):634-40; BBRC 2002 Oct 18;298(1):95-102.

Les résultats montrant que l'exposition aux CEM agit via l'activation des CCVD fournissent, pour la première fois, une réponse à l'énigme relative à la manière dont l'exposition aux CEM composés de photons de basse énergie peut affecter notre biologie et la médecine. Parce que l'augmentation du Ca2+ intracellulaire produite par activation des CCVD peut agir, à son tour, pour stimuler la synthèse de l'oxyde nitrique (NO), de telles augmentations peuvent également avoir un rôle important.

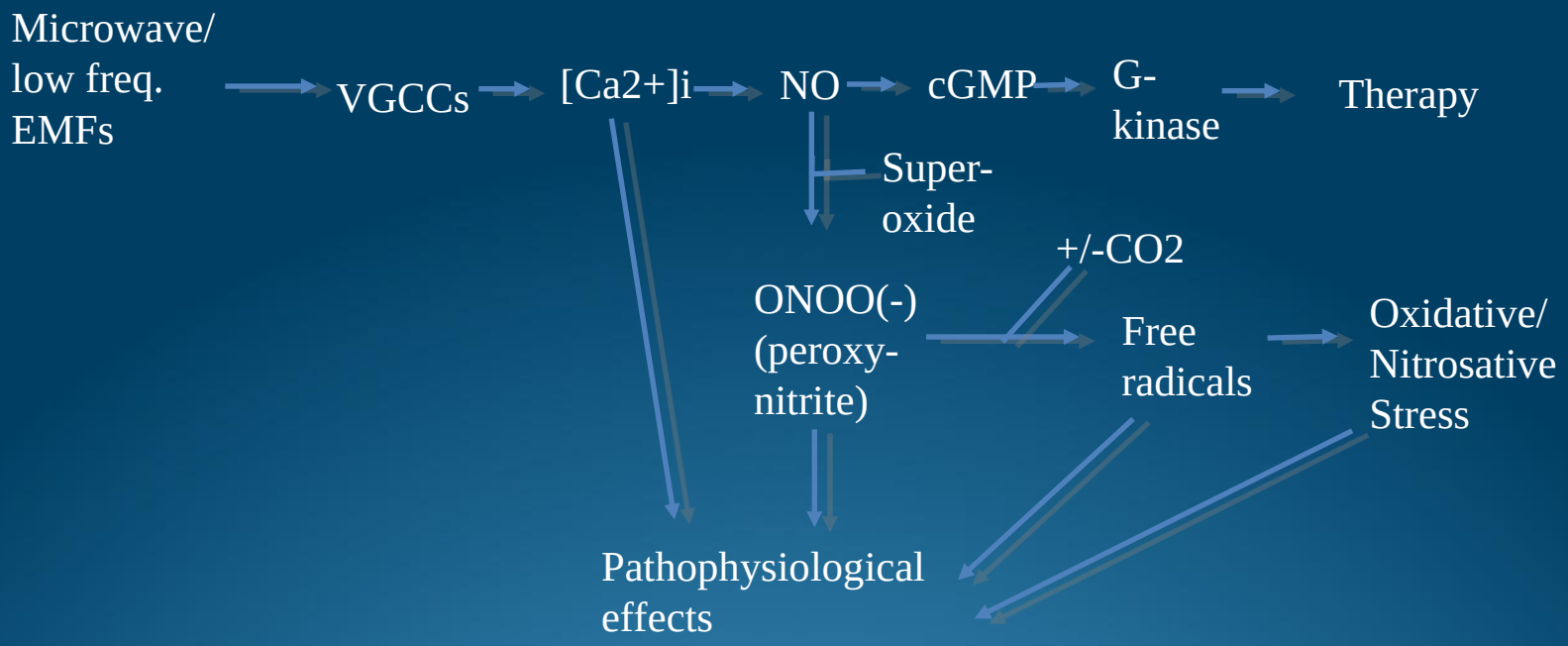
Pilla a récemment montré que ces expositions aux hyperfréquences pulsées des CEM produisent des augmentations quasi instantanées du Ca2+ intracellulaire mais aussi de la synthèse de l'oxyde nitrique (NO) (le tout survenant en moins de 5 secondes) :

Pilla AA. Electromagnetic fields instantaneously modulate nitric oxide signaling in challenged biological systems. Biochem Biophys Res Commun. 2012;426:330-3.

La plupart des réponses physiologiques au Ca2+ et à l’oxyde nitrique, agissent comme suit :

L’ON augmente le taux de GMP cyclique (GMPc), ce qui conduit à la stimulation de la protéine kinase GMPc-dépendante (protéine kinase G).

En revanche, la plupart des effets physiopathologiques de NO sont médiés par son rôle de précurseur du péroxynitrite (ONOO-), induisant la production de radicaux libres et de stress oxydatif.


Microwave/
low freq.
EMFs
VGCCs
[Ca2+]i
NO
cGMP
G-
kinase
Therapy
Super-
oxide
+/-CO2
ONOO(-)
(peroxy-
nitrite)
Free
radicals
Oxidative/
Nitrosative
Stress
Pathophysiological
effects

Arthur A. Pilla a publié un modèle d’effets thérapeutiques des CEM et a passé en revue les données probantes qui l’approuvent ; un modèle qui était très similaire mais pas identique au mien, que vous venez de voir sur la diapositive précédente. Il déclare dans le titre, l’abstract et la première phrase de son article que ce sont tous des effets non-thermiques.

Nonthermal electromagnetic fields: from first messenger to therapeutic applications.
Pilla AA.
Electromagn Biol Med. 2013 Jun;32(2):123-36.

J'ai proposé un mécanisme similaire à celui décrit par Pilla dans deux publications.

Certains documents pertinents pour mon exposé :

Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. Pall ML. J Cell Mol Med. 2013 Aug;17(8):958-65.

Cet article a été sélectionné pour figurer sur le site « Global Medical Discovery » comme l'un des articles médicaux les plus importants de 2013.

➢ Pall ML. 2014 Electromagnetic field activation of voltage-gated calcium channels: role in therapeutic effects. Electromagn Biol Med. 2014 Apr 8.

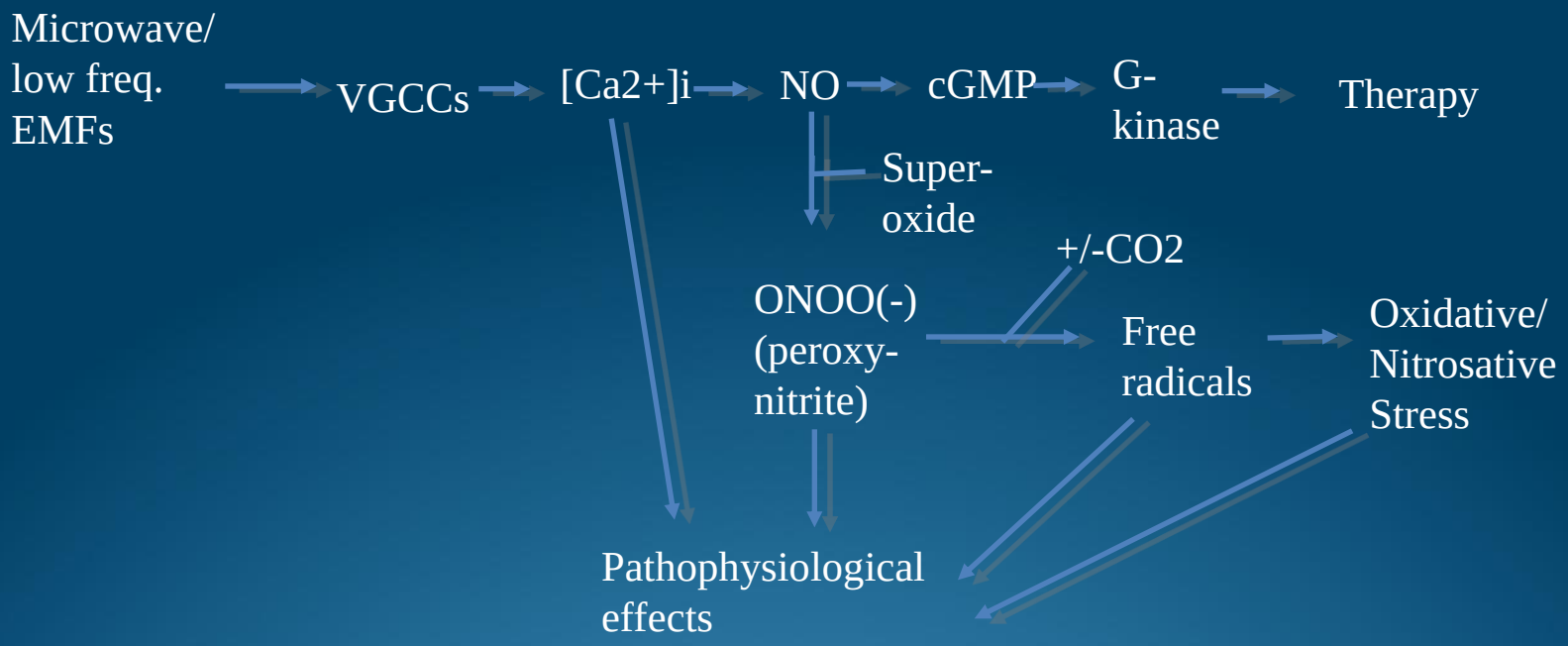
➢ Pall ML. 2014 Microwave electromagnetic fields act by activating voltage-gated calcium channels: Why the current international safety standards do not predict biological hazard. Recent Res Devel Mol Cell Biol, 7(2014): 0-00 ISBN: 978-81-308-0000-0, in press.

➢ Pall M. L. 2009 Multiple chemical sensitivity: Toxicological questions and mechanisms. In General and Applied Toxicology, 3rd Edition, John Wiley & Sons, pp. 2303-2352.

Table 1. Apparent Mechanisms of Action for Microwave Exposures Producing Diverse Biological Effects (See Fig. 1)

Reported Biologic Response	Apparent Mechanism(s)	Citation(s)/ Comments
Oxidative stress	Peroxynitrite & consequent free radical formation	[1-3]; detected via a large number of oxidative stress markers
Single strand breaks in cellular DNA	Free radical attack on DNA	[1-3]
Double strand breaks in cellular DNA	Same as above	Same as above; detected from micronuclei and other chromosomal changes
Cancer	Single and double strand breaks, 8-nitroguanine and other pro-mutagenic changes in cellular DNA; produced by elevated NO, peroxynitrite	[3] and this paper
Breakdown of blood-brain barrier	Peroxynitrite activation of matrix metalloproteinases (MMPs) leading to proteolysis of tight junction proteins	[3]
Male and female infertility	Induction of double strand DNA breaks; Other oxidative stress mechanisms; [Ca2+]i mitochondrial	[3]

Male and female infertility	Induction of double strand DNA breaks; Other oxidative stress mechanisms; [Ca2+]i mitochondrial effects causing apoptosis; in males, breakdown of blood-testis barrier	[3]
Therapeutic effects	Increases in $[Ca]_i$ and NO/NO signaling	[1-3; 13]
Depression; diverse neuropsychiatric symptoms	VGCC activation of neurotransmitter release; other effects?; possible role of excess epinephrine/norepinephrine	These were reported in occupational exposures [21]; also reported in people living near cell phone towers
Melatonin depletion; sleep disruption	VGCCs, elevated $[Ca]_I$ leading to disruption of circadian rhythm entrainment as well as melatonin synthesis	[3]
Cataract formation	VGCC activation and $[Ca]_I$ elevation; calcium signaling and also peroxynitrite/oxidative stress	This paper
Tachycardia, arrhythmia, sometimes leading to sudden cardiac death	Very high VGCC activities found in cardiac (sinoatrial node) pacemaker cell; excessive VGCC activity and [Ca2+]i levels produces these electrical changes in the heart	[3]


Microwave/
low freq.
EMFs
VGCCs
[Ca2+]i
NO
cGMP
G-
kinase
Therapy
Super-
oxide
+/-CO2
ONOO(-)
(peroxy-
nitrite)
Free
radicals
Oxidative/
Nitrosative
Stress
Pathophysiological
effects

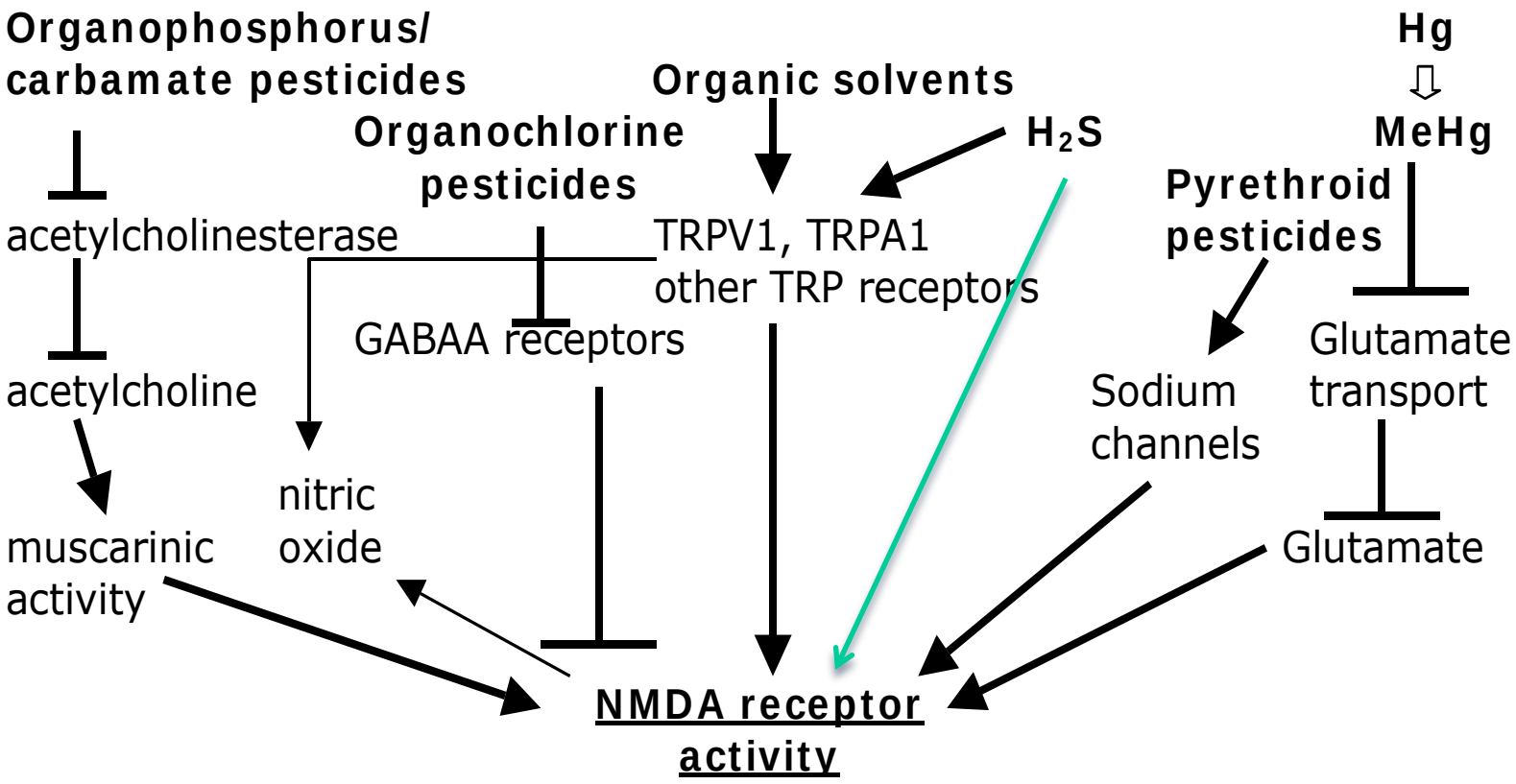
Ce ne sont pas les seuls effets physiopathologiques de ces champs électromagnétiques, mais ceux-ci sont parmi les mieux compris en termes mécanistiques.

Et ils vous donnent une idée de l'ampleur des effets observés.

Maintenant, nous allons parler de l'hypersensibilité électromagnétique (EHS). On pense que des cas d'EHS sont causés par des expositions préalables aux champs électromagnétiques, en particulier aux CEM micro-ondes/radiofréquences.

Ici, l'une des principales sources d'information sur un possible mécanisme d'EHS est ce que nous savons sur le mécanisme de la sensibilité chimique multiple (MCS - multiple chemical sensitivity). EHS et MCS ont beaucoup de choses en commun : des cas de chaque peuvent être initiés par des expositions préalables, à des substances chimiques dans le cas de la MCS et à des champs électromagnétiques dans le cas de l'hypersensibilité électromagnétique (EHS), de telles expositions causant alors des réactions d'hypersensibilité élevée. Elles sont souvent comorbides (qui se produit chez les mêmes individus). Elles impliquent toutes deux des symptômes provenant du cerveau et d'autres symptômes provenant des tissus périphériques. Dans les deux cas, il existe beaucoup de variations symptomatiques d'un individu à l'autre, compatible avec un mécanisme local principal avec une distribution tissulaire variable.

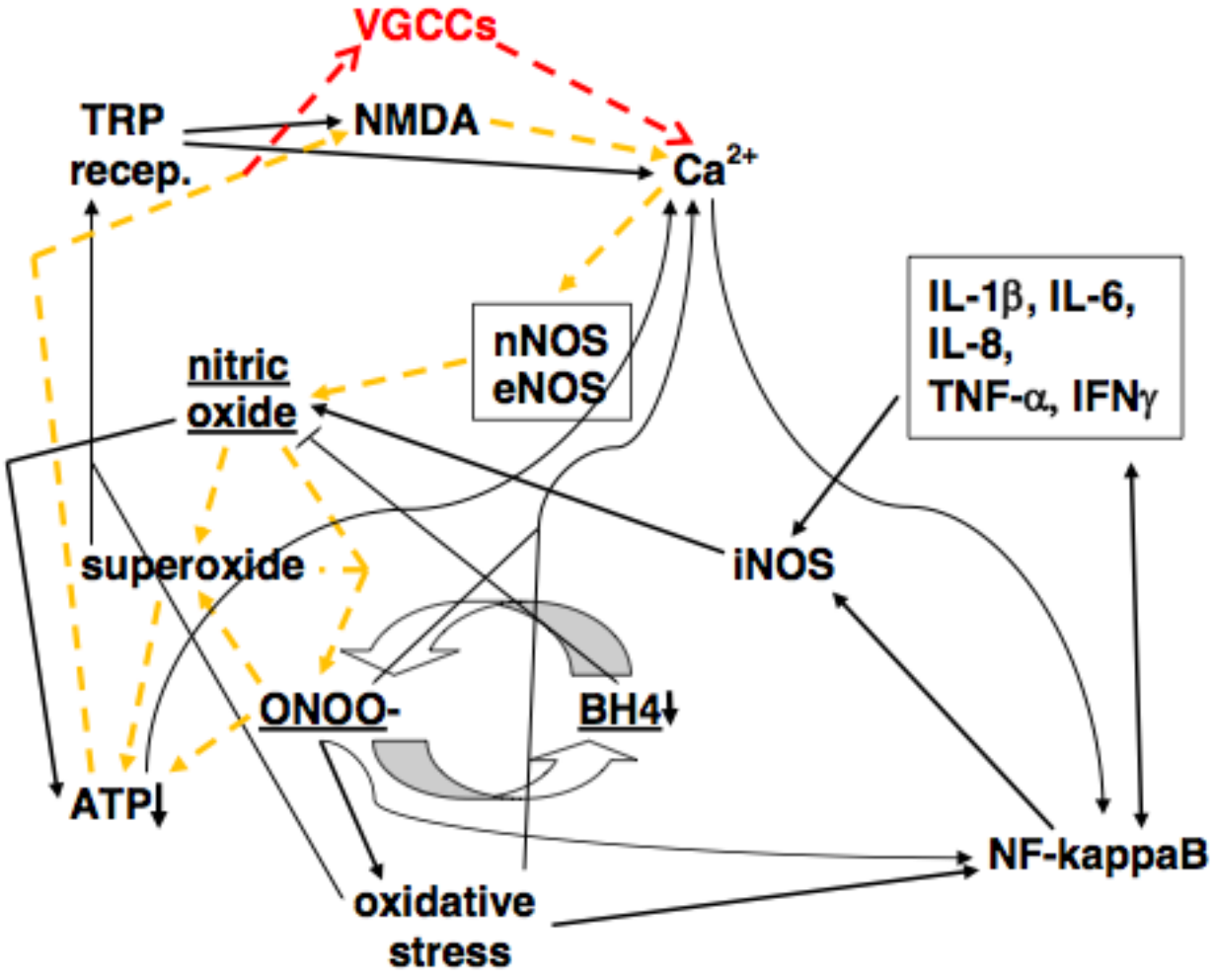
Chemical Action in MCS



Il existe toute une série de similitudes entre les récepteurs NMDA et les CCVD de type L :

1. Les deux ouvrent un canal ionique lorsqu'ils sont activés.
2. Les deux canaux restent ouverts pour une période de temps relativement longue par rapport aux autres canaux.
3. Les deux permettent à des quantités importantes de calcium de circuler dans la cellule.
4. On pense que les effets des deux sont médiés par un excès de calcium intracellulaire [Ca2+]i.
5. Les deux produisent de grandes quantités d’oxyde nitrique (NO), en raison de l'action de deux oxyde nitrique synthases calcium-dépendantes, avec le NO qui induit souvent dans les deux cas la production de péroxynitrite.
6. Tous deux se sont révélés être en mesure de stimuler la potentialisation à long terme, un processus dans le système nerveux central impliqué dans l'apprentissage et la mémoire en produisant une sensibilisation neurale.

Il peut être proposé, par conséquent, que toutes ces similitudes connexes ont des rôles en permettant à chacun d'entre eux de produire les niveaux élevés de sensibilités que nous appelons MCS ou EHS. S’il y a une chose essentielle que vous deviez retenir de ce discours, c'est que les propriétés semblables des récepteurs NMDA et des CCVD de type L sont presque certainement derrière les deux types de sensibilité !!!


VGCCs
TRP recep.
NMDA
Ca2+
nNOS eNOS
IL-1β, IL-6, IL-8, TNF-α, IFNγ
nitric oxide
superoxide
iNOS
ONOO-
BH4
ATP
NF-kappaB
oxidative stress

Nous pensons que les mécanismes étiologiques de la MCS (sensibilité chimique multiple) sont centrés sur deux mécanismes interdépendants :

1. Ce que l'on appelle le cycle NO/ONOO-, c'est-à-dire un cercle vicieux biochimique, essentiellement local, qui est initié par divers déclencheurs, y compris ceux qui agissent via l'augmentation de l'activité NMDA, et qui se propage lui-même au fil du temps.

2. Et un autre mécanisme connexe suggéré par le Dr Iris Bell et d'autres chercheurs pour son implication dans la MCS, à savoir la sensibilisation neurale causée par ce qui est connu sous le nom de potentialisation à long terme. Cela peut également impliquer l'activité du récepteur NMDA et d'autres mécanismes qui font partie du cycle NO/ONOO-. Le 1 et le 2 sont examinés en détail dans ma revue de toxicologie sur la MCS.

L'exposition aux CEM, en activant les CCVD de type L devraient également être en mesure d'induire les deux mécanismes. Nous l'avons déjà dit, il existe des données sur le fait que les CCVD de type L peuvent initier la potentialisation à long terme, tout comme les récepteurs NMDA. De même, ils produisent de fortes augmentations des taux de calcium intracellulaire qui peuvent, avec leurs effets en aval, agir pour initier le cycle NO/ONOO-.

En conséquence, dans le cerveau, l'EHS agit comme suit :

➢ Les CEM micro-ondes sont plus actifs en activant les CCVD dans certaines régions du cerveau que dans d'autres.
➢ Dans ces régions où ils sont les plus actifs ils élèveront les taux de [Ca2+]i, d'oxyde nitrique et de péroxynitrite, démarrant le cycle NO/ONOO(-).
➢ Cela rendra cette zone plus sensible à une exposition supplémentaire car le cycle a déjà commencé, provoquant une plus grande sensibilité qu'auparavant.
➢ Cela stimulera également une potentialisation à long terme, faisant que les synapses deviennent hypersensibles. Vous avez donc encore une sensibilité supplémentaire.
➢ La protéine kinase C est également stimulée par une exposition préalable et par le cycle NO/ONOO(-), ce qui fait que les CCVD sont encore plus sensibles à la stimulation.

Il peut aussi y avoir des sensibilités qui se développent dans les tissus périphériques qui ont des niveaux élevés de CCVD, tels que dans les cellules de stimulateur cardiaque et dans une partie des cellules endocrines. Ici le mécanisme est probablement similaire à ce qui se passe dans le cerveau sauf qu'il n'y a peut-être pas de mécanisme de potentialisation à long terme impliqué.

Vous pouvez donc obtenir une hypersensibilité cardiaque (tachycardie induite par les CEM), mais aussi dans certains cas une hypersensibilité de certains des tissus endocriniens, les deux ont été signalées.

La thérapie pour l'hypersensibilité électromagnétique devrait être axée sur :

➢ L'abaissement du NO/ONOO(-) et des dommages causés par le cycle NO/ONOO(-)
➢ La réduction de la sensibilité des CCVD, en particulier des CCVD de type L qui sont responsables de la plupart des réponses aux CEM (gabapentine, huile de poisson, d'autres suppléments)
➢ L'évitement des expositions aux CEM, dans la mesure où cela est possible

Tests objectifs pour l'hypersensibilité électromagnétique (EHS) :

Les tests pour l'EHS dépendent de la mesure de la sensibilité de la réponse à l'exposition aux CEM.

Les réponses d'organes spécifiques ne fonctionnent pas sur toutes les personnes souffrant d'EHS parce que le cycle NO/ONOO(-) est essentiellement local ; il est localisé dans différents tissus chez des individus différents. Ainsi, certaines personnes EHS répondront à l'exposition avec une tachycardie ou une intolérance au glucose, comme le montrent Havas et ses collègues, mais cela ne sera pas le cas pour d'autres. Par conséquent, ce type de tests/examens fonctionne pour certaines personnes souffrant d'EHS mais pas pour d'autres.

Un test/examen général pourrait consister à mesurer l' d'oxyde nitrique (NO) du corps entier, généralement mesuré via le nitrate/nitrite, ou à mesurer le stress oxydatif du corps entier, tous deux mesurés avant et après l'exposition. Ce genre de mesures est compliqué pour une autre raison : la gravité de la sensibilité variera chez les gens qui sont hypersensibles et l'on veut éviter de donner aux personnes les plus sensibles plus qu'ils ne peuvent tolérer.
Il existe aussi un test/examen des lymphocytes qui est à l'étude dans lequel la sensibilité de la réponse des lymphocytes peut être étudiée in vitro.

Le cycle NO/ONOO(-) a été proposé à l'origine comme une explication détaillée de l'ensemble du groupe de maladies sur lesquelles est axée cette réunion, y compris l'EM/SFC et la fibromyalgie. J'ai déjà publié au sujet de 23 maladies différentes qui sont des maladies liées au cycle NO/ONOO(-). La 22ème publication était un document de 57 pages sur l'insuffisance cardiaque, qui montre de manière très détaillée que l'insuffisance cardiaque est une maladie du mécanisme ONOO/NO(-). Cela signifie que le cycle n'est plus seulement une théorie, il est largement validé par une maladie pour laquelle une étude extraordinairement détaillée a été menée. Ce n'est pas une hypothèse !

The NO/ONOO- cycle as the central cause of heart failure.

Pall ML.

Int J Mol Sci. 2013 Nov 13;14(11):22274-330. doi: 10.3390/ijms141122274. Review.

En résumé :

- Les micro-ondes et autres champs électromagnétiques agissent par activation des CCVD
- Les réponses physiopathologiques sont produites par excès de [Ca2+]i, NO, péroxynitrite et le stress oxydatif
- Les réponses thérapeutiques se produisent via la signalisation de NO
- L'EHS peut être comprise, en raison des similitudes avec la MCS, comme étant due au [Ca2+]i, NO, péroxynitrite et au stress oxydatif.
- Ce mécanisme EHS permet de faire des prédictions en termes de traitements, certains d'entre eux ayant déjà fait l'objet d'études
- Il permet également de faire des prévisions en termes d'essais, certains d'entre eux ayant déjà été documentés.
- Le rôle du cycle NO/ONOO(-) dans le déclenchement de ces maladies de sensibilité, à savoir EM/SFC et fibromyalgie, les lie étiologiquement les unes aux autres ainsi qu'à beaucoup d'autres maladies.

WIRELESS RADIATION AND HEALTH

THE CASE FOR THE PRECAUTIONARY PRINCIPLE FOR THE CURRENT AND THE FUTURE 5G & IoT TECHNOLOGY

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Dariusz Leszczynski, 22nd Korean EMF Workshop, Seoul, South Korea, August 30, 2018

WHO I AM… EDUCATION AND WORK

- Two doctorates in molecular biology and biochemistry/cell biology
- Adjunct Professor of Biochemistry, University of Helsinki, Finland
- Currently retired (2018)
- Independent Expert; actively advising and lecturing (2014 - present)
  - 22 years (1992-2013) at STUK – Radiation and Nuclear Safety Authority in Finland
  - 2003-2007 as Head of Radiation Biology Laboratory
  - 2000-2013 as Research Professor
- Assistant Professor at Harvard Medical School, USA; 1997-1999
- Guangbiao Professor at Zhejiang Univ., Hangzhou, China; 2006-2009
- Visiting Professor at Swinburne Univ. Technology, Melbourne, Australia; 2012-2013

WHO I AM… EXPERT EXPERIENCE

- 20 years of experimental work on EMF and health
- Testified and advised
  - Polish Ministry of Digitization; 2016
  - Canadian Parliament's House of Commons' hearing; 2015
  - India's Minister of Health and Family Welfare; 2014
  - USA Senate Appropriations Committee hearing; 2009
  - Parliament of Finland
- Member of 2011 International Agency for Research on Cancer (IARC) Working Group for classification of the carcinogenicity of cell phone radiation
- Advised e.g.: National Academies, USA; World Health Organization; Bundesamt für Strahlenshutz, Germany; International Commission on Non-Ionizing Radiation Protection (ICNIRP); Swiss National Foundation; The Netherlands Organization for Health Research and Development;

THE KNOWLEDGE…

THERE ARE THINGS WE KNOW THAT WE KNOW.

THERE ARE KNOWN UNKNOWNS. THAT IS TO SAY THERE ARE THINGS THAT WE NOW KNOW WE DON'T KNOW.

BUT THERE ARE ALSO UNKNOWN UNKNOWNS. THERE ARE THINGS WE DON'T KNOW WE DON'T KNOW.

Donald Rumsfeld, US Secretary of Defense, NATO Briefing, June 6, 2002 [http://www.nato.int/docu/speech/2002/s020606g.htm]

HUMAN HEALTH POLICIES

Policies concerning human health and wireless technology are based solely on "*what we know that we know*".

"*What we know that we do not know*" is dismissed as irrelevant

(case of not done yet research !)

WORLD HEALTH ORGANIZATION: DEFINITION OF HEALTH

"*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.*"

- According to the WHO, it is a health effect when people are stressed and concerned by the worry of radiation exposure
- This applies to all wireless communication technologies
- The larger the "*worried*" or "*concerned*" population is, the larger the health problem is

CELL PHONES: THE *ASSUMED* LACK OF HEALTH HAZARD APPEARS TO BE FALSE

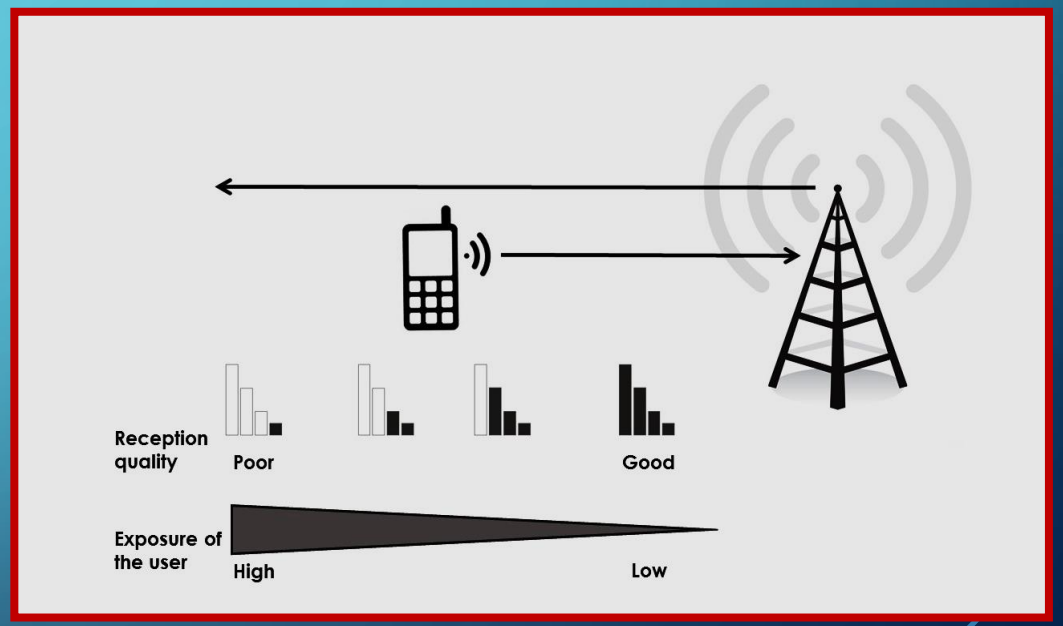
- In early 1980s communications technology developed for US Department of Defense was put into commerce
- Food and Drug Administration (FDA) allowed cell phones to be sold without pre-market testing for human health hazard
- FDA rationale - the "*low power exclusion*"
- In 2011, based on the post-deployment research, International Agency for Research on Cancer (IARC) classified cell phone radiation as a *possible* human carcinogen

EPIDEMIOLOGY CASE-CONTROL STUDIES SUPPORT BRAIN CANCER RISK

- International Agency for Research on Cancer 2011 classification was based on the results of Interphone and Hardell studies
- Currently, the four case-control epidemiological studies suggest the cell phone radiation increases risk of developing brain cancer in avid users
  - Regular user (!) – no problem at all but… definition: 1 call/week for 6 months
  - Avid user = ca. 30 minutes/day for 10+ years
  - Interphone 40%; Hardell 170%, CERENAT 100%, Canadian Interphone 100% increase in glioma risk
- Interphone 2016 analysis of full data confirms location of cancer in the most exposed parts of brain
- NOTICE: all case-control studies **underestimate** risk of brain cancer because of poor radiation dosimetry

EPIDEMIOLOGY CASE-CONTROL STUDIES HAVE NO RADIATION EXPOSURE DATA

- Surrogate for radiation exposure – minutes of using cell phone
- Such surrogate leads to underestimation of the effect
- Two persons talking for the same length of time may have entirely different radiation exposure because of the different proximity to cell tower
- **Persons with dramatically different radiation exposure are analyzed as if having the same exposure** because they have the same minutes of use
- Epidemiology underestimates cancer risk



HUGE NUMBER OF CELL PHONE USERS BUT NO DRAMATIC INCREASE IN BRAIN CANCER IN WHOLE POPULATION

- Brain cancer – rare disease
- Cancer latency is tens of years
- Length of use of cell phone and how avidly used
- Cancer statistics are too general – do not differentiate between types of brain cancer or age groups having it – might be misleading (e.g. men 50-79)
- Cancer cause – cell phone radiation only a co-inducer of cancer?
- Individual sensitivity – not everyone reacts to this low-power radiation

THE PRECAUTIONARY PRINCIPLE
WORLD COMMISSION ON THE ETHICS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGY (COMEST)

- Because the PP deals with risks with poorly known outcomes and poorly known probability, the unquantified *possibility* is sufficient to trigger the consideration of the PP. This distinguishes the PP from the prevention principle: if one does have a credible ground for quantifying probabilities, then the prevention principle applies instead.

CONDITIONS FOR INVOKING THE PRECAUTIONARY PRINCIPLE

"…Whether or not to invoke the Precautionary Principle is a decision exercised where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on environment, or human, animal or plant health may be potentially dangerous and inconsistent with the chosen level of protection…"

INVOKING THE PRECAUTIONARY PRINCIPLE IS JUSTIFIED

- ***Scientific information is insufficient, inconclusive, or uncertain***
  - IARC classification of cell phone radiation as possible carcinogen (Group 2B) means that the science is insufficient, inconclusive, and uncertain
- ***There are indications that the possible effects on human health may be potentially dangerous***
  - Epidemiological studies, Interphone, Hardell, CERENAT, Canadian Interphone show an increased risk of brain cancer in long-term avid users – potentially dangerous effect
- ***Inconsistent with the chosen level of protection***
  - Epidemiological studies, showing increased risk in long-term avid users, were generated in populations using regular cell phones, compliant with the current safety standards = current safety standards are insufficient to protect users

THE IMPACT OF IMPLEMENTING THE PRECAUTIONARY PRINCIPLE

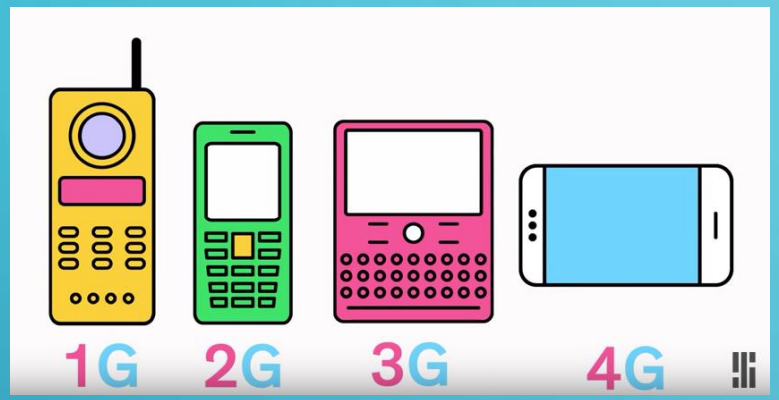
- Consideration and implementation of the Precautionary Principle (PP) does not equal prevention of the use of wireless communication technology
- Strong opposition from telecom industry because implementation of PP may cause:
  - Technology providers can be made responsible to prove their product is safe – this may require telecoms to fund expensive bio-med research
  - Requirement of making more efficient (less radiation emissions) technology
  - Limiting current rampant and uncontrolled deployment of wireless networks (not possible with 5G technology)
- Implementation of PP will create new knowledge through research
- Implementation of PP will create new jobs in research and technology

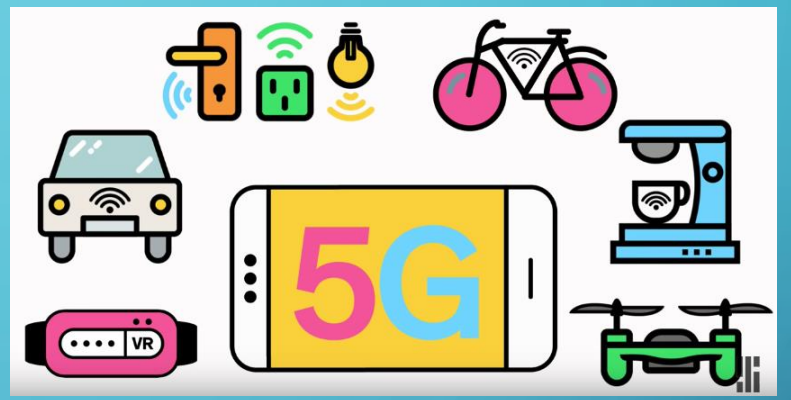
CLAIMS THAT THE PRECAUTIONARY PRINCIPLE IS SUFFICIENTLY IMPLEMENTED IN THE CURRENT SAFETY LIMITS ARE NOT SUPPORTED BY THE SCIENTIFIC EVIDENCE INDICATING AN INCREASED HEALTH RISK, E.G. DEVELOPING BRAIN CANCER BY THE LONG-TERM AVID USERS OF CELL PHONES

RADIATION EXPOSURES CHANGE
USERS ARE UNDER-INFORMED

- **Laptops**, old, did not emit wireless radiation - keeping on the lap was **OK**
- **Laptops**, new, connect to internet, emit wireless radiation – keeping on the lap is **not OK**
- **Tablet**, connect to internet, emit wireless radiation – keeping close to the body is **not OK**
- **Cell phones**, non-smart,
  - emitted radiation when speaking/listening; on idle radiation emission was negligible
  - it was **OK** to keep in the pocket
- **Smart phones**
  - emit radiation when speaking/listening
  - when connected to internet - synchronizing apps
  - when using as base-station (tethering)
  - it is **not OK** to keep in pocket smart phone connected to internet

5G TECHNOLOGY





Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

SERIOUS LIMITATIONS OF BIOMEDICAL RESEARCH ON MILLIMETER-WAVES

- Very limited number of studies
  - EMF Portal (www.emf-portal.org) lists <200 studies
  - Few more studies possible to find in PubMed database
- Lack of studies examining responses of human physiology to exposure (human volunteer studies)
- Complete lack of studies on chronic, long-term, exposures
- Studies from a very limited number of research groups (!)
- Lack of replication studies confirming correctness of observations (!)

ENVIRONMENT OF HUMAN SKIN
[*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- False assumption that because radiation will be absorbed by skin only there will be no major health problem
- Functions of the skin microbiota in health and disease by James A. Sanford and Richard L. Gallo; *Semin Immunol. 2013 Nov 30; 25(5): 370–377.*
  - "*…The skin, the human body's largest organ, is home to a diverse and complex variety of innate and adaptive immune functions…*"
  - "*…the skin immune system should be considered a collective mixture of elements from the host and microbes acting in a mutualistic relationship…*"

HUMAN VOLUNTEER STUDIES ON MILLIMETER-WAVES

[*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- Just a *handful* of studies with a *trickle* of information
  - Local skin heating
  - Effect on pain sensation
  - Effect on acupuncture sites
  - Effects on blood flow

IN VITRO EFFECTS ON HUMAN CELLS
[*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- Just a couple of hundreds of studies, with effects and without effects
  - Promotion of synthesis of extracellular matrix
  - Induction of apoptosis
  - Promotion of proliferation and G1 to S phase transition
  - Inhibition of NO-dependent apoptosis via p38MAPK pathway
  - Changes in protein expression
  - Effects on NF-KB pathway via TNF-alpha and cyclophosphamide
  - Effects on c-fos expression
  - Lack of effects on Hsp27 and Hsp70 (no thermal effect?)
  - Number of studies shows the opposite, no effects…

EFFECTS ON MICROBES (SKIN & ELSEWHERE) [*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

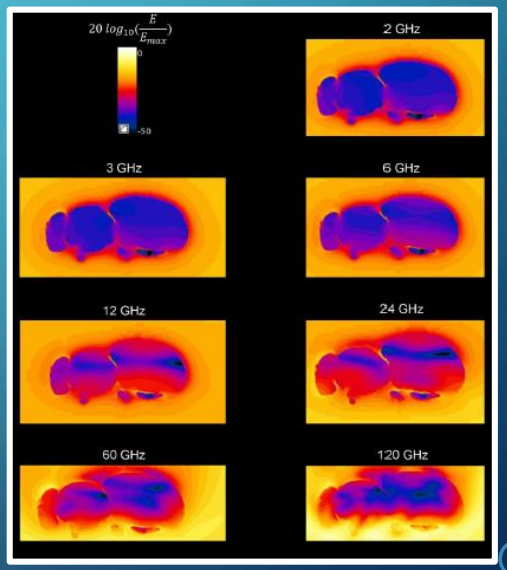
- Just a handful of studies (<20?)
  - Inhibition of bacterial growth (53 GHz)
  - Enhancement of bacterial sensitivity to antibiotics (53 GHz)
  - Inhibition of growth and viability of bacteria (70 GHz)
  - Effects on metabolic pathways in bacteria (53 GHz)
  - Co-effects of mm-Waves and UVC (enhanced survival)
  - Co effects with X-rays (repair of the damage)
  - Effects on structure if bacterial genome

SPECIFIC "ELECTROMAGNETIC EFFECT" [*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- Transcriptome analysis reveals the contribution of thermal and the specific effects in cellular response to millimeter wave exposure. Habauzit et al. *PLoS One, 2014, 9:e109435-1-e109435-10*
  - Exposure affected gene expression
  - Seven genes affected and confirmed
  - Effect observed when temperature of cells increased
  - When temperature was controlled effect disappeared but…
  - …just by increasing temperature it was not possible to mimic the thermal-exposure effect on genes
  - Hence, proposed possibility of an "*electromagnetic*" component of the exposure effect

SENSITIVITY OF INSECTS (E.G. BEES) [*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz. Thielens et al. (team included Luc Martens and Wout Joseph); *Scientific Reports 2018, 8:3924*
- *"…Our simulations showed that a shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370%…"*
- *"…This could lead to changes in insect behaviour, physiology, and morphology over time due to an increase in body temperatures, from dielectric heating…"*



INDIVIDUAL SENSITIVITY
[*EXAMPLES, NOT A COMPREHENSIVE OVERVIEW*]

- At 42 GHz effect on human blood cells depended on the dose radiation and on the "individual peculiarities of donors of the blood cells" (study from 1998)
- Skin of different people reacts differently to stimuli – will it happen with millimeter-waves… we have no idea because we did not examine it at all
- It is likely that the majority of population will not be affected by exposures but it is also likely that there is a more sensitive subpopulation; it should be discovered and protected
- Research on physiological effects of millimeter-waves on skin, and its impact on the whole body physiology, is urgently needed

INDUSTRY FUNDED REVIEW STUDY: AN UNFOUNDED CLAIMS OF SAFETY FOR 5G

- Safe for Generations to Come. Wu et al. *IEEE Microw. Mag. 2015; 16: 65–84*
- In April 2014, the Brooklyn 5G Summit, sponsored by NOKIA and the New York University (NYU) WIRELESS Research Center
- **Assumption**: low-power = not causing health effects because it is non-thermal
- "…*Compared with lower frequency bands, relatively little careful research has been conducted evaluating the potential of more subtle long-term effects than tissue damage due directly to heating at mmWave frequencies…*"

DÉJÀ VU?

- Cell phones 1G – 4G
  - 1G technology emitting low power - no health hazard envisioned in 1980's
  - Today – 3G & 4G – technology emitting low power – classified by WHO/IARC as a possible human carcinogen
- Future 5G and Internet of Things (IoT)
  - Technology emitting low power – assumption of no heath hazard
  - No research to support assumption because no research done (!)
  - The future research outcomes are enigma… but deployed 5G will remain deployed, no matter what warnings might come from the science

PREDICTABLE FUTURE WITH 5G

- Base stations networks will be deployed first, followed by…
- Gadgets in pockets…
  - *"No one is ready with components small enough for handsets; those will come later. Laptops are and tablets are likely to get 5G connectivity before 5G handsets appear."*
- Users will be exposed in addition to 3G and 4G radiation to the new type of radiation – the millimeter-waves
- Current talk that users will not be exposed in close-range to millimeter-waves is incorrect… initially will not but later will be

Source: https://www.edn.com/electronics-blogs/5g-waves/4458814/Movandi-optimizes-mmWave-5G-front-ends

ONCE DEPLOYED…REMAIN DEPLOYED… NO MATTER WHAT THE POST-DEPLOYMENT SCIENCE WILL SAY

- Network operators' revenue opportunity for wireless connectivity is likely to exceed $3 trillion ($3,000,000,000,000) by 2026, with the vast majority of revenue growth coming from new industrial applications powered by 5G (report from Ericsson)
- The 5G-enabled health services segment alone will be worth $1.1 trillion by 2035 (report from Qualcomm)

Source: https://www.edn.com/electronics-blogs/5g-waves/4459091/5G--It-s-the-use-cases--dummy

CONCLUSIONS

- Current science justifies the implementation of the Precautionary Principle for the 3G and 4G technologies
- Limiting unnecessary exposures is achievable with 3G and 4G technologies
- Limiting unnecessary exposures with 5G will be impossible
- Safety limits for radiation exposure will be of paramount importance in 5G because the avoidance of exposures will be impossible
- The need of research is very urgent because of the rapidly ongoing deployment of 5G technology and lack of knowledge about effects of the mm-waves
- Delay in the massive deployment of the 5G is advisable, to gather the appropriate science

5G: Great risk for EU, U.S. and International Health! Compelling Evidence for Eight Distinct Types of Great Harm Caused by Electromagnetic Field (EMF) Exposures and the Mechanism that Causes Them

Written and Compiled by Martin L. Pall, PhD
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Washington State University
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martin_pall@wsu.edu 503-232-3883 May 17, 2018

Summary:

We know that there is a massive literature, providing a high level of scientific certainty, for each of eight pathophysiological effects caused by non-thermal microwave frequency EMF exposures. This is shown in from 12 to 35 reviews on each specific effect, with each review listed in Chapter 1, providing a substantial body of evidence on the existence of each effect. Such EMFs:

1. Attack our nervous systems including our brains leading to widespread neurological/neuropsychiatric effects and possibly many other effects. This nervous system attack is of great concern.
2. Attack our endocrine (that is hormonal) systems. In this context, the main things that make us functionally different from single celled creatures are our nervous system and our endocrine systems – even a simple planaria worm needs both of these. Thus the consequences of the disruption of these two regulatory systems is immense, such that it is a travesty to ignore these findings.
3. Produce oxidative stress and free radical damage, which have central roles in essentially all chronic diseases.
4. Attack the DNA of our cells, producing single strand and double strand breaks in cellular DNA and oxidized bases in our cellular DNA. These in turn produce cancer and also mutations in germ line cells which produce mutations in future generations.
5. Produce elevated levels of apoptosis (programmed cell death), events especially important in causing both neurodegenerative diseases and infertility.
6. Lower male and female fertility, lower sex hormones, lower libido and increased levels of spontaneous abortion and, as already stated, attack the DNA in sperm cells.
7. Produce excessive intracellular calcium [Ca2+]i and excessive calcium signaling.
8. Attack the cells of our bodies to cause cancer. Such attacks are thought to act via 15 different mechanisms during cancer causation.

There is also a substantial literature showing that EMFs also cause other effects including life threatening cardiac effects (Chapter 3). In addition substantial evidence suggests EMF causation of very early onset dementias, including Alzheimer's, digital and other types of dementias (Chapter 3); and there is evidence that EMF exposures in utero and shortly after birth can cause ADHD and autism (Chapter 5).

Each of these effects is produced via the main mechanism of action of microwave/lower frequency EMFs, activation of voltage-gated calcium channels (VGCCs) (Chapter 2). Each of them is produced via what are called downstream effects of VGCC activation. It follows from this that we have a good understanding not only that these effects occur, but also how they can occur. The extraordinary sensitivity of the VGCC voltage sensor to the forces of the EMFs tells us that the current safety guidelines allow us to be exposed to EMF levels that are something like

7.2 million times too high. That sensitivity is predicted by the physics. Therefore, the physics and the biology are each pointing to the same mechanism of action of non-thermal EMFs.

The different effects produced are obviously very deep concerns. They become much deeper and become existential threats when one considers that several of these effects are both cumulative and eventually irreversible. There is substantial evidence for the cumulative nature and eventual irreversibility of the neurological/neuropsychiatric effects, of the reproductive effects, the mutational DNA effects, the cardiac effects, of some but not other of the hormonal effects (Chapter 3); any causation of ADHD and autism may add additional concerns (here the cumulative nature is probably limited to the perinatal period). When we know that sperm counts have dropped by more than 50% throughout the technologically advanced countries on earth, it is difficult to avoid the conclusion that the vast majority of the population in those countries is already substantially impacted. The same conclusion can be made based on the widespread nature of the neuropsychiatric effects in those countries. Both of those effects will get much much worse even with no increase in current exposures, due to the cumulative nature and irreversibility of these effects. I expect we will see crash in human reproduction almost to zero as happened in the Magras and Xenos mouse study which I estimate to occur within about 5 years, without any increases in our exposures. Obviously 4G and 5G will make the situation much worse. Similarly I expect that the deterioration in brain function that we are already seeing will seal our fate if we fail to act rapidly and vigorously. Our collective brain function may become completely incapable of dealing with such a mega-crisis situation.

Now it can be argued that some of these may not develop as I expect, although those expectations are based on the best available evidence. One may even be able to argue this for all of those expectations. However, when we have substantial risk of multiple existential threats to every single technologically advanced country on earth, failure to act vigorously means there is a very high probability of complete destruction of these societies. And the chaos which would inevitably ensue, in a world that still has nuclear weapons, may well lead to extinction. In the face of these types or risk, the only reasonable course is to move with great vigor to stop new exposures and lower current exposures. One can still access the internet, using wired connections. And we can lower cell phone tower and cell phone radiation substantially. Smart meters, if needed, can work via wired connections.

Over 60% of this document (Chapters 5 & 6), is focused on the failures of statements from SCENIHR, the telecommunications industry, the U.S. FCC and the U.S. FDA to reflect the science. Their statements repeatedly omit much, often all of the most important science. Their statements are rife not only with omissions, but also with easily demonstrable falsehoods and with false logic. These have often occurred at times where we know that they knew better. These have occurred along with vigorous efforts by the telecommunications industry to corrupt the science by attacking individual scientists whose only fault is that they have obtained important findings that the industry does not like. These attacks have occurred along with vigorous efforts to corrupt two agencies that have important regulatory roles.

There are also possible concerns about individual industry-linked research studies. All wireless communication devices put out polarized EMFs that carry information via pulsations. Both the pulsations and the polarization make these EMFs much more biologically active. There are three other factors that also influence the production of effects. Several industry-linked studies may have used these factors, along with using very tiny numbers of individual animals in their studies, to produce studies which may have been designed to fail (Chapter 5). It is not clear at this point whether this type of concern is quite limited or whether it is very broad.

The European Commission has done nothing to protect European citizens from any of these very serious health hazards and the U.S. FDA, EPA and National Cancer Institute have done nothing to protect American citizens. The U.S. FCC has been much worse than that, acting vigorously with wanton disregard for our health.

Preface

The document that follows was, in its original form, sent to many of the authorities of the European Union, in conjunction with other documents sent to the same people by a group of European scientists. It was in response two documents that were, in turn, written by Mr. Ryan and Dr. Vinciūnas responding to a large group of European and other international scientists expressing great concern about the safety of 5G. I was asked by the leaders of the group of scientists to write my own response to those two documents. Mr. Ryan made the statement that "There is consistent evidence presented by national and international bodies (International Commission on Non Ionising Radiation Protection - ICNIRP, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) that exposure to electromagnetic fields does not represent a health risk, if it remains below the limits set by Council Recommendation 1999/519/EC1." In fact, that is not either the ICNIRP or SCENIHR position – their position, and similar positions have been taken by the U.S. FCC, FDA and the National Cancer Institute, is that the evidence is inconsistent or conflicting and therefore, in their view, no conclusions can be drawn. Some of these organization have also stated that there is no known mechanism by which effects can be produced. What is shown below is that there is a vast amount of evidence in the independent scientific literature that conflicts with both the conclusion about lack of demonstrated effects and the conclusion about lack of mechanism.

The European Commission, according to the Ryan and Vinciūnas documents and the U.S. National Cancer Institute, according to their web site, are each depending on the SCENIHR 2015 document to make judgments about EMF effects. Consequently, the reliability of SCENIHR 2015 is an essential element in determining the reliability of both of their assessments.

The document that is presented below, differs from the document that was emailed to EU authorities in three different ways: 1. The original document was sent as an email with multiple attachments. In this document attachments are simply provided as citations. The current document is a stand-alone document. 2. Some material is inserted to discuss positions taken by the U.S. FCC, FDA and National Cancer Institute, so as to be particularly relevant to the U.S. situation. 3. Substantial additional evidence is also provided.

The revised document contains seven chapters followed by a citation list for the entire document:

Chapter 1. Eight Extremely Well-Documented Effects of Non-Thermal EMF Exposures: Role of Pulsations, Other Factors that Influence EMF Effects

Both the earlier Ryan document and the more recent Arūnas document each fail to pay any attention to the extensive scientific literature that has been accumulated on non-thermal electromagnetic field (EMF) effects. The scientific consensus of independent scientists based on information accumulated over the last 7 decades is just the opposite of what each of them states. I am copying into this document, at the end of Chapter 1, a series of 8 extremely well-documented effects of such EMF exposure, together with a list of review articles, most of them being peer reviewed articles published in well respected journals in the PubMed database, *that have each reviewed a body of evidence demonstrating the existence of each such effect*.

What are the effects produced by non-thermal exposures to microwave frequency EMFs, where we have an extensive scientific literature? Each of the following effects has been documented in from 12 to 34 reviews, listed at the end of Chapter 1.

1. Three types of cellular DNA attacks, producing single strand breaks in the cellular DNA, double strand breaks in cellular DNA and oxidized bases in cellular DNA. Each of these DNA changes have roles in cancer causation and in producing the most important mutational changes in humans and diverse animals. Double stranded DNA breaks produce chromosomal breaks, rearrangements, deletions and duplications and copy number mutations; they also produce gene amplification, an important mechanism in cancer causation. Single strand breaks in cellular DNA cause aberrant recombination events leading to copy number mutations. Oxidized bases cause point mutations. When these occur in somatic cells, they can each have roles in causing cancer. When these occur in germ line cells (and they have be shown to occur in sperm following EMF exposures), they cause the three most important types of mutations in future generations, chromosomal mutations, copy number mutations and point mutations. (21 different reviews documenting these types of cellular DNA damage)
2. A wide variety of changes leading to lowered male fertility, lowered female fertility, increased spontaneous abortion, lowered levels of estrogen, progesterone and testosterone, lowered libido (18 reviews). Human sperm count has dropped to below 50% of what used to be considered normal throughout the technologically advanced countries of the world [1]. Reproductive rates have fallen below replacement levels in every technologically advanced country of the world, with a single exception. These include every EU country, the U.S., Canada, Japan, South Korea, Taiwan, Singapore, Australia and New Zealand. Reproduction averages, in these countries, about 73% of replacement levels according to 2015 or 2016 data. A study on mouse reproduction [2] showed that radio/microwave frequency EMF exposure at doses well within our current safety guidelines produced substantial dose-dependent decreases in reproduction within

the first set of litters; further exposure produced dose-dependent complete or almost complete sterility that was found to be largely irreversible. When we have a technology that is universally present in these technologically advanced countries, that we know impacts reproduction, and reproduction has already dropped well below replacement levels, and we may be facing a catastrophic and irreversible decline in reproduction and there are more and more plans to expose us still further, don't you think that we should take note of the science? Mr. Ryan and Dr. Vinciūnas seem to be saying not at all. (Please note that the U.S. FCC and FDA also completely ignore this existential threat)

3. Neurological/neuropsychiatric effects (25 reviews). My own paper on this [3] and two earlier reviews cited in it found that there are whole series of repeatedly found EMF effects which have also become extremely widespread complaints in our technologically advanced societies, namely: sleep disturbance/insomnia; fatigue/tiredness; headache; depression/depressive symptoms; lack of concentration/attention/cognitive dysfunction; dizziness/vertigo; memory changes; restlessness/tension/anxiety/stress/agitation; irritability. These findings are not just based on epidemiological findings but are also based on profound impacts of EMFs, at levels well within our safety guidelines, on brain structure and function and also on the mechanism of non-thermal EMF action discussed below. When we have these neuropsychiatric effects becoming more and more common in technologically advanced societies all over the world, and *we know each of these is caused EMF exposures*, shouldn't we take note of this relationship?
4. Apoptosis/cell death (13 reviews). The two most important consequences of large increases in apoptosis (programmed cell death) are in causation of the neurodegenerative diseases and lowered reproduction although there are others.
5. Oxidative stress/free radical damage (19 reviews). Oxidative stress has roles in all or almost all chronic diseases. It is reported to have essential roles in producing the reproductive effects and the attacks on cellular DNA and may also have roles in producing the neurological effects and some of the cancer-causing effects shown to be produced here by EMF exposures.
6. Widespread endocrine (that is hormonal) effects (12 reviews). The steroid hormone levels drop with EMF exposure, whereas other hormone levels increase with initial exposure. The neuroendocrine hormones and insulin levels often drop with prolonged EMF exposure, possibly due to endocrine exhaustion.
7. Increases in intracellular calcium ([Ca2+]i) levels following EMF exposure (15 reviews). Calcium signaling also increases following EMF exposure.
8. Cancer causation (35 reviews). Brain cancer, salivary cancer, acoustic neuromas and two other types of cancer go up with cell phone use. People living near cell phone towers have increased cancer rates. Other types of EMFs are each implicated. Short wave radio, radio ham operators and people exposed to radar all are reported to have increased cancer incidence. Perhaps most telling, heavy-long term cell phone users have the highest incidence of brain cancer and have predominantly cancer increases on the ipsilateral side of the head (the side they use their cell phones), as opposed to the contralateral side. I have a paper [7], focused not on whether EMFs cause cancer but rather on ***how*** they can cause cancer. The paper shows that "downstream effects" of the main target of the EMFs in the cells of our bodies, can cause cancer in 15 different ways, including increases in cancer initiation, promotion and progression. Progression effects include both tissue invasion and metastasis. Each of these cancer causation effects are caused via mechanisms produced by downstream effects of the main non-thermal EMF mechanism, as discussed in Chapter 2.
9. Therapeutic effects of such EMFs. Such EMFs when focused on a specific region of the body where there is some dysfunction and when used at specific intensities, can have therapeutic effects. In my 2013 paper [4], I cited 12 different reviews where EMF

stimulation of bone growth was used therapeutically. There are something like 4000 papers on various therapeutic effects. Strangely, the telecommunications industry does not acknowledge these therapeutic effects, preferring rather to maintain the fiction that there are no non-thermal effects.

There is another set of reviews, 13 in this case, with each showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed EMFs. This is particularly important because all wireless communication devices communicate via pulsations, making them potentially much more dangerous. It follows from this that if you wish to study the effects of Wi-Fi, cell phones, cordless phones, cell phone towers, smart meters or 5G, you had better study the real thing or at least something that pulses very much like the real thing. There are many studies that don't do this, but falsely claim to be genuine Wi-Fi, cell phone or cordless phone studies. Other factors that influence the occurrence of non-thermal EMF effects include the frequency being used, the polarization of the EMFs and the cell type being studied [4,5,8-11]. Furthermore there are intensity "windows" that produce maximum biological effects, such that both lower and higher intensities produce much less effect [5,8,9]. These window effect studies clearly show that dose-response curves are both non-linear and non-monotone, such that it is difficult or impossible to predict effects based on relative intensity even when all other factors are the same. The role of each of these factors is completely ignored by ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute as well as by many other industry-friendly groups. When each of these organizations concludes that "results are inconsistent" they are comparing studies based on superficial similarities but not on these demonstrated causal factors. What is being observed, therefore, is genuine biological heterogeneity, not inconsistency. It has been known since the beginning of modern science in the 16th century that how you do your studies is important in determining what results are obtained. How is it possible that ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute have forgotten this important fact?

The primary literature studies demonstrating roles of pulsation, frequency, polarization, cell type and intensity windows in determining biological effects are entirely dependent on having genuine effects to study. None of these studies could have been done without an effect to study. Consequently, the claims that there are no well-documented EMF effects are nonsense, based not only on the eight extremely well-documented effects summarized above, but also on the entire literature demonstrating the role of pulsation, frequency, polarization, cell type and intensity windows.

Now I haven't said anything about how these non-thermal EMF effects are produced. I am taking much of Chapter 2 from a recent paper [11].

Reviews each showing important health-related non-thermal effects of microwave frequency electromagnetic fields (EMFs).

These review lists were prepared by Dr. Martin L. Pall, Professor Emeritus of Biochemistry and Basic Medical Sciences, Washington State University. martin_pall@wsu.edu
BA degree in Physics, Phi Beta Kappa, with honors, Johns Hopkins University; PhD in Biochemistry & Genetics, Caltech.

Specific effects and reviews each reporting the effect in multiple primary literature studies:

Cellular DNA damage: Single strand and double strand breaks in cellular DNA and oxidized bases in cellular DNA, leading to chromosomal and other mutational changes:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
2. Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect 105(Suppl 6):1579-1587.
3. Yakymenko IL, Sidorik EP, Tsybulin AS. 1999 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999), 2011 Mar-Apr:20-28.
4. Aitken RJ, De Iuliis GN. 2007 Origins and consequences of DNA damage in male germ cells. Reprod Biomed Online 14:727-733.
5. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
6. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109-1117.
7. Phillips JL, Singh NP, Lai H. 2009 Electromagnetic fields and DNA damage. Pathophysiology 16:79-88.
8. Ruediger HW. 2009 Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology. 16:89-102.
9. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
10. Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.
11. Yakimenko IL, Sidorik EP, Tsybulin AS. 2011 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999). 2011 Mar-Apr;83(2):20-28.
12. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1
13. Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.
14. Pall, M. L. 2015 Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116. doi: 10.1515/reveh-2015-0001.
15. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
16. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263-R276.
17. Batista Napotnik T, Reberšek M, Vernier PT, Mali B, Miklavčič D. 2016 Effects of high voltage nanosecond electric pulses on eukaryotic cells (in vitro): A systematic review. Bioelectrochemistry. 2016 Aug;110:1-12. doi: 10.1016/j.bioelechem.2016.02.011.
18. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.

19. Pall ML. 2018 How cancer can be caused by microwave frequency electromagnetic field (EMF) exposures: EMF activation of voltage-gated calcium channels (VGCCs) can cause cancer including tumor promotion, tissue invasion and metastasis via 15 mechanisms. Chapter 7 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 163-184.
20. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
21. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

Lowered fertility, including tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovarian remodeling, oocyte (follicle) loss, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, lowered libido:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
2. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by B Haigh. Consultants Bureau, New York/London, 146 pages.
3. Goldsmith JR. 1997 Epidemiological evidence relevant to radar (microwave) effects. Environ Health Perspect 105(Suppl 6):1579-1587.
4. Aitken RJ, De Iuliis GN. 2007 Origins and consequences of DNA damage in male germ cells. Reprod Biomed Online 14:727-733.
5. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109-1117.
6. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
7. Kang N, Shang XJ, Huang YF. 2010 [Impact of cell phone radiation on male reproduction]. Zhonghua Nan Ke Xue 16:1027-1030.
8. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1
9. La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. 2012 Effects of the exposure to mobile phones on male reproduction: a review of the literature. J Androl 33:350-356.
10. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.
11. Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. 2013 Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol 246:869-875.
12. Adams JA, Galloway TS, Mondal D, Esteves SC, Mathews F. 2014 Effect of mobile telephones on sperm quality: a systematic review and meta-analysis. Environ Int 70:106-112.
13. Liu K, Li Y, Zhang G, Liu J, Cao J, Ao L, Zhang S. 2014 Association between mobile phone use and semen quality: a systematic review and meta-analysis. Andrology 2:491-501.

14. K Sri N. 2015 Mobile phone radiation: physiological & pathophysiological considerations. Indian J Physiol Pharmacol 59:125-135.
15. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
16. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263-R276
17. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
18. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

Neurological/neuropsychiatric effects:

1. Marha K. 1966 Biological Effects of High-Frequency Electromagnetic Fields (Translation). ATD Report 66-92. July 13, 1966 (ATD Work Assignment No. 78, Task 11). http://www.dtic.mil/docs/citations/AD0642029 (accessed March 12, 2018)
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14. Levitt, B. B., Lai, H. 2010. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18, 369-395. doi.org/10.1139/A10-018
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18. Pall ML. 2016 Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75(Pt B):43-51. doi: 10.1016/j.jchemneu.2015.08.001.
19. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
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21. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. 2016 EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health DOI 10.1515/reveh-2016-0011.
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23. Lai H. 2018. A Summary of Recent Literature (2007–2017) on Neurological Effects of Radio Frequency Radiation. Chapter 8 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 185-220.
24. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
25. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

Apoptosis/cell death (an important process in production of neurodegenerative diseases that is also important in producing infertility responses):

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
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9. Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.
10. Pall ML. 2016 Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75(Pt B):43-51. doi: 10.1016/j.jchemneu.2015.08.001.
11. Batista Napotnik T, Reberšek M, Vernier PT, Mali B, Miklavčič D. 2016 Effects of high voltage nanosecond electric pulses on eukaryotic cells (in vitro): A systematic review. Bioelectrochemistry. 2016 Aug;110:1-12. doi: 10.1016/j.bioelechem.2016.02.011.
12. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.
13. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

Oxidative stress/free radical damage (important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage):

1. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.
2. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
3. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109-1117
4. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
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Increased intracellular calcium: intracellular calcium is maintained at very low levels (typically about 2 X 10-9 M) except for brief increases used to produce regulatory responses, such that sustained elevation of intracellular calcium levels produces many pathophysiological (that is disease-causing) responses).

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Pulsed EMFs are, in most cases much more biologically active than are non-pulsed EMFs. This is important because all wireless communication devices communicate via pulsations and because the "smarter" the devices are, the more they pulse because the pulsations convey the information. What should be obvious is that you cannot study such pulsation roles if there were no biological effects produced by such EMFs. *The pulsation studies alone tell us that there are many such EMF effects.*

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Each of these reviews, typically cite from 5 to over 100 primary literature citations, each showing that non-thermal EMF exposures produce the effect under which they are listed. It follows from this, that there are not only 11 or more reviews documenting each of these effects, but there is also a massive primary literature documenting these effects as well. It follows from this that the ICNIRP, FCC and International Safety Guidelines, which are entirely based only on thermal effects are inadequate and there have been petitions and other statements of international groups of scientists expressing great concern about this. *It follows that the ICNIRP, FCC and International safety guidelines are completely unscientific and cannot be relied upon to protect our safety.*

Chapter 2: How Each Such EMF Effect Is Produced via Voltage-Gated Calcium Channel Activation: Role of the Voltage Sensor in Producing the Extraordinary Sensitivity to EMF Effects

The Pall, 2013 [4] study showed that in 24 different studies (there are now a total of 26 [5]), effects of low-intensity EMFs, both microwave frequency and also lower frequency EMFs, could be blocked by calcium channel blockers, drugs that are specific for blocking voltage-gated calcium channels (VGCCs). There were 5 different types of calcium channel blockers used in these studies each thought to be highly specific, each structurally distinct and each binding to a different site on the VGCCs. *In studies where multiple effects were studied, all studied effects were blocked or greatly lowered by calcium channel blockers*. These studies show that EMFs produce diverse non-thermal effects via VGCC activation in many human and animal cells and even in plant cells where some similar calcium channels are involved [6]. Furthermore, many different effects shown to be produced in repeated studies by EMF exposures, including the effects discussed above, can each be produced by downstream effects of VGCC activation, via increased intracellular calcium [Ca2+]i, as discussed below.

Various EMFs act via VGCC activation, as shown by calcium channel blocker studies. These include microwave frequency EMFs, nanosecond pulse EMFs, intermediate frequency EMFs, extremely low frequency EMFs and even static electrical fields and static magnetic fields.

It is important to discuss why the VGCCs are so sensitive to activation by these low-intensity EMFs. Each of the VGCCs have a voltage sensor which is made up of 4 alpha helixes, each designated as an S4 helix, in the plasma membrane. Each of these S4 helixes has 5 positive charges on it, for a total of 20 positive charges making up the VGCC voltage sensor [5,8]. Each of these charges is within the lipid bilayer part of the plasma membrane. The electrical forces on the voltage sensor are extraordinarily high for three distinct reasons [5,8]. 1. The 20 charges on the voltage sensor make the forces on voltage sensor 20 times higher than the forces on a single charge. 2. Because these charges are within the lipid bilayer section of the membrane where the dielectric constant is about $1/120^{th}$ of the dielectric constant of the aqueous parts of the cell, the law of physics called Coulomb's law, predicts that the forces will be approximately 120 times higher than the forces on charges in the aqueous parts of the cell. 3. Because the plasma membrane has a high electrical resistance whereas the aqueous parts of the cell are highly

conductive, the electrical gradient across the plasma membrane is estimated to be concentrated about 3000-fold. The combination of these factors means that comparing the forces on the voltage sensor with the forces on singly charged groups in the aqueous parts of the cell, the forces on the voltage sensor are approximately 20 X 120 X 3000 = 7.2 million times higher [5,8]. The physics predicts, therefore, extraordinarily strong forces activating the VGCCs via the voltage sensor. It follows that the biology tells us that the VGCCs are the main target of the EMFs and the physics tells us why they are the main target. *Thus the physics and biology are pointing in exactly the same direction*.

We have, then, very strong arguments that the EMFs act directly on the voltage-sensor to activate the VGCCs. There are several other types of evidence, each providing important evidence supporting this view:

1. In a study published by Pilla [12], it was found that pulsed EMFs produced an "instantaneous" increase in calcium/calmodulin-dependent nitric oxide synthesis in cells in culture. What this study [12] showed was that following EMF exposure, the cells in culture, must have produced a large increase in [Ca2+]i, this in turn produced a large increase in nitric oxide synthesis, the nitric oxide diffused out of the cells and out of the aqueous medium above the cells into the gas phase, where the nitric oxide was detected by a nitric oxide electrode. This entire sequence occurred in less than 5 seconds. This eliminates almost any conceivable indirect effect, except possibly via plasma membrane depolarization. Therefore, it is likely that the pulsed EMFs are acting directly on the voltage sensors of the VGCCs and possibly the voltage-gated sodium channels, to produce the [Ca2+]i increase.

2. There are also additional findings pointing to the voltage sensor as the direct target of the EMFs. In addition to the VGCCs, there are also voltage-gated sodium, potassium and chloride channels, with each of these having a voltage sensor similar to those found in the VGCCs. Lu et al [13] reported that voltage gated sodium channels, in addition to the VGCCs were activated by EMFs. Tabor et al [14] found that Mauthner cells, specialized neurons with special roles in triggering rapid escape mechanisms in fish, were almost instantaneously activated by electrical pulses, which acted via voltage-gated sodium channel activation to subsequently produce large [Ca2+]i increases. Zhang et al [15] reported that in addition to the VGCCs, potassium and chloride channels were each activated by EMFs, although these other voltage-gated ion channels had relatively modest roles, compared with the VGCCs, in producing biological effects. Each of these three studies [13-15] used specific blockers for these other voltage-gated ion channels to determine their roles. The Tabor et al [14] study also used genetic probing to determine the role of the voltage-gated sodium channels. Lu et al [13] also used whole cell patch clamp measurements to measure the rapid influx of both sodium and calcium into the cell via the voltage-gated channels following EMF exposure. Sodium influx, particularly in electrically active cells, acts in the normal physiology to depolarize the plasma membrane, leading to VGCC activation such that the voltage-gated sodium channels may act primarily via indirect activation of the VGCCs. In summary then, we have evidence that in animal including human cells, seven distinct classes of voltage-gated ion channels are each activated by EMF exposures: From Ref. [4], four classes of voltage-gated ion channels were shown from calcium channel blocker studies, to be activated by EMFs, L-type, T-type, N-type and P/Q –type VGCCs. In this paragraph we have evidence that three other channels are also activated, voltage-gated sodium channels, voltage-gated potassium channels and voltage-gated chloride channels. Furthermore the plant studies strongly suggest that the so called TPC channels, which contain a similar voltage sensor, are activated in plants allowing calcium influx into plants to produce similar EMF-induced responses [6]. In summary, then we have evidence for eight different ion channels being activated by EMF exposure, four classes of VGCCs, one class each of voltage-gated sodium,

potassium and chloride channels and also one class of plant channel, with each of these channels having a similar voltage-sensor regulating its opening. One can put those observations together with the powerful findings from the physics, that the electrical forces on the voltage-sensor are stunningly strong, something like 7.2 million times stronger than the forces on the singly charged groups in the aqueous phases of the cell. Now you have a stunningly powerful argument that the voltage sensor is the predominant direct target of the EMFs.

3. The most important study on this subject, was published by Tekieh et al [16]. It showed that microwave frequency EMFs directly activate the VGCCs in isolated membranes. A variety of microwave frequencies were used in these studies and each such frequency produced VGCC activation in a completely cell-free system. This study clearly shows that the EMF activation of the VGCCs is direct and not due to some indirect regulatory effect.

How then does the estimated sensitivity of the voltage-sensor, about 7.2 million times greater forces than the forces on singly charged groups, compare with previous estimates of levels of EMF exposure needed to produce biological effects? The ICNIRP 2009 [17] safety guidelines allowed for 2 to 10 W/m^2 exposure, depending upon frequency. In contrast, the Bioinitiative Working Group 2007 [18] proposed a precautionary target level of 3 to 6 $\mu W/m^2$ or about a million-fold lower, using a safety factor of 10. If one uses a more commonly used safety factor of 50 to 100, then the 7.2 million-fold sensitivity of the voltage-sensor, predicted by the physics, falls right in the middle of the Bioinitiative Working Group 2007 calculations. So again, it can be argued that the physics and the biology are pointing in the same direction, in this case pointing to the same approximate range of sensitivity.

You may be wondering why I am spending so much time and space going through each of these studies. The answer is that a well over a trillion dollar (or trillion euro) set of industries, the telecommunications industry, has been putting out propaganda for over two decades, arguing that there cannot be a mechanism of action of these non-thermal EMFs to produce biological effects; and that these EMFs are too weak to do anything and that only thermal effects are documented. It is essential to dot every **i** and cross every **t** with regard to the main mechanism of action of non-thermal effects. That is exactly what has been done here.

<u>How Can the Diverse Effects of Such EMF Exposures Be Produced by VGCC Activation?</u>

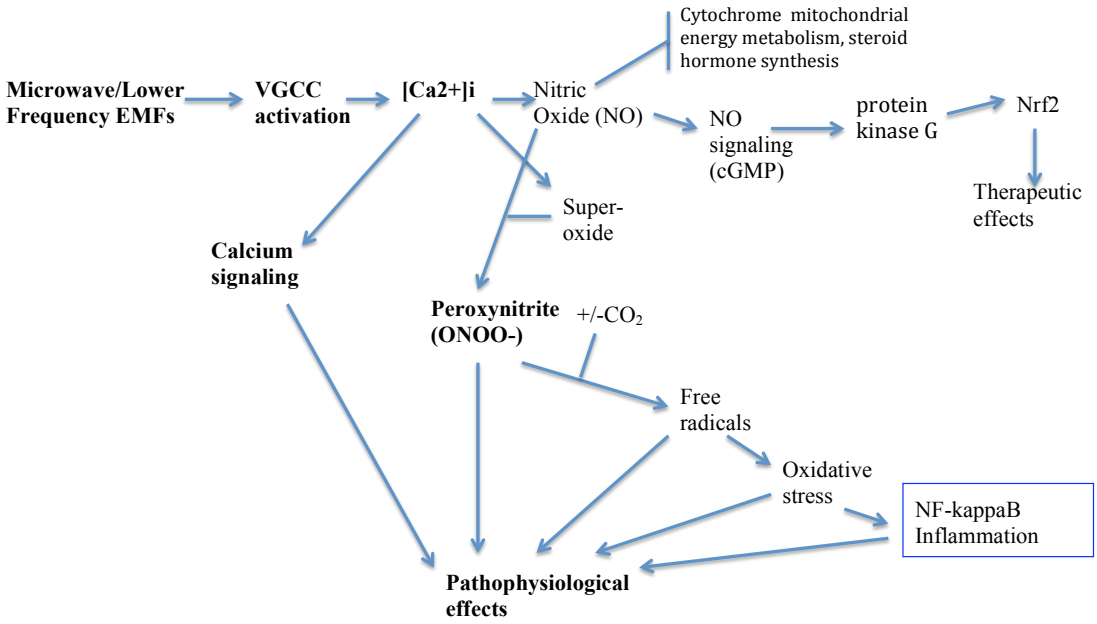

Fig. 1 How EMFs Act via VGCC Activation to Produce Various Effects

The mechanisms by which various effects can be generated by VGCC activation are outlined in Fig. 1. Going across the top of Fig. 1, it can be seen that increased intracellular calcium [Ca2+]i can increase nitric oxide (NO) synthesis, stimulating the NO signaling pathway (going to the right from top, center), to produce therapeutic effects. NO (very top) can also bind to cytochromes and inhibit their activity. NO binding to the terminal oxidase in the mitochondria inhibits energy metabolism and lowers, therefore, ATP. NO binding to cytochrome P450s, lowers synthesis of steroid hormones, including estrogen, progesterone and testosterone. The P450 lowering also lowers detoxification and vitamin D activity. Most of the pathophysiological effects are produced by the peroxynitrite/free radical/oxidative stress pathway center to lower right (Fig. 1) and also by excessive calcium signaling pathway (slightly left of center, Fig. 1). Some of the ways these are thought to produce various well-established EMF effects are outlined in Table 1.

Table 1. How Eight Established Effects of EMFs Can Be Produced by VGCC Activation

EMF effect	Probable mechanism(s)
Oxidative stress	Produced by elevated levels of peroxynitrite and the free radical breakdown products of peroxynitrite and its CO_2 adduct. Four studies of EMF exposure, cited in [4] showed that oxidative stress following exposure was associated with major elevation of 3-nitrotyrosine, a marker of peroxynitrite, thus confirming this interpretation. Two other studies each found 3-nitrotyrosine elevation, both following 35 GHz exposures [19,20].
Lowered male/female fertility, elevated spontaneous abortion, lowered libido	Both the lowered male fertility and lowered female fertility are associated with and presumably caused by the oxidative stress in the male and female reproductive organs. Spontaneous abortion is often caused by chromosomal mutations, so the germ line mutations may have a causal role. Lowered libido may be caused by lowered estrogen, progesterone and testosterone levels. It seems likely that

	these explanations may be oversimplified. One additional mechanism that may be important in producing lowered fertility is that VGCC activation and consequent high [Ca2+]i levels is known to have a key role in avoiding polyspermy. Consequently, if this response is triggered before any fertilization of an egg has occurred, it may prevent any sperm from fertilizing and egg.
Neurological/ neuropsychiatric effects	Of all cells in the body, the neurons have the highest densities of VGCCs, due in part to the VGCC role and [Ca2+]i role in the release of every neurotransmitter in the nervous system. Calcium signaling regulates synaptic structure and function in 5 different ways, each likely to be involved here. Oxidative stress and apoptosis are both thought to have important roles. Lowered sleep and increased fatigue are likely to involve lowered nocturnal melatonin and increased nocturnal norepinephrine.
Apoptosis	Apoptosis can be produced by excessive Ca2+ levels in the mitochondria and by double strand breaks in cellular DNA; it seems likely that both of these mechanisms are involved following EMF exposure. A third mechanism for triggering apopotosis, endoplasmic reticulum stress (see bottom row in this Table), may also be involved.
Cellular DNA damage	Cellular DNA damage is produced by the free radical breakdown products of peroxynitrite directly attacking the DNA [7].
Changes in non-steroid hormone levels	The release of non-steroid hormones is produced by VGCC activation and [Ca2+]i elevation. The immediate effects of EMF exposures is to increase hormone release and to raise, therefore, hormone levels. However many hormone systems become "exhausted" as a consequence of chronic EMF exposures. The mechanism of exhaustion is still uncertain, but it may involve oxidative stress and inflammation.
Lowered steroid hormone	Steroid hormones are synthesized through the action of cytochrome P450 enzymes; activity of these hormones is inhibited by binding of high levels of nitric oxide (NO) leading to lowered hormone synthesis.
Calcium overload	Produced by excessive activity of the VGCCs; secondary calcium overload is produced by oxidative stress activation of TRPV1, TRPM2 and possibly some other TRP receptors, opening the calcium channel of these receptors.
Heat shock protein induction	There is a large literature showing that excessive [Ca2+]i induces very large increases in heat shock proteins. This is thought to be produced by complex calcium signaling changes involving the endoplasmic reticulum, mitochondria and the cytosol and also involving excessive [Ca2+]i producing increasing protein misfolding [21-23]. It should be noted that some calcium is essential for proper protein folding in the endoplasmic reticulum such that only excessive calcium leads to misfolding and consequent endoplasmic reticulum stress.

Each of the seven established EMF effects, discussed above, can be generated through the mechanisms outlined in Fig. 1, as shown by Table 1. An eighth, heat shock protein induction can also be so explained (Table 1). Several other such effects, including EMF causation of

cataracts, breakdown of the blood-brain barrier, lowered nocturnal melatonin are also so explained, as discussed earlier [5]. The primary mechanism for therapeutic effects was discussed in [4,24,25] and was also shown to be generated via such VGCC downstream effects. Fifteen mechanisms for EMF cancer causation are described in ref [7]; these are far too complex to describe in this document so the reader is referred to ref [7].

It can be seen, in summary, that we are far beyond the issue whether there are non-thermal EMF effects. Rather many researchers have identified many established effects of EMF exposure. The main direct targets of non-thermal EMF exposure, the VGCCs have also been identified and how these get activated by EMF exposure acting on the VGCC voltage-sensor has also been determined. And finally we have identified how a wide variety of these effects can be generated via downstream effects produced by such VGCC activation.

Our current safety guidelines are based only on heating (thermal) effects. Heating is produced predominantly by forces on singly charged groups in the aqueous phases of the cell but the forces on the voltage sensor are approximately 7.2 million times higher. Therefore, our current safety guidelines are allowing us to be exposed to EMFs that are approximately 7.2 million times too strong. That 7.2 million figure is somewhat similar to the estimate given by the Bioinitiative Report and by the Building Biologists, based on completely different considerations.

It should be obvious, that non-thermal EMFs:

1. Attack our nervous systems including our brains leading to widespread neuropsychiatric effects and possibly many other effects. This nervous system attack is of great concern.
2. Attack our endocrine (that is hormonal) systems. In this context, the main things that make us functionally different from single celled creatures are our nervous system and our endocrine systems – even a simple planaria worm needs both of these. Thus the consequences of the disruption of these two regulatory systems is immense, such that it is a travesty to ignore these findings.
3. Produce oxidative stress and free radical damage, which have central roles in all common chronic diseases.
4. Attack the DNA of our cells, producing single strand and double strand breaks in cellular DNA and oxidized bases in our cellular DNA. These in turn produce both cancer and mutations in germ line cells with germ line mutations producing mutations impacting future generations.
5. Produce elevated levels of apoptosis (programmed cell death), events especially important in causing both neurodegenerative diseases and infertility.
6. Lower male and female fertility, lowered sex hormones, lowered libido, increased levels of spontaneous abortion and, as already stated, attacks on the DNA in sperm cells.
7. Produce excessive intracellular calcium [Ca2+]i and increased calcium signaling.
8. Act in the cells of our bodies via 15 different mechanisms to cause cancer.

By attacking all of these important systems in the body, EMFs attack everything we care about including our health (in many ways), our reproductive systems, the integrity of our genomes and our ability to produce healthy offspring.

There are 79 different reviews listed at the end of Chapter 1, with each documenting the existence of one or more of these various non-thermal EMF effects. What, then, do the two organization reports that the EU authorities and U.S. authorities rely upon, ICNIRP and SCENIHR 2015, have to say about these independent reviews. The answer is absolutely nothing! Neither one of them

uses any of these independent reviews to assess EMF effects. This whole area is discussed in much more detail in Chapter 5, below.

Chapter 3. Strong Evidence for Cumulative and Irreversible EMF Effects

Two questions that must be raised about the effects of these low-intensity EMFs producing biological effects is are they cumulative and are they reversible? I am aware of several different types of evidence for cumulative effects and also for irreversible effects.

Three of the human occupational exposure studies from the 1970's reviewed in the Raines, National Aeronautics and Space Administration (NASA) study [26], showed that effects increased substantially with increasing time of exposure to a particular type and intensity of EMF. While these three studies each show cumulative effects but they provide no data on possible irreversibility of these neurological/neuropsychiatric effects. However the largest review of such occupational exposures (Hecht [28]) does provide substantial evidence on the cumulative nature and irreversibility of these neurological/neuropsychiatric effects.

Hecht [28] reviewed 60 different studies of occupational exposures that were done between 1960 and 1990 in the Soviet Union and East Germany. These were occupational exposure studies of over 3500 people, who were exposed to microwave frequency EMFs at intensities of less than $1/1000^{th}$ of our safety guidelines. These studies [28] found that these EMFs produced neuropsychiatric effects similar to those found in my much more recent study [3], listed in Chapter 1 as well as on cardiac effects. Neither the neuropsychiatric findings nor the cardiac findings were unique however. Similar neuropsychiatric effects have been found to be caused by low intensity EMF exposures [27,29-34]. Cardiac effects have also been found in humans [26,29,30,32,34,35] similar to those found by Hecht [28].

Hecht [28] reports that exposures at those very low intensities for up to 3 years produced increased sympathetic nervous system activity, apparently in response to the EMF stress, following the classic stress sequence described by Hans Selye in 1953. No other effects were apparent during this circa 3 year period. However longer exposure produced observable neurological/neuropsychiatric and cardiac effects as well as other effects which were initially modest. Exposures of 3 to 5 years typically produced effects that could be largely reversed after 2 to 3 years in a no-EMF exposure environment. Hecht states that "if detected early, effective therapy is possible." However longer than 4 to 5 years exposures produced more severe effects which did not reverse when the persons were subsequently put into a no-EMF exposure environment. These and other effects continued to worsen with 10 years of exposure or longer. This cumulative nature of such EMF exposures was noted in two earlier reviews cited by Hecht et al [36,37]. These studies, then, provide very large amounts of evidence both for the cumulative nature of these neuropsychiatric effects, as well as the apparent irreversibility of these effects as they become more severe. Hecht also notes that "decline in health status increasingly amplifies EMF effects." This a pattern of increasing apparent sensitivity produced by previous exposure is similar to that described in the Western literature on electromagnetic hypersensitivity (EHS), something that Hecht recognizes [28]. EHS something that is discussed very briefly below in this section.

There are strong similarities between the Hecht [28] findings on microwave frequency EMFs in humans and the impacts of such EMFs on cellular and organ histology in rodents, as were reviewed in Tolgskaya and Gordon [38] and discussed in Pall [3]. In rodents, initially non-thermal exposures over periods of 1 to 2 months produced modest changes in structure of the brain and of the neurons. When such exposures ceased, most of the structural changes

disappeared – that is the changes were largely reversed when the animals were placed back into a no-EMF environment. However more months of exposure produced much more severe impacts on brain and neuronal structure and these were irreversible [38, 3]. More recent, Western country and other country studies cited in [3], provide much further support for brain impacts similar to those found in Soviet and also other country brain studies reviewed by Tolgskaya and Gordon[38]. Tolgskaya and Gordon [38,3] also reported findings that in histological studies, the nervous system was the most sensitive organ in the body, followed closely by effects on the heart and the testis, although many other organs were also impacted. Thus, the Tolgskaya and Gordon review [38,3] provides very important support for the findings of neurological/neuropsychiatric effects, the cardiac effects, discussed immediately above and below, and the reproductive effects discussed in Chapter 1. By comparing the animal studies with the human studies, one can see the striking similarities, with the major difference being that the effects in rodents are much more rapid than the effects on humans. Given the much higher metabolic rates in rodents and much lower life spans in rodents, the timing difference is not surprising. With regard to the issues of cumulative nature and irreversibility, both rodent and human studies provide strong support for both neurological and neuropsychiatric effects showing both cumulative nature and irreversibility and show a similar pattern of cumulative effects with the cardiac effects.

What are the cardiac effects discussed briefly above, that are produced by non-thermal microwave frequency EMF exposures? The effects include tachycardia (rapid heartbeat) where some people with apparent EHS, on blinded exposure to cordless phone radiation have instantaneous tachycardia, an effect that is also essentially instantaneously reversible on cessation of exposure [28,35,36]. So tachycardia can be an almost instantaneous response to EMFs and it is sometimes also found with arrhythmia. Prolonged exposures produce both arrhythmias and bradycardia (slow heart beat) [26-30,32]. Similar EMF cardiac effects were seen in animal studies, with the earliest of these going back to the late 1960s.

Some of the early studies on long-term EMF cardiac effects are listed in Table 2, below. They show that such chronic exposures produce bradycardia and sometimes arrhythmia. The early Soviet studies (labeled USSR) reported similar findings to those found in the western studies (Table 2).

Table 2. Chronic Exposure, Non-Thermal EMF Cardiac Effects from NASA Review [26]

Study	**Effects Reported**
Schwan 1977	Cardiology changes
Dwyer 1978	Bradycardia, hypotension
Sadicikova (USSR)	Bradycardia, hypo & hypertension, cardiac pain, systolic murmur
Kalyada (USSR)	"cardiovascular changes"
Sadichikova (USSR)	Changes in cardiovascular system
Pressman 1970	QRS interval in ECG increased (bradycardia), also arrhythmia
Domanski (USSR)	Bradycardia, hypotension, ECG changes (shows both bradycardia and arrhythmia)
Lerner (1980)	Bradycardia
Stuchley (1978)	Bradycardia (measured in 2 ways), hyper & hypotension, cardiac pain, systolic murmur.

Arrhythmias, especially when they are accompanied by bradycardia, are often associated with sudden cardiac death. We are having an epidemic of young, apparently healthy athletes dying in

the middle of an athletic competition of apparent sudden cardiac death, which may, therefore be possibly caused by EMF exposures [39]. Some of these individuals have been saved from death [39] and subsequently found to be suffering from bradycardia and arrhythmias. Another type of cardiac effect is that when apparent EHS people are exposed to Wi-Fi, cell phone, cell phone tower or smart meter radiation, they are reported to suffer from heart palpitations. Each of these four types of cardiac effects, tachycardia, arrhythmias, bradycardia and heart palpitations involve aberrations in the electrical control of the heartbeat. How can these be produced?

The heartbeat is controlled by pacemaker cells in what is called the sino-atrial node of the heart. Those pacemaker cells have been shown to have very high densities of the T-type VGCCs which may make these cells particularly susceptible to direct effects of the EMFs (recall that EMFs act via VGCC activation). The T-type and the L-type VGCCs have essential roles in controlling the heartbeat. It follows that EMF exposures, acting directly on the pacemaker cells of the heart, can produce tachycardia responses. Furthermore, gene mutations in a VGCC gene that produce increased VGCC activity can produce both tachycardia and arrhythmia in young babies carrying those mutations; these young children die of sudden cardiac death at a very young age. How then do we get bradycardia? Bradycardia is produced when EMFs chronically impact the sino-atrial node, such that the dysfunction involved in heart failure, which is very complex, produces dysfunction of the pacemaker cells of the heart, producing bradycardia [40].

It follows from this that EMF-produced bradycardia and chronic arrhythmias are likely to be caused by heart-failure-like changes that particularly impact the sino-atrial node of the heart, including the tissue remodeling found in heart failure. This model has been confirmed by the findings of Liu et al [41], who found that pulsed microwave frequency EMF produced tissue remodeling that specifically impacted the sino-atrial node of the heart with remodeling changes similar to those found in heart failure [40]. Heart failure develops in a cumulative fashion and, based on current medicine at least, is an irreversible process involving tissue remodeling and a large number of other biochemical and physiological changes [41]. It seems likely, therefore, that the EMF effects on the heart are both cumulative and irreversible.

You will recall, from the discussion at the beginning of Chapter 1, that there are 18 reviews documenting that EMF produces lowered fertility. These act via diverse mechanisms. These include tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovary remodeling and oocyte apoptosis, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, and lowered libido. We already have sperm count drops to below 50% of normal in every technologically advanced country on earth [1]. We also have fertility drops to well below replacement levels in every technologically advanced country on earth, with one exception. Clinical observations argue that while there are sometimes technical fixes that allow some reproduction, infertility appears to be inherently irreversible. The Magras and Xenos [2] in mice, also discussed in Chapter 1 shows that radiofrequency radiation exposures well below our safety guidelines, produce immediate drops in mouse reproduction in the first litter. Further exposures to the same EMF levels produced a crash in reproduction essentially to zero, a crash that appeared to be essentially irreversible.

We don't know that humans will behave very similarly to mice. We do know that the EMFs produce the diverse effects on human reproduction listed in the previous paragraph. My prediction is that even if exposures level off where they are now, we will start seeing crashes in reproduction within about 5 years. If we go ahead with 5G, that crash may be almost instantaneous.

Mutation accumulation produced by cellular DNA damage is likely to be both cumulative and irreversible, as well, because later mutations are highly unlikely to reverse previously occurring mutations. It has been estimated that all we need to have is an increase in germ line mutation of 2 ½ to 3-fold, to become over time, extinct from the very high levels of mutations in each newborn. From the high levels of DNA damage produced in human sperm from common EMF exposures, we may be already well above that level.

It follows from this that we already face four existential threats produced by microwave frequency EMF exposures to the survival of every technologically advanced society on earth:

1. Cumulative and irreversible neurological/neuropsychiatric effects.
2. Cumulative and irreversible reproductive effects.
3. Cumulative and irreversible cardiac effects, leading to sudden cardiac death.
4. DNA effects in germ line, including sperm cells, leading to major impacts on our gene pool and high mutation frequencies.

Any one of these can destroy us on its own and with the ever increasing exposures and especially the vast increases in exposure that the 5G rollout will inevitably produce, that destruction is likely to be imminent. These don't even take into consideration the cancer effects, the hormonal effects or other effects produced by increased oxidative stress or increased apoptotic cell death. There is extraordinary evidence for each of these effects of EMF exposure, which have been repeatedly documented in the reviews listed in Chapter 1.

The following information is derived from an abstract that I used for a talk at the Neuroscience 2016 meeting in Los Angeles, a meeting that was focused on Alzheimer's disease and similar dementias. The discussion here raises the question of whether Alzheimer's and other dementias may be still another set of irreversible diseases where cumulative effects of microwave frequency EMFs may have important causal roles. Dementias and other types of neurological deaths have had unexplained rapid recent increases [42-44]. The parallel between these increases and the increases in cell phone and other EMF exposures suggested that such exposures may cause dementia increases [45]. Reports show people circa age 30 developing Alzheimer's or other very early onset dementias and even younger people are reported to develop digital dementias, dementias caused by heavy use of digital devices [46-48]. One of the questions being raised here, is whether digital dementias are caused, at least in part, by the EMF exposures produced by these digital devices and the Wi-Fi fields involved in their usage, rather than solely by such things as screen time, as is often assumed. As you have seen in chapter 2, microwave and lower frequency EMFs act via activation of the VGCCs, leading to increases in intracellular calcium ([Ca2+]i) and downstream effects including increased Ca2+ signaling, NO, superoxide, peroxynitrite, free radicals, oxidative stress, NF-kappaB and mitochondrial dysfunction.

Each of these downstream effects have been shown to have important roles in causing Alzheimer's disease and other neurodegenerative diseases [49-51]. These all suggest plausible mechanisms for action for EMFs causing Alzheimer's disease. Furthermore the amyloid-beta protein (Aβ) which has an specific role in causing Alzheimer's disease, is produced in increasing amounts by elevated [Ca2+]i, and small Aβ aggregates form Ca2+ channels in the plasma membrane and aggregates also raise [Ca2+]i via increased VGCC and RYRr activity, suggesting a vicious cycle between Aβ and [Ca2+]i in Alzheimer's disease. This argues that increased intracellular calcium levels, produced by the EMFs increases Aβ and increased Aβ increases intracellular calcium, in what may be the central mechanism in causing Alzheimer's disease.

Four rodent studies support an EMF role in Alzheimer's disease. A series of short pulses of EMFs in young rats, produced the following in the equivalent of middle aged rats: elevated brain Aβ and oxidative stress; lowered cognition and memory [52,53]. 900 MHz exposures produces oxidative stress, increased Aβ and lowered miR-107, all found in Alzheimer's disease brains [52-55]. There are many animal studies showing roles for [Ca2+]i through both VGCCs and RYRs in causing Alzheimer's disease in rodent models; these include studies with calcium channel blockers and studies of transgenic mice with varying VGCC and RYR expression. Very low EMF exposures can produce, however, protective responses [56,57]; this is not surprising because EMF therapy is thought to act via NO signaling and protein kinase G (see Fig.1, Chapter 2) and this pathway is reported to protect from Alzheimer's disease. Epidemiological studies have shown that exposure of humans of 50/60 Hz EMFs, which also act via VGCC activation, can cause elevated Alzheimer's disease incidence [58,59]. Interestingly, a 1997 article in Microwave News, discussing two such epidemiological findings on EMFs and Alzheimer's disease in humans, found that occupational exposures to EMFs produced as much as a four-fold increase in Alzheimer's disease [59A]. That same article [59A] suggested a similar mechanism to the mechanism suggested here, namely that increased [Ca2+]i following EMF exposure produces increases in Aβ. In conclusion, a wide range of studies support the view that low intensity microwave frequency exposures acting via VGCC activation and [Ca2+]i, can produce increases in Aβ and other causal factors of Alzheimer's disease in humans and in animals and EMFs have been shown to produce Alzheimer's effects in rats.

These various findings on EMFs and Alzheimer's disease, the increasingly early onset of dementias and the occurrence of digital dementias, all suggest we may have another very high level threat caused by EMF exposures, possibly involving cumulative EMF effects and leading to severe, irreversible brain damage.

Chapter 4 EMFs Including Wi-Fi May Be Particularly Damaging to Young People

Most arguments that have been made that microwave frequency EMFs may be much more damaging to young children have centered on the much smaller skulls and skull thickness in young children, increasing the exposure of their brains to EMFs [60, 61]. However there are other arguments to be made. EMFs have been shown to be particularly active in producing effects on embryonic stem cells [62-71]. Because such stem cells occur at much higher cell densities in children, with stem cell densities the highest in the fetus and decreasing with increasing age [62, 63], impacts on young children are likely to be much higher than in adults. The decreased DNA repair and increased DNA damage following EMF exposure, in conjunction with the increased cell division in young children, strongly suggest that young children may be increasingly susceptible to cancer following such exposures [62-64, 71]. Two reviews discussed in the next chapter provide further evidence on higher cancer susceptibility of children. EMF action on stem cells may also cause young children to be particularly susceptible to disruption of brain development [66,71], something that may be relevant to autism causation.

It is my belief that the role of [Ca2+]i in synapse development is also relevant to the possible EMF causation of autism. The Hecht review of Soviet occupational exposure studies [28] reports that "younger persons show a greater sensitivity to electromagnetic fields than adults." These are all very problematic issues and we cannot rule out the possibility that there are other problematic issues as well. Redmayne and Johansson [72] reviewed the literature showing that there are age-related effects, such that young people are more sensitive to EMF effects. It follows from these various findings that the placement of Wi-Fi into schools around the country and the not uncommon placing of cell phone towers on schools may well both be a high level threats to the health of our children as well being a threat to teachers and any very sensitive fetuses teachers

may be carrying, as well. Mr. Barrie Trower, a retired military intelligence expert from the U.K. has been going around the world, at his expense, speaking against Wi-Fi in schools. His knowledge on this is based in part on classified information which he is unable to discuss, but has given him great concern.

Chapter 5: The Importance of the SCENIHR 2015 Document and the Many Omissions, Flaws and Falsehoods in That Document

One thing that I think we can all agree upon, is that the SCENIHR 2015 [73] document is an important document. The reason for its importance is that previous industry-friendly documents, and there have been many of them, have only reviewed very limited amounts of the literature on EMF effects. Consequently all of these other documents are open to the criticism that they have cherry picked what little data they have chosen to discuss. SCENIHR 2015 [73] has a reference list of almost 48 pages in length, going from page 233 to 280. So it appears that SCENIHR 2015 may have done a much more thorough and defensible review of the literature. Our assessement of SCENIHR 2015 [73] is important because of the confidence expressed in this document both by Mr. Ryan and Dr. Vinciūnas and also by the U.S. National Cancer Institute. The question that is being raised here is whether SCENIHR 2015 is thorough and defensible or not.

The Speit/Schwarz Controversy: How SCENIHR Has Put Out Seven Falsehoods in Support of the Industry Progaganda Position

I am going to start by discussing a single particularly important issue from [73]. At the end of Table 5 in [73]. there is a claim that a 2013 study by Speit et al [74] was unable to replicate the findings of a 2008 study published by Schwarz et al [75]. In Table 5 they state further that Speit el al found "No effect on DNA integrity (MN) and DNA migration (comet); Repetition study of Schwarz et al, 2008." What is called loss of DNA integrity here, measured by formation of micronuclei (MN), is caused by the formation of double strand breaks in cellular DNA. The comet assay measures single strand breaks in cellular DNA. Schwarz et al [75] found strong evidence that there were large increases in both single strand and double strand breaks in cellular DNA following very low intensity exposures to a cell phone-like pulsed radiation, but SCENIHR claims that Speit et al [74] were unable to repeat the earlier study. Elsewhere (p.89, bottom) SCENIHR states that "By using the same exposure system and the same experimental protocols as the authors of the original study, they failed to confirm the results. They did not find any explanation for these conflicting results (Speit et al, 2013)."

A careful examination of both [74] and [75] finds the following: 1. Speit et al [74] used a lymphocytic cell line, HL-60; Schwarz et al [75] studied human fibroblasts. This is a big difference because, as we have already said, different cell types behave differently. 2. Speit et al [74] used 1800 MHz radiation; Schwarz et al [75] used 1950 MHz radiation (the frequency of UMTS, also called 3G). Again we have a potentially important difference because effects are influenced by the frequency used. 3. Speit et al [74] used a continuous wave EMF; Schwarz et al [75] used a highly pulsed EMF, with high levels of both KHz and MHz pulsations to mimic the pulsation pattern of 3G cell phones. This is expected to produce very large differences between the two studies. 4. Speit et al [74] used a reverberation exposure chamber; Schwarz et al [75] did not use any exposure chamber. This could be another very large difference between the two studies, a difference that will be discussed toward the end of this chapter. 5. So where did the claim come from that Speit was trying to repeat the Schwarz study? Speit et al [74] says in their paper that they were trying to repeat another study (not Schwarz) that was described in a report but was never published. 6. Speit et al [74] do not even cite the Schwarz et al [75] paper, so obviously they did not intend to repeat Schwarz. We have then SCENIHR 2015 stating three

multifaceted falsehoods that Speit et al [74] tried to repeat the earlier studies of Schwarz et al [75], that they were unable to repeat those Schwarz et al [75] studies and that they used identical methodology to that used by Schwarz et al [75]. In addition to those three are four underlying falsehoods – namely that the two studies used very different methodologies, notably differing in the cell type studied, differing in the frequency used, differing widely in the in pulsations used and differing in the use of an exposure chamber. *Each of these falsehoods are SCENIHR's not Speit et al [74]'s, each of them can be easily seen to be false by even a superficial reading of these two papers.*

As you might guess, there is a major story behind all of this. The very low intensity exposure used in the Schwarz et al [75] study produced large numbers of DNA breaks, larger than that produced by 1600 chest X-rays. This conclusion can be made by comparing the results of Schwarz et al [75] with the earlier study of Lutz and Adlkofer [76]. From this comparison, it seems clear that non-ionizing radiation similar to 3G radiation can be much more dangerous to the DNA of our cells than is a similar energy of ionizing radiation. When this was found, the industry went into attack mode, attacking the two Professors who collaborated in [75], Prof. Franz Adlkofer in Germany and Prof. Hugo Rüdinger in Austria. The first couple of years of these attacks have been described in some detail on pp 117-131 in Dr. Devra Davis' book Disconnect [77]. Before the SCENIHR 2015 document was drafted, it was clear that the publishers who had published Adlkofer's and Rüdinger's work, not just the Schwarz et al [75] study but other papers by the same research group, had long since rejected the industry propaganda claims. In addition. Adlkofer had won a lawsuit in the German courts against his main accuser. He has subsequently since won a second such lawsuit. The last paragraph on p.89 in SCENIHR 2015 is word for word industry propaganda. What is clear is that SCENIHR is wittingly or unwittingly serving as a propagandist for the industry in and that process, SCENIHR has no difficulty in putting forth seven obvious, individually important falsehoods.

One question that needs to be raised is how is it possible for microwave frequency EMFs to produce much more cellular DNA damage than a comparable energy level of ionizing radiation? Both ionizing radiation and microwave/lower frequency EMFs act via free radicals to attack the DNA. If you examine Fig. 1, Chapter 2, you will see how low intensity microwave frequency EMFs can act (p. 20). The free radicals that attack the DNA are breakdown products peroxynitrite.. The sequence of events leading to those free radicals starts, of course with the extraordinarily high sensitivity of the VGCC voltage sensor to the electrical forces of the EMFs that open the VGCC calcium channels. Following that there are three steps in the process leading to peroxynitrite elevation *each of which have high levels of amplification*. The first of these is that when the VGCC channels are open, they allow the influx of about a million calcium ion per second into the cell. The second amplification is that elevated intracellular calcium [Ca2+]i activates the synthesis of both nitric oxide (NO) and superoxide. The third amplification is that the formation of peroxynitrite is proportional to the product of nitric oxide concentration *times* the superoxide concentration. When you have three sequential amplification mechanisms, you can get a very large response, in this case free radical attack on cellular DNA, from a very small initial signal. That is where much of the existential crises are coming are from, with EMFs threatening the survival of every technologically advanced country on earth.

Going back to falsehoods perpetrated by SCENIHR regarding Speit/Schwarz, here are two possible interpretations for those seven falsehoods. One is that SCENIHR is simply an industry propaganda organ. The second is that we have a group of scientists (SCENIHR) who are largely incompetent and that it is just coincidence that these seven falsehoods serve the industry propaganda case. Either of these interpretations completely destroy the claims of confidence in

SCENIHR that Mr. Ryan and Dr. Vinciūnas made in the documents they wrote that were referred to in the Preface of this document.

I have written here another 27 pages critiquing the SCENIHR 2015 [73] document. If you are already convinced that the SCENIHR claims that there are no established non-thermal EMF effects are false and that we have eight extremely well documented effects (Chapter 1) and that we have detailed mechanisms of how these effects are produced (Chapter 2), then I suggest you skip to the summary of Chapter 5 starting on p. 57 and then go on to the consider the U.S. situation in Chapter 6 and 5G in Chapter 7. If, however, you are not so convinced, you need to read the intervening 27 pages.

22 Reviews on EMF Effects, 20 of Which Are Ignored by SCENIHR, Two of Which Are Discussed in [73] but Essentially Dismissed

Now let's go on to consider how SCENIHR 2015 [73] considers the many independent reviews, listed in Chapter 1, which disagree with them and also fall into the 2009 through 2013 period that SCENIHR claims to have thoroughly considered. See Table 3.

Table 3: 2009 to 2013 Reviews that Should Have Been Cited and Discussed in SCENIHR 2015

Citation	Brief Summary	What does SCENIHR 2015 say about it?
[78] Khurana VG, Teo C, Kundi M, Hardell L, Carlberg M. 2009 Cell phones and brain tumors: a review including the long-term epidemiologic data. Surg Neurol 72:205-214.	Meta-analysis study of cell phone usage and brain cancer. The results indicate that using a cell phone for > or = 10 years approximately doubles the risk of being diagnosed with a brain tumor on the same ("ipsilateral") side of the head preferred for cell phone use. The data achieve statistical significance for glioma and acoustic neuroma but not for meningioma. CONCLUSION: The authors conclude that there is adequate epidemiologic evidence to suggest a link between prolonged cell phone usage and the development of an ipsilateral brain tumor.	Nothing. Review is not cited and not discussed.
[79] Desai NR, Kesari KK, Agarwal A. 2009 Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on the male reproductive system. Reproduct Biol Endocrinol 7:114.	This review identifies the plasma membrane as a target of RF-EMW. In addition, the effects of RF-EMW on plasma membrane structures (i.e. NADH oxidase, phosphatidylserine, ornithine decarboxylase) and voltage-gated calcium channels are discussed. We explore the disturbance in reactive oxygen species (ROS) metabolism caused by RF-EMW and delineate NADH oxidase mediated ROS formation as playing a central role in oxidative stress (OS) due to cell phone radiation (with a focus on the male reproductive system). This review also addresses: 1) the controversial effects of RF-EMW on mammalian cells and sperm DNA as well as its effect on apoptosis, 2) epidemiological, in vivo animal and in vitro studies on	Nothing. Review is not cited and not discussed.

	the effect of RF-EMW on male reproductive system.	
[80] Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.	Effects of cell phone exposure on the cardiovascular system, sleep and cognitive function, as well as localized and general adverse effects, genotoxicity potential, neurohormonal secretion and tumour induction. The proposed mechanisms by which cell phones adversely affect various aspects of human health, and male fertility in particular, are explained, and the emerging molecular techniques and approaches for elucidating the effects of mobile phone radiation on cellular physiology using high-throughput screening techniques, such as metabolomics and microarrays, are discussed. A novel study is described, which is looking at changes in semen parameters, oxidative stress markers and sperm DNA damage in semen samples exposed in vitro to cell phone radiation.	Nothing. Review is not cited and not discussed.
[81] Ruediger HW. 2009 Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology. 16:89-102.	101 publications are exploited which have studied genotoxicity of radiofrequency electromagnetic fields (RF-EMF) in vivo and in vitro. Of these 49 report a genotoxic effect and 42 do not. In addition, 8 studies failed to detect an influence on the genetic material, but showed that RF-EMF enhanced the genotoxic action of other chemical or physical agents. Variation in results may in part be explained by the different cellular systems and from the variety of analytical methods being used. Taking altogether there is ample evidence that RF-EMF can alter the genetic material of exposed cells in vivo and in vitro and in more than one way. This genotoxic action may be mediated by microthermal effects in cellular structures, formation of free radicals, or an interaction with DNA-repair mechanisms.	Nothing. Review is not cited and not discussed.
[82] Phillips JL, Singh NP, Lai H. 2009 Electromagnetic fields and DNA damage. Pathophysiology 16:79-88.	A major concern of the adverse effects of exposure to non-ionizing electromagnetic field (EMF) is cancer induction. Since the majority of cancers are initiated by damage to a cell's genome, studies have been carried out to investigate the effects of electromagnetic fields on DNA and chromosomal structure. Additionally, DNA damage can lead to changes in cellular functions and cell death. Single cell gel electrophoresis, also known as the 'comet assay', has been widely used in EMF research to determine DNA damage, reflected as single-strand breaks, double-strand breaks, and crosslinks. Studies have also been carried out to investigate chromosomal conformational changes and micronucleus formation in cells after exposure to EMF. This review describes the comet assay and its utility to qualitatively and quantitatively assess DNA damage, reviews studies that have	Nothing. Review is not cited and not discussed.

	investigated DNA strand breaks and other changes in DNA structure, and then discusses important lessons learned from our work in this area.	
[83] Davanipour Z, Sobel E. 2009 Long-term exposure to magnetic fields and the risks of Alzheimer's disease and breast cancer: Further biological research. Pathophysiology 16:149-156.	Extremely low frequency (ELF) and radio frequency (RF) magnetic fields (MFs) pervade our environment. Whether or not these magnetic fields are associated with increased risk of serious diseases, e.g., cancers and Alzheimer's disease, is thus important when developing a rational public policy. Our objective was to provide an unbiased review of the current knowledge and to provide our general and specific conclusions. RESULTS: The evidence indicates that long-term significant occupational exposure to ELF MF may certainly increase the risk of both Alzheimer's disease and breast cancer. There is now evidence that two relevant biological processes (increased production of amyloid beta and decreased production of melatonin) are influenced by high long-term ELF MF exposure that may lead to Alzheimer's disease. There is further evidence that one of these biological processes (decreased melatonin production) may also lead to breast cancer. Finally, there is evidence that exposures to RF MF and ELF MF have similar biological consequences. CONCLUSION: It is important to mitigate ELF and RF MF exposures through equipment design changes and environmental placement of electrical equipment.	Nothing. Review is not cited and not discussed.
[84] Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.	Latest epidemiological data reveal a significant increase in risk of development of some types of tumors in chronic (over 10 years) users of mobile phone. It was detected a significant increase in incidence of brain tumors (glioma, acoustic neuroma, meningioma), parotid gland tumor, seminoma in long-term users of mobile phone, especially in cases of ipsilateral use (case-control odds ratios from 1.3 up to 6.1). Two epidemiological studies have indicated a significant increase of cancer incidence in people living close to the mobile telephony base station as compared with the population from distant area. These data raise a question of adequacy of modern safety limits of electromagnetic radiation (EMR) exposure for humans. For today the limits were based solely on the conception of thermal mechanism of biological effects of RF/MW radiation. Meantime the latest experimental data indicate the significant metabolic changes in living cell under the low-intensive (non-thermal) EMR exposure. Among reproducible biological effects of low-intensive MWs are reactive oxygen species overproduction, heat shock proteins	Nothing. Review is not cited and not discussed.

	expression, DNA damages, apoptosis. Practical steps must be done for reasonable limitation of excessive EMR exposure, along with the implementation of new safety limits of mobile telephony devices radiation, and new technological decisions, which would take out the source of radiation from human brain.	
[85] Carpenter DO. 2010 Electromagnetic fields and cancer: the cost of doing nothing. Rev Environ Health 25:75-80.	Concern of health hazards from EMFs has increased as the use of cell phones and other wireless devices has grown in all segments of society, especially among children. While there has been strong evidence for an association between leukemia and residential or occupational exposure to ELF EMFs for many years, the standards in existence are not sufficiently stringent to protect from an increased risk of cancer. For RF EMFs, standards are set at levels designed to avoid tissue heating, in spite of convincing evidence of adverse biological effects at intensities too low to cause significant heating. Recent studies demonstrate elevations in rates of brain cancer and acoustic neuroma only on the side of the head where individuals used their cell phone. Individuals who begin exposure at younger ages are more vulnerable. These data indicate that the existing standards for radiofrequency exposure are not adequate. While there are many unanswered questions, the cost of doing nothing will result in an increasing number of people, many of them young, developing cancer.	Nothing. Review is not cited and not discussed.
[86] Giuliani L, Soffritti M (Eds). 2010 NON-THERMAL EFFECTS AND MECHANISMS OF INTERACTION BETWEEN ELECTROMAGNETIC FIELDS AND LIVING MATTER, RAMAZZINI INSTITUTE EUR. J. ONCOL. LIBRARY Volume 5, National Institute for the Study and Control of Cancer and Environmental Diseases "Bernardino Ramazzini" Bologna, Italy 2010, 400 page monograph.	Contains entire articles on: 1. Influence of mobile phone radiation on cognitive function. 2. Impact of DECT cordless phone radiation on heart rate variability and on the autonomic nervous system. 3 & 4. Two articles on the impact of radiofrequency radiation on the blood-brain barrier. 5 & 6. Two articles on microwave/radiofrequency radiation and cancer causation. 7. Epidemiological studies of EMF impact on human reproduction.	Nothing. Review is not cited and not discussed.
[87] Khurana, V. G., Hardell, L., Everaert,	We identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone	Nothing. Review is not

J., Bortkiewicz, A., Carlberg, M., Ahonen, M. 2010 Epidemiological evidence for a health risk from mobile phone base stations. Int. J. Occup. Environ. Health 16, 263-267.	base stations (cell phone antennae). Seven of these studies explored the association between base station proximity and neurobehavioral effects and three investigated cancer. We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact.	cited and not discussed.
[88] Levitt, B. B., Lai, H. 2010. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18, 369-395. doi.org/10.1139/A10-018	Both anecdotal reports and some epidemiology studies, reviewed in this study, have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations. Cardiac effects were also reported. Symptoms reported may be classic microwave sickness, first described in 1978. Nonionizing electromagnetic fields are among the fastest growing forms of environmental pollution. Some extrapolations can be made from research other than epidemiology regarding biological effects from exposures at levels far below current exposure guidelines.	Nothing. Review is not cited and not discussed.
[89] Kang N, Shang XJ, Huang YF. 2010 [Impact of cell phone radiation on male reproduction]. Zhonghua Nan Ke Xue 16:1027-1030.	With the popularized use cell phones, more and more concern has been aroused over the effects of their radiation on human health, particularly on male reproduction. Cell phone radiation may cause structural and functional injuries of the testis, alteration of semen parameters, reduction of epididymal sperm concentration and decline of male fertility. This article presents an overview on the impact of cell phone radiation on male reproduction.	Nothing. Review is not cited and not discussed.
[90] Yakymenko, I., Sidorik, E., Kyrylenko, S., Chekhun, V. 2011. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. Exp. Oncol. 33(2), 62-70.	The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine	Nothing. Review is not cited and not discussed.

	decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.	
[91] Yakimenko IL, Sidorik EP, Tsybulin AS. 2011 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999). 2011 Mar-Apr;83(2):20-28.	Review is devoted to the analysis of biological effects of microwaves. The results of last years' researches indicated the potential risks of long-term low-level microwaves exposure for human health. The analysis of metabolic changes in living cells under the exposure of microwaves from mobile communication systems indicates that this factor is stressful for cells. Among the reproducible effects of low-level microwave radiation are overexpression of heat shock proteins, an increase of reactive oxygen species level, an increase of intracellular Ca2+, damage of DNA, inhibition of DNA reparation, and induction of apoptosis. Extracellular-signal-regulated kinases ERK and stress-related kinases p38MAPK are involved in metabolic changes. Analysis of current data suggests that the concept of exceptionally thermal mechanism of biological effects of microwaves is not correct. In turn, this raises the question of the need to revaluation of modern electromagnetic standards based on thermal effects of non-ionizing radiation on biological systems.	Nothing. Review is not cited and not discussed.
[92] Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1 . Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.	The safety of human exposure to an ever-increasing number and diversity of electromagnetic field (EMF) sources both at work and at home has become a public health issue. To date, many *in vivo* and *in vitro* studies have revealed that EMF exposure can alter cellular homeostasis, endocrine function, reproductive function, and fetal development in animal systems. Reproductive parameters reported to be altered by EMF exposure include male germ cell death, the estrous cycle, reproductive endocrine hormones, reproductive organ weights, sperm motility, early embryonic development, and pregnancy success. At	Nothing. Review is not cited and not discussed.

2012.39.1.1	the cellular level, an increase in free radicals and [Ca(2+)]i may mediate the effect of EMFs and lead to cell growth inhibition, protein misfolding, and DNA breaks. The effect of EMF exposure on reproductive function differs according to frequency and wave, strength (energy), and duration of exposure. In the present review, the effects of EMFs on reproductive function are summarized according to the types of EMF, wave type, strength, and duration of exposure at cellular and organism levels.	
[93] La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. 2012 Effects of the exposure to mobile phones on male reproduction: a review of the literature. J Androl 33:350-356.	The use of mobile phones is now widespread. A great debate exists about the possible damage that the radiofrequency electromagnetic radiation (RF-EMR) emitted by mobile phones exerts on different organs and apparatuses. The aim of this article was to review the existing literature exploring the effects of RF-EMR on the male reproductive function in experimental animals and humans. Studies have been conducted in rats, mice, and rabbits using a similar design based upon mobile phone RF exposure for variable lengths of time. Together, the results of these studies have shown that RF-EMR decreases sperm count and motility and increases oxidative stress. In humans, 2 different experimental approaches have been followed: one has explored the effects of RF-EMR directly on spermatozoa and the other has evaluated the sperm parameters in men using or not using mobile phones. The results showed that human spermatozoa exposed to RF-EMR have decreased motility, morphometric abnormalities, and increased oxidative stress, whereas men using mobile phones have decreased sperm concentration, decreased motility (particularly rapid progressive motility), normal morphology, and decreased viability. These abnormalities seem to be directly related to the duration of mobile phone use.	Nothing. Review is not cited and not discussed.
[94] Biointiative Working Group, David Carpenter and Cindy Sage (eds). 2012 Bioinitiative 2012: A rationale for biologically-based exposure standards for electromagnetic radiation. http://www.bioinitiative.org/participants/why-we-care/	Sections on EMF effects: SECTION 4: EVIDENCE FOR INADEQUACY OF THE STANDARDS SECTION 5: EVIDENCE FOR EFFECTS ON GENE AND PROTEIN EXPRESSION SECTION 6: EVIDENCE FOR GENOTOXIC EFFECTS – RFR AND ELF DNA DAMAGE SECTION 7: EVIDENCE FOR STRESS RESPONSE (STRESS PROTEINS) SECTION 8: EVIDENCE FOR EFFECTS ON IMMUNE FUNCTION SECTION 9: EVIDENCE FOR EFFECTS ON NEUROLOGY AND BEHAVIOR SECTION 10: EFFECTS OF EMF FROM WIRELESS COMMUNICATION UPON THE	Nothing. Review is not cited and not discussed.

	BLOOD-BRAIN BARRIER SECTION 11: EVIDENCE FOR BRAIN TUMORS AND ACOUSTIC NEUROMAS SECTION 12: EVIDENCE FOR CHILDHOOD CANCERS (LEUKEMIA) SECTION 13: EVIDENCE FOR EFFECTS ON MELATONIN: ALZHEIMER'S DISEASE AND BREAST CANCER SECTION 14: EVIDENCE FOR BREAST CANCER PROMOTION SECTION 15: EVIDENCE FOR DISRUPTION BY THE MODULATING SIGNAL SECTION 16: PLAUSIBLE GENETIC AND METABOLIC MECHANISMS FOR BIOEFFECTS OF VERY WEAK ELF MAGNETIC FIELDS ON LIVING TISSUE SECTION 17 EVIDENCE BASED ON EMF MEDICAL THERAPEUTICS SECTION 18: FERTILITY AND REPRODUCTION EFFECTS OF EMF SECTION 19: FETAL AND NEONATAL EFFECTS OF EMF SECTION 20: FINDINGS IN AUTISM CONSISTENT WITH EMF AND RFR	
[4] Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.	The direct targets of extremely low and microwave frequency range electromagnetic fields (EMFs) in producing non-thermal effects have not been clearly established. However, studies in the literature, reviewed here, provide substantial support for such direct targets. Twenty-three studies have shown that voltage-gated calcium channels (VGCCs) produce these and other EMF effects, such that the L-type or other VGCC blockers block or greatly lower diverse EMF effects. Furthermore, the voltage-gated properties of these channels may provide biophysically plausible mechanisms for EMF biological effects. Downstream responses of such EMF exposures may be mediated through Ca(2+) /calmodulin stimulation of nitric oxide synthesis. Potentially, physiological/therapeutic responses may be largely as a result of nitric oxide-cGMP-protein kinase G pathway stimulation. A well-studied example of such an apparent therapeutic response, EMF stimulation of bone growth, appears to work along this pathway. However, pathophysiological responses to EMFs may be as a result of nitric oxide-peroxynitrite-oxidative stress pathway of action. A single such well-documented example, EMF induction of DNA single-strand breaks in cells, as measured by alkaline comet assays, is reviewed here. Such single-strand breaks are	This was cited. Sole statement is: "(see Pall, 2013 for a review of studies suggesting effects through voltage-gated calcium channels)." None of the important implications listed on the left are used in any way in the rest of the SCENIHR 2015 document See text for further discussion..

	known to be produced through the action of this pathway. Data on the mechanism of EMF induction of such breaks are limited; what data are available support this proposed mechanism. Other Ca(2+) - mediated regulatory changes, independent of nitric oxide, may also have roles. This article reviews, then, a substantially supported set of targets, VGCCs, whose stimulation produces non-thermal EMF responses by humans/higher animals with downstream effects involving Ca(2+) /calmodulin-dependent nitric oxide increases, which may explain therapeutic and pathophysiological effects.	
[95] Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. 2013 Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol 246:869-875.	The aim of the study was to discuss the mechanisms and risk factors of EMR changes on reproductive functions and membrane oxidative biology in females and males. It was reported that even chronic exposure to EMR did not increase the risk of reproductive functions such as increased levels of neoantigens abort. However, the results of some studies indicate that EMR induced endometriosis and inflammation and decreased the number of follicles in the ovarium or uterus of rats. In studies with male rats, exposure caused degeneration in the seminiferous tubules, reduction in the number of Leydig cells and testosterone production as well as increases in luteinizing hormone levels and apoptotic cells. In some cases of male and female infertility, increased levels of oxidative stress and lipid peroxidation and decreased values of antioxidants such as melatonin, vitamin E and glutathione peroxidase were reported in animals exposed to EMR. In conclusion, the results of current studies indicate that oxidative stress from exposure to Wi-Fi and mobile phone-induced EMR is a significant mechanism affecting female and male reproductive systems.	This was listed on p.285 under ***Literature identified but not cited.*** SCENIHR chose not to cite or discuss this paper, although they had identified it.
[96] Ledoigt G, Belpomme D. 2013 Cancer induction molecular pathways and HF-EMF irradiation. Adv Biol Chem 3:177-186.	The response of cells to different types of electromagnetic fields can be induced by low-level (athermal) high frequency (HF) electromagnetic fields (EMFs) exposure associated with mobile phone technologies. There are many examples of biological effects involving the epigenome. EMFs could trigger protein activation mediated by ligands, such as Ca2+, that alter the conformation of binding proteins, especially the NADPH plasmic membrane oxidase, so inducing increased formation of reactive oxygen species (ROS) that may alter proteomic functions. Classical anti-apoptotic and procarcinogenic signaling pathways that are commonly found activated in human malignancies and in inflammation mainly involve the tran-	Nothing. Review is not cited and not discussed.

	scription factor NF-κB. The microenvironment that exists during chronic inflammation can contribute to cancer progression. The data support the proposition that long term HF-EMF exposure associated with improper use of cell phones can potentially cause cancer.	
[97] Hardell L, Carlberg M. 2013 Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. Rev Environ Health 28:97-106. doi: 10.1515/reveh-2013-0006.	BACKGROUND: Wireless phones, i.e., mobile phones and cordless phones, emit radiofrequency electromagnetic fields (RF-EMF) when used. An increased risk of brain tumors is a major concern. The International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) evaluated the carcinogenic effect to humans from RF-EMF in May 2011. It was concluded that RF-EMF is a group 2B, i.e., a "possible", human carcinogen. Bradford Hill gave a presidential address at the British Royal Society of Medicine in 1965 on the association or causation that provides a helpful framework for evaluation of the brain tumor risk from RF-EMF. METHODS:All nine issues on causation according to Hill were evaluated. Regarding wireless phones, only studies with long-term use were included. In addition, laboratory studies and data on the incidence of brain tumors were considered. RESULTS: The criteria on strength, consistency, specificity, temporality, and biologic gradient for evidence of increased risk for glioma and acoustic neuroma were fulfilled. Additional evidence came from plausibility and analogy based on laboratory studies. Regarding coherence, several studies show increasing incidence of brain tumors, especially in the most exposed area. Support for the experiment came from antioxidants that can alleviate the generation of reactive oxygen species involved in biologic effects, although a direct mechanism for brain tumor carcinogenesis has not been shown. In addition, the finding of no increased risk for brain tumors in subjects using the mobile phone only in a car with an external antenna is supportive evidence. Hill did not consider all the needed nine viewpoints to be essential requirements. CONCLUSION:Based on the Hill criteria, glioma and acoustic neuroma should be considered to be caused by RF-EMF emissions from wireless phones and regarded as carcinogenic to humans, classifying it as group 1 according to the IARC classification. Current guidelines for exposure need to be urgently revised.	Nothing. Review is not cited and not discussed. The Hill criteria are THE well-accepted way of analyzing biological plausiblility of epidemiologic al evidence. It is unacceptable for SCENIHR not to consider this review when attempting to analyze epidemiologic al evidence of EMF cancer causation.
[98] Hardell L, Carlberg M, Hansson Mild K. 2013 Use of	The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24-31 May	This paper is cited and discussed

mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. Pathophysiology 2013;20(2):85-110.	2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR)=1.71, 95% confidence interval (CI)=1.04-2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640h in total gave OR=2.29, 95% CI=1.56-3.37. The results for meningioma were OR=1.25, 95% CI=0.31-4.98 and OR=1.35, 95% CI=0.81-2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR=1.81, 95% CI=0.73-4.45. For ipsilateral cumulative use ≥1640h OR=2.55, 95% CI=1.50-4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR)=1.2, 95% CI=1.002-1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I-II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.	very briefly. See text for discussion.
[99] Davis DL, Kesari S, Soskolne CL, Miller AB, Stein Y. 2013 Swedish review strengthens grounds for concluding that	Mobile phones are two-way microwave radios that also emit low levels of electromagnetic radiation. Inconsistent results have been published on potential risks of brain tumors tied with mobile phone use as a result of important methodological differences in study design and statistical power. Some studies have	Nothing. Review is not cited and not discussed.

radiation from cellular and cordless phones is a probable human carcinogen. Pathophysiology 20:123-129.	examined mobile phone users for periods of time that are too short to detect an increased risk of brain cancer, while others have misclassified exposures by placing those with exposures to microwave radiation from cordless phones in the control group, or failing to attribute such exposures in the cases. In 2011, the World Health Organization, International Agency for Research on Cancer (IARC) advised that electromagnetic radiation from mobile phone and other wireless devices constitutes a "possible human carcinogen," 2B. Recent analyses not considered in the IARC review that take into account these methodological shortcomings from a number of authors find that brain tumor risk is significantly elevated for those who have used mobile phones for at least a decade. Studies carried out in Sweden indicate that those who begin using either cordless or mobile phones regularly before age 20 have greater than a fourfold increased risk of ipsilateral glioma. Given that treatment for a single case of brain cancer can cost between $100,000 for radiation therapy alone and up to $1 million depending on drug costs, resources to address this illness are already in short supply and not universally available in either developing or developed countries. Significant additional shortages in oncology services are expected at the current growth of cancer. No other environmental carcinogen has produced evidence of an increased risk in just one decade. Empirical data have shown a difference in the dielectric properties of tissues as a function of age, mostly due to the higher water content in children's tissues. High resolution computerized models based on human imaging data suggest that children are indeed more susceptible to the effects of EMF exposure at microwave frequencies. If the increased brain cancer risk found in young users in these recent studies does apply at the global level, the gap between supply and demand for oncology services will continue to widen. Many nations, phone manufacturers, and expert groups, advise prevention in light of these concerns by taking the simple precaution of "distance" to minimize exposures to the brain and body. We note that brain cancer is the proverbial "tip of the iceberg"; the rest of the body is also showing effects other than cancers.	

Of these 22 reviews, 19 are found in the PubMed database, the most widely used medical database in the world, so there is no excuse for not discussing these 19, but only two of them were discussed (see below). With regard to the eight different types of effects that I consider established non-thermal EMF effects, each of them were reviewed in multiple studies described in Table 3 as follows: Cancer 12 reviews [78,82,83-87,90,94,96-98]; Oxidative stress/free

radicals 8 reviews [79,80,84,90,92,-96]; Cellular DNA damage 10 review [4,79,80-82,84,90-92,94]; Apoptosis/cell death 3 reviews [79,82,91]; Lowered fertility 7 reviews [80,86,89,92-95]; Neurological/neuropsychiatric effects 4 reviews [80,87,88,94]; Calcium overload 4 reviews [4,91,92,96]; Endocrine effects 2 reviews [92,95]. It is not clear why so many important reviews on effects are not found in SCENIHR 2015 [73]. What is perhaps surprising, is that these reviews also document many other effects, none of which are clearly acknowledged by SCENIHR. These include stress responses; breakdown of the blood-brain barrier; fetal and neonatal effects; therapeutic effects; Alzheimer's disease; increased nitric oxide; endometriosis; changes in protein levels (proteomics) and changes in gene expression; NF-kappaB elevation; increased suicide; changes in protein kinase activity including ERK and p32MAPK; mechanisms associated with oxidative stress including elevated NADPH/NADH oxidase increased lipid peroxidation and decreased enzymatic antioxidant activity, increased ornithine decarboxylase; and autism. It can be seen from this that the SCENIHR 2015 document seems to be systematically avoiding considering substantial bodies of evidence regarding a very large range of repeatedly reported EMF effects, each of which challenges the SCENIHR position that no effects are established.

Three specific issues regarding apparent cancer causation by EMFs need to be discussed here. Five of these reviews each review a body of evidence showing that cancer rates are higher on the side of the head where people use their cell phones and cordless phones, the ipsilateral side, as opposed to the opposite side of the head, called the contralateral side [78,84,85,98,99]. These are very important studies because they are not likely to be affcted by how complete the reporting data are, or whether there are affects produced by chemicals, ionizing radiation or other EMFs; each of these factors should not be specific for the side of the head impacted. The contralateral side of the head serves as a control that can be compared with the ipsilateral side of the head. What is strange about the SCENIHR 2015 document, is that it avoids discussing all of these data presented in these five reviews. That is even true for [98] which is discussed very briefly in SCENIHR 2015. Only one body of evidence from [98] is discussed in SCENIHR 2015 but several others are not discussed, including the two bodies of evidence which each find statistically significant rises in ipsilateral cancer as compared with contralateral cancer. The ipsilateral findings produce very strong arguments that cell phones and/or cordless phones do cause brain cancer in humans. The best evidence suggests that both cell phones and cordless phones do cause cancer. What does SCENIHR 2015 [73] say about ipsilateral cancer? [73] states, on p. 74 that "ORs for glioma were higher in subjects who reported phone use mostly on the same side of the head (ipsilateral) as their tumour than for use on the opposite side (contralateral). For meningioma, ORs for temporal lobe tumours were slightly lower than for other locations, while a similar pattern as for glioma of higher ipsilateral ORs compared to contralateral ORs was seen." On p. 76, SCENIHR states that "Afterwards, in an attempt to quantify the relationship, Interphone and the Hardell studies were analysed in a meta-analytical approach (Hardell et al., 2013a), an OR of 1.71 (CI: 1.04-2.81) was found for temporal glioma among ipsilateral mobile phone users of 10+ years of use…." On p. 77, regarding a study designed to assess the reliability of self-reported cell phone usage in young brain cancer patients, a study **not** designed to assess ipsilateral effects in patients whose cancer cases may likely have been caused by cell phone usage, the SCENIHR 2015 document states "No clear patterns were seen when comparing ipsilateral and contralateral use." That is not surprising. It can be seen from this that 2 out of 3 studies that SCENIHR discussed argue that there is increased ipsilateral cancer and argue therefore that cell phones or cordless phones do cause cancer. Furthermore, they ignore large amounts of data, cited in [78,84,85,98,99] that provide further support for this view. When SCENIHR wishes to take the opposite position from that taken in these reviews, it is incumbent on SCENIHR to cite them, to discuss the data and opinion presented in those reviews and then and only then can they argue for their position. Having failed to do those things, SCENIHR loses credibility in any argument that they are doing what they can to protect our

health. The same is true for all of the other effects where they similarly fail to cite large numbers of obviously relevant reviews, each arguing for various health effects produced by EMF exposures.

Two other findings from these reviews are important in assessing EMF cancer causation. Refs. [85 and 99] each provide evidence that younger people are more susceptible to cancer causation by EMFs than are adults. SCENIHR takes the opposite view but cannot argue credibly without considering those who differ. The other finding found in [97] is that the epidemiological evidence on cancer causation by microwave frequency EMFs satisfies most of the Hill criteria. The Hill criteria are THE well-accepted criteria that allow one to distinguish chance associations from causal roles in epidemiology. Because epidemiology is the main basis for the arguments that SCENIHR makes against the conclusion that EMFs cause cancer, it is essential that SCENIHR carefully examine the Hill criteria. They fail to do so. They also ignored this study where these criteria were examined and where it was concluded that the majority of the Hill criteria argue that EMFs do cause cancer. This again, undercuts any claim that SCENIHR has carefully considered critically important findings with regard to EMF health effects.

There are several places in the SCENIHR 2015 document, where they state that no mechanisms have been identified by which claimed effects of EMFs can be produced. These can be found by searching the SCENIHR 2015 document using "mechanism" as the search term. However [4] clearly states that the VGCC activation mechanism triggered by EMF exposure can produce, via this mechanism, cellular DNA damaging effects, can produce therapeutic effects and can produce oxidative stress effects. It can be seen, therefore that SCENIHR has no problem making repeated claims that have been falsified by information that they presumably have examined. It also can be seen from this, that even in the cases where SCENIHR cites and very briefly discusses a review that disagrees with them, one can have no assurance that the information is used by SCENIHR in its assessment of health impacts. The causation of cellular DNA damage by EMFs acting via VGCC activation also has important implications with regard to cancer causation. Because almost all cases of cancer start with mutagenic DNA damage in the cell destined to become a cancer cell, this shows how EMFs can initiate the process of carcinogenesis.

It is clear that the SCENIHR 2015 document neither cited nor discussed 20 out of 22 reviews that have documented non-thermal effects of EMFs. In addition, the most important findings of the two that were cited in the document were ignored in the document as well. Therefore SCENIHR has systematically avoided discussing the most important implications of reviews that fell into the time frame they purport to have studied and disagreed with SCENIHR on the existence of important effects. The question can be raised, however, as to whether the SCENIHR has done a better job in its consideration of primary literature citations. To answer that question, I am using a database of important primary literature, regarding effects of cell phone EMFs that we are commonly exposed to.

<u>23 Genuine Cell Phone Studies, Each of Which Should Be Discussed in SCENIHR 2015, 20 of Which Are Not.</u>

Panagopoulos et al [100] showed that whereas 46 out of 48 studies on genuine cell phone radiation showed health-related effects, the majority of studies on simulated cell phones reported no statistically significant effects. They [100] interpreted the difference of results as having been caused by the lowered pulsation rate of the "simulated" cell phone exposures. While I am sure that is part of the explanation, there may be other possible differences that are discussed later in this chapter.

Of those 48 genuine cell phone studies, 23 fell into the time frame (Jan. 2009 through Dec. 2013) reviewed in SCENIHR, 2015. Because of the importance of cell phones and therefore cell phone radiation in our lives, I am using these 23 as a database of primary literature studies that should all be covered in the SCENIHR 2015 [73] document. How many of these 23 were reviewed and cited in SCENIHR 2015? The answer is four (17%) and I will discuss how each of them were discussed below. I have inserted 17 of these into Table 4 below, but six were left out, because they are easy to summarize. These six are all Drosophila studies, none of which were discussed in SCENIHR 2015 [73] but are easy to summarize. All six Drosophila studies were focused on lowered fertility following EMF exposure, with the majority of these focused on lowered female fertility. Four of the six found increased apoptosis following cell phone EMF exposaure and four of the six also found cellular DNA damage following exposure. These are important because of the similarities of each of these effects to effects found in mammals. They are also important because they found DNA damage in Drosophila eggs, whereas mammalian eggs no similar studies have been done because of the difficulty in doing so. Two of these six Drosophila studies, also identified a low intensity exposure window which produced much larger effects than did lower or higher intensities. These exposure windows make it difficult or impossible to predict EMF effects based on EMF intensities. However, the industry and industry friendly groups such as SCENIHR repeatedly make such false predictions.

In mammals there are many studies showing DNA damage in sperm following EMF exposure. This DNA damage in germ line cells is particularly importance because of the importance of mutations passed onto progeny. Table 4 summarizes the other 17 genuine cell phone radiation findings that that SCENIHR 2015 [73] should be discussing, 15 of which were not discussed or cited in SCENIHR 2015.

Table 4: Genuine Cell Phone Studies that Fell into the 2009 through 2013 SCENIHR 2015 period

Citation studied	Cell Phone Effects Reported	SCENIHR comments
1. Mailankot M, Kunnath AP, Jayalekshmi H, Koduru B, Valsalan R. 2009 Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8GHz) mobile phones induces oxidative stress and reduces sperm motility in rats. Clinics (Sao Paulo) 64:561-565.	The present study was designed to evaluate the effects of RF-EMR from mobile phones on free radical metabolism and sperm quality. MATERIALS AND METHODS: Male albino Wistar rats (10-12 weeks old) were exposed to RF-EMR from an active GSM (0.9/1.8 GHz) mobile phone for 1 hour continuously per day for 28 days. Controls were exposed to a mobile phone without a battery for the same period. The phone was kept in a cage with a wooden bottom in order to address concerns that the effects of exposure to the phone could be due to heat emitted by the phone rather than to RF-EMR alone. Animals were sacrificed 24 hours after the last exposure and tissues of interest were harvested. RESULTS: One hour of exposure to the phone did not significantly change facial temperature in either group of rats. No significant difference was observed in total sperm count between controls and RF-EMR exposed groups. However, rats exposed to RF-EMR exhibited a significantly reduced percentage of motile sperm. Moreover, RF-EMR exposure resulted in a significant increase in lipid peroxidation and low GSH content in the testis and epididymis.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.

	CONCLUSION: Given the results of the present study, we speculate that RF-EMR from mobile phones negatively affects semen quality and may impair male fertility.	
2. Gul A, Celebi H, Uğraş S. 2009 The effects of microwave emitted by cellular phones on ovarian follicles in rats. Arch Gynecol Obstet 280:729-733. doi: 10.1007/s00404-009-0972-9.	The aim of this study was to investigate whether there were any toxic effects of microwaves of cellular phones on ovaries in rats. METHODS: In this study, 82 female pups of rats, aged 21 days (43 in the study group and 39 in the control group) were used. Pregnant rats in the study group were exposed to mobile phones that were placed beneath the polypropylene cages during the whole period of pregnancy. The cage was free from all kinds of materials, which could affect electromagnetic fields. A mobile phone in a standby position for 11 h and 45 min was turned on to speech position for 15 min every 12 h and the battery was charged continuously. On the 21st day after the delivery, the female rat pups were killed and the right ovaries were removed. The volumes of the ovaries were measured and the number of follicles in every tenth section was counted. RESULTS: The analysis revealed that in the study group, the number of follicles was lower than that in the control group. The decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries. CONCLUSION: We suggest that the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.	Not cited and not discussed by SCENIHR.
3. Imge EB, Kiliçoğlu B, Devrim E, Cetin R, Durak I. 2010 Effects of mobile phone use on brain tissue from the rat and a possible protective role of vitamin C - a preliminary study. Int J Radiat Biol 86:1044-1049. doi: 10.3109/09553002.2010.501838.	To evaluate effects of mobile phone use on brain tissue and a possible protective role of vitamin C. MATERIALS AND METHODS: Forty female rats were divided into four groups randomly (Control, mobile phone, mobile phone plus vitamin C and, vitamin C alone). The mobile phone group was exposed to a mobile phone signal (900 MHz), the mobile phone plus vitamin C group was exposed to a mobile phone signal (900 MHz) and treated with vitamin C administered orally (per os). The vitamin C group was also treated with vitamin C per os for four weeks. Then, the animals were sacrificed and brain tissues were dissected to be used in the analyses of malondialdehyde (MDA), antioxidant potential (AOP), superoxide dismutase, catalase (CAT), glutathione peroxidase (GSH-Px), xanthine oxidase, adenosine deaminase (ADA) and 5'nucleotidase (5'-NT). RESULTS: Mobile phone use caused an inhibition in 5'-NT and CAT activities as compared to the control group. GSH-Px activity and the MDA level were also found to be reduced in the mobile phone group but not significantly. Vitamin C caused a significant increase in the activity of GSH-Px and non-significant increase in the activities of 5'-NT,	Not cited and not discussed by SCENIHR.

	ADA and CAT enzymes. CONCLUSION: Our results suggest that vitamin C may play a protective role against detrimental effects of mobile phone radiation in brain tissue.	
4. Sharma VP, Kumar NR. 2010 Changes in honeybee behavior under the influence of cell phone radiation. Curr Science 98: 1376-1378.	Honeybee behaviour and biology has been affected by electrosmog since these insects have magnetite in their bodies which helps them in navigation. There are reports of sudden disappearance of bee populations from honeybee colonies. The reason is still not clear. We have compared the performance of honeybees in cellphone radiation exposed and unexposed colonies. A significant ($p < 0.05$) decline in colony strength and in the egg laying rate of the queen was observed. The behaviour of exposed foragers was negatively influenced by the exposure, there was neither honey nor pollen in the colony at the end of the experiment.	Not cited and not discussed by SCENIHR.
5. Vecchio F, Babiloni C, Ferreri F, Buffo P, Cibelli G, Curcio G, van Dijkman S, Melgari JM, Giambattistelli F, Rossini PM. 2010 Mobile phone emission modulates inter-hemispheric functional coupling of EEG alpha rhythms in elderly compared to young subjects. Clin Neurophysiol 121:163-171. doi: 10.1016/j.clinph.2009.11.002.	It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate--after a prolonged exposure--inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young subjects [Vecchio et al., 2007]. Here we tested the hypothesis that this effect can vary on physiological aging as a sign of changes in the functional organization of cortical neural synchronization. METHODS: Eyes-closed resting EEG data were recorded in 16 healthy elderly subjects and 5 young subjects in the two conditions of the previous reference study. The GSM device was turned on (45 min) in one condition and was turned off (45 min) in the other condition. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following bands: delta (about 2-4 Hz), theta (about 4-6 Hz), alpha 1 (about 6-8 Hz), alpha 2 (about 8-10 Hz), and alpha 3 (about 10-12 Hz). The aging effects were investigated comparing the inter-hemispheric EEG coherence in the elderly subjects vs. a young group formed by 15 young subjects (10 young subjects of the reference study; Vecchio et al., 2007). RESULTS: Compared with the young subjects, the elderly subjects showed a statistically significant ($p<0.001$) increment of the inter-hemispheric coherence of frontal and temporal alpha rhythms (about 8-12 Hz) during the GSM condition. CONCLUSIONS: These results suggest that GSM-EMFs of a mobile phone affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms as a function of the physiological aging. SIGNIFICANCE: This study provides further evidence that physiological aging is related to changes in the functional organization of cortical neural synchronization.	Was cited and discussed – see text.
6. Kumar NR,	The present study was carried out to find the effect of cell	Not cited

Sangwan S, Badotra P. 2011 Exposure to cell phone radiations produces biochemical changes in worker honey bees. Toxicol Int. 2011 Jan;18(1):70-2. doi: 10.4103/0971-6580.75869.	phone radiations on various biomolecules in the adult workers of Apis mellifera L. The results of the treated adults were analyzed and compared with the control. Radiation from the cell phone influences honey bees' behavior and physiology. There was reduced motor activity of the worker bees on the comb initially, followed by en masse migration and movement toward "talk mode" cell phone. The initial quiet period was characterized by rise in concentration of biomolecules including proteins, carbohydrates and lipids, perhaps due to stimulation of body mechanism to fight the stressful condition created by the radiations. At later stages of exposure, there was a slight decline in the concentration of biomolecules probably because the body had adapted to the stimulus.	and not discussed by SCENIHR.
7. Favre D. 2011 Mobile phone-induced honeybee worker piping. Apidologie 42:270-279.	Electromagnetic waves originating from mobile phones were tested for potential effects on honeybee behavior. Mobile phone handsets were placed in the close vicinity of honeybees. The sound made by the bees was recorded and analyzed. The audiograms and spectrograms revealed that active mobile phone handsets have a dramatic impact on the behavior of the bees, namely by inducing the worker piping signal. In natural conditions, worker piping either announces the swarming process of the bee colony or is a signal of a disturbed bee colony.	Not cited and not discussed by SCENIHR.
8. Cammaerts MC, Debeir O, Cammaerts R. 2011. Changes in Paramecium caudatum (protozoa) near a switched-on GSM telephone. Electromagn Biol Med. 2011 Mar;30(1):57-66. doi: 10.3109/15368378.2011.566778.	The protozoan Paramecium caudatum was examined under normal conditions versus aside a switched-on GSM telephone (900 MHz; 2 Watts). Exposed individuals moved more slowly and more sinuously than usual. Their physiology was affected: they became broader, their cytopharynx appeared broader, their pulse vesicles had difficult in expelling their content outside the cell, their cilia less efficiently moved, and trichocysts became more visible. All these effects might result from some bad functioning or damage of the cellular membrane. The first target of communication electromagnetic waves might thus be the cellular membrane.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.
9. Çam ST, Seyhan N. 2012 Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Biol 88:420-424. doi: 10.3109/09553002.2012.666005.	To analyze the short-term effects of radiofrequency radiation (RFR) exposure on genomic deoxyribonucleic acid (DNA) of human hair root cells. SUBJECTS AND METHODS: Hair samples were collected from eight healthy human subjects immediately before and after using a 900-MHz GSM (Global System for Mobile Communications) mobile phone for 15 and 30 min. Single-strand DNA breaks of hair root cells from the samples were determined using the 'comet assay'. RESULTS: The data showed that talking on a mobile phone for 15 or 30 min significantly increased ($p < 0.05$) single-strand DNA breaks in cells of hair roots close to the phone. Comparing the 15-min and 30-min data using the paired t-	Not cited and not discussed by SCENIHR.

	test also showed that significantly more damages resulted after 30 min than after 15 min of phone use. CONCLUSIONS: A short-term exposure (15 and 30 min) to RFR (900-MHz) from a mobile phone caused a significant increase in DNA single-strand breaks in human hair root cells located around the ear which is used for the phone calls.	
10. Vecchio F, Tombini M, Buffo P, Assenza G, Pellegrino G, Benvenga A, Babiloni C, Rossini PM. 2012 Mobile phone emission increases inter-hemispheric functional coupling of electroencephalographic α rhythms in epileptic patients. Int J Psychophysiol 84:164-171. doi: 10.1016/j.ijpsycho.2012.02.002.	It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate - after a prolonged exposure - inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young and elderly subjects (Vecchio et al., 2007, 2010). Here we tested the hypothesis that this can be even more evident in epileptic patients, who typically suffer from abnormal mechanisms governing synchronization of rhythmic firing of cortical neurons. Eyes-closed resting EEG data were recorded in ten patients affected by focal epilepsy in real and sham exposure conditions. These data were compared with those obtained from 15 age-matched normal subjects of the previous reference studies. The GSM device was turned on (45 min) in the "GSM" condition and was turned off (45 min) in the other condition ("sham"). The mobile phone was always positioned on the left side in both patients and control subjects. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following frequency bands: delta (about 2-4 Hz), theta (about 4-6 Hz), alpha1 (about 6-8 Hz), alpha2 (about 8-10 Hz), and alpha3 (about 10-12 Hz). The effects on the patients were investigated comparing the inter-hemispheric EEG coherence in the epileptic patients with the control group of subjects evaluated in the previous reference studies. Compared with the control subjects, epileptic patients showed a statistically significant higher inter-hemispheric coherence of temporal and frontal alpha rhythms (about 8-12 Hz) in the GSM than "Sham" condition. These results suggest that GSM-EMFs of mobile phone may affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms in epileptic patients. If confirmed by future studies on a larger group of epilepsy patients, the modulation of the inter-hemispheric alpha coherence due to the GSM-EMFs could have clinical implications and be related to changes in cognitive-motor function.	Was cited and discussed – see text.
11. Al-Damegh MA. 2012 Rat testicular impairment induced by electromagnetic radiation from a conventional cellular	OBJECTIVE: The aim of this study was to investigate the possible effects of electromagnetic radiation from conventional cellular phone use on the oxidant and antioxidant status in rat blood and testicular tissue and determine the possible protective role of vitamins C and E in preventing the detrimental effects of electromagnetic	Listed under literature identified but not cited.

telephone and the protective effects of the antioxidants vitamins C and E. Clinics 67:785-792	radiation on the testes. MATERIALS AND METHODS: The treatment groups were exposed to an electromagnetic field, electromagnetic field plus vitamin C (40 mg/kg/day) or electromagnetic field plus vitamin E (2.7 mg/kg/day). All groups were exposed to the same electromagnetic frequency for 15, 30, and 60 min daily for two weeks. RESULTS: There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in the electromagnetism-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in the electromagnetism-exposed animals. CONCLUSION: Our results indicate that the adverse effect of the generated electromagnetic frequency had a negative impact on testicular architecture and enzymatic activity. This finding also indicated the possible role of vitamins C and E in mitigating the oxidative stress imposed on the testes and restoring normality to the testes.	SCENIHR knew about this paper but decided not to discuss it.
12. Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.	Neurobehavioral disorders are increasingly prevalent in children, however their etiology is not well understood. An association between prenatal cellular telephone use and hyperactivity in children has been postulated, yet the direct effects of radiofrequency radiation exposure on neurodevelopment remain unknown. Here we used a mouse model to demonstrate that in-utero radiofrequency exposure from cellular telephones does affect adult behavior. Mice exposed in-utero were hyperactive and had impaired memory as determined using the object recognition, light/dark box and step-down assays. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) revealed that these behavioral changes were due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. We present the first experimental evidence of neuropathology due to in-utero cellular telephone radiation. Further experiments are needed in humans or non-human primates to determine the risk of exposure during pregnancy.	Was cited and discussed, see text.
13. Liu C, Gao P, Xu SC, Wang Y, Chen CH, He MD, Yu ZP, Zhang L, Zhou Z. 2013 Mobile phone radiation induces mode-dependent	A mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 min in standby, listen, dialed or dialing modes for 24 h. DNA damage was determined using an alkaline comet assay. RESULTS: The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. Moreover, there	Not cited and not discussed by SCENIHR.

DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. Int J Radiat Biol. 2013. 89: 993-1001. doi: 10.3109/09553002.2013.811309.	were significantly higher increases in the dialed and dialing modes than in the listen mode. Interestingly, these results were consistent with the radiation intensities of these modes. However, the DNA damage effects of MPR in the dialing mode were efficiently attenuated by melatonin pretreatment. CONCLUSIONS: These results regarding mode-dependent DNA damage have important implications for the safety of inappropriate mobile phone use by males of reproductive age and also suggest a simple preventive measure: Keeping mobile phones as far away from our body as possible, not only during conversations but during 'dialed' and 'dialing' operation modes. Since the 'dialed' mode is actually part of the standby mode, mobile phones should be kept at a safe distance from our body even during standby operation. Furthermore, the protective role of melatonin suggests that it may be a promising pharmacological candidate for preventing mobile phone use-related reproductive impairments.	
14. Koca O, Gökçe AM, Öztürk MI, Ercan F, Yurdakul N, Karaman MI. 2013 Effects of intensive cell phone (Philips Genic 900) use on the rat kidney tissue. Urol J. 2013 Spring;10:886-891.	To investigate effects of electromagnetic radiation (EMR) emitted by cell phones on the rat kidney tissue. MATERIALS AND METHODS: Twenty-one male Albino rats were divided into 3 groups, each comprising 7 rats. Group 1 was exposed to a cell phone in speech mode for 8 hours/day for 20 days and their kidneys were removed. Group 2 was exposed to EMR for 20 days and then their kidneys were removed after an interval of 20 days. Cell phone used in the present study was Philips Genie 900, which has the highest specific absorption rate on the market. RESULTS: Light microscopic examination of the kidney tissues obtained from the first group of rats revealed glomerular damage, dilatation of Bowman's capsule, formation of large spaces between the tubules, tubular damage, perivascular edema, and inflammatory cell infiltration. The mean severity score was 4.64 ± 1.7 in group 1, 4.50 ± 0.8 in group 2, and 0 in group 3. While there was no significant difference between group 1 and group 2 ($P > .05$), the mean severity scores of groups 1 and 2 were significantly higher than that of the control group ($P = .001$ for each). CONCLUSION: Considering the damage in rat kidney tissue caused by EMR-emitting cell phones, high-risk individuals should take protective measures.	Not cited and not discussed by SCENIHR.
15. Meo SA, Al Rubeaan K. 2013 Effects of exposure to electromagnetic field radiation (EMFR) generated by activated mobile	Extensive use of mobile phones has been accompanied by a common public debate about possible adverse effects on human health. No study has been published so far to establish any association between the fastest growing innovation of mobile phone and fasting blood glucose. The aim was to determine the effects of exposure to electromagnetic field radiation generated by mobile	Not cited and not discussed by SCENIHR.

phones on fasting blood glucose. Int J Occup Med Environ Health 26:235-241. doi: 10.2478/s13382-013-0107-1.	phones on fasting blood glucose in Wistar Albino rats. MATERIALS AND METHODS: 40 Male Albino rats (Wistar Strain) were divided into 5 equally numerous groups. Group A served as the control one, group B received mobile phone radiation for less than 15 min/day, group C: 15-30 min/day, group D: 31-45 min/day, and group E: 46-60 min/day for a total period of 3 months. Fasting blood glucose was determined by using Spectrophotometer and serum insulin by Enzyme-linked Immunosorbent Assay (ELISA). The Homeostatic Model (HOMA-B) was applied for the assessment of β-cell function and (HOMA-IR) for resistance to insulin. RESULTS: Wister Albino rats exposed to mobile phone radiation for longer than 15 min a day for a total period of 3 months had significantly higher fasting blood glucose ($p < 0.015$) and serum insulin ($p < 0.01$) compared to the control group. HOMA-IR for insulin resistance was significantly increased ($p < 0.003$) in the groups that were exposed for 15-30 and 46-60 min/day compared to the control rats. CONCLUSION:The results of the present study show an association between long-term exposure to activated mobile phones and increase in fasting blood glucose and serum insulin in Albino rats.	
16. Tsybulin O, Sidorik E, Brieieva O, Buchynska L, Kyrylenko S, Henshel D, Yakymenko I. 2013 GSM 900 MHz cellular phone radiation can either stimulate or depress early embryogenesis in Japanese quails depending on the duration of exposure. Int J Radiat Biol 89:756-763. doi: 10.3109/09553002.2013.791408.	Our study was designed to assess the effects of low intensity radiation of a GSM (Global System for Mobile communication) 900 MHz cellular phone on early embryogenesis in dependence on the duration of exposure. MATERIALS AND METHODS: Embryos of Japanese Quails were exposed in ovo to GSM 900 MHz cellular phone radiation during initial 38 h of brooding or alternatively during 158 h (120 h before brooding plus initial 38 h of brooding) discontinuously with 48 sec ON (average power density 0.25 μW/cm(2), specific absorption rate 3 μW/kg) followed by 12 sec OFF intervals. A number of differentiated somites were assessed microscopically. Possible DNA damage evoked by irradiation was assessed by an alkaline comet assay. RESULTS: Exposure to radiation from a GSM 900 MHz cellular phone led to a significantly altered number of differentiated somites. In embryos irradiated during 38 h the number of differentiated somites increased ($p < 0.001$), while in embryos irradiated during 158 h this number decreased ($p < 0.05$). The lower duration of exposure led to a significant ($p < 0.001$) decrease in a level of DNA strand breaks in cells of 38-h embryos, while the higher duration of exposure resulted in a significant ($p < 0.001$) increase in DNA damage as compared to the control. CONCLUSION: Effects of GSM 900 MHz cellular phone radiation on early embryogenesis can be either stimulating or deleterious depending on the duration of exposure.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.

17. Luo Q, Jiang Y, Jin M, Xu J, Huang HF. 2013 Proteomic analysis on the alteration of protein expression in the early-stage placental villous tissue of electromagnetic fields associated with cell phone exposure. Reprod Sci 20:1055-1061. doi: 10.1177/1933719112473660.	To explore the possible adverse effects and search for cell phone electromagnetic field (EMF)-responsive proteins in human early reproduction, a proteomics approach was employed to investigate the changes in protein expression profile induced by cell phone EMF in human chorionic tissues of early pregnancy in vivo. METHODS: Volunteer women about 50 days pregnant were exposed to EMF at the average absorption rate of 1.6 to 8.8 W/kg for 1 hour with the irradiation device placed 10 cm away from the umbilicus at the midline of the abdomen. The changes in protein profile were examined using 2-dimensional electrophoresis (2-DE). RESULTS: Up to 15 spots have yielded significant change at least 2- to 2.5-folds up or down compared to sham-exposed group. Twelve proteins were identified-procollagen-proline, eukaryotic translation elongation factor 1 delta, chain D crystal structure of human vitamin D-binding protein, thioredoxin-like 3, capping protein, isocitrate dehydrogenase 3 alpha, calumenin, Catechol-O-methyltransferase protein, proteinase inhibitor 6 (PI-6; SerpinB6) protein, 3,2-trans-enoyl-CoA isomerase protein, chain B human erythrocyte 2,3-bisphosphoglycerate mutase, and nucleoprotein. CONCLUSION: Cell phone EMF might alter the protein profile of chorionic tissue of early pregnancy, during the most sensitive stage of the embryos. The exposure to EMF may cause adverse effects on cell proliferation and development of nervous system in early embryos. Furthermore, 2-DE coupled with mass spectrometry is a promising approach to elucidate the effects and search for new biomarkers for environmental toxic effects.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.

If you look through the studies described in Table 4, you will see multiple studies in oxidative stress/free radical damage, on changes in tissue structure (sometimes called remodeling), on cellular DNA damage, on male fertility (and also one on female fertility), on behavioral changes and on neurological changes. There is also one study on insulin/type 2 diabetes (hormonal effect). It follows from this that five of the effects that were extensively documented in large numbers of reviews (Chapter 1) are further demonstrated, as being caused be cell phone radiation, in these studies. In addition the tissue remodeling and proteomic changes discussed in Chapter 3 are also further demonstrated here. One question that needs to be raised with regard to SCENIHR is why so many clearly important primary literature studies of cell phone radiation (perhaps the most important source of human microwave irradiation) are not discussed in SCENIHR 2015. I will discuss certain particular articles that I think are particularly important for *particular reasons*. Subsequently, I will discuss the three articles that SCENIHR does discuss.

One of the more interesting studies not discussed by SCENIHR, is #11 in Table 4. This was published by a woman scientist in Saudi Arabia. What it shows is that 15, 30 or 60 minutes per day of cell phone radiation disrupts the structure of the rat testis and also produces high levels of oxidative stress as shown by measuring 5 different markers of oxidative stress. Such studies have been done for several decades, with oxidative stress having been shown in many different organs

following EMF exposures. What is particularly important in this study is that high levels of two different antioxidants, vitamin C and vitamin E, were each shown to produce substantial protection of the testis structure from the EMF effects while partially normalizing the oxidative stress elevation. What this clearly shows is that the oxidative stress causes the testis tissue disruption. So we don't just have evidence for two effects, testis disruption and oxidative stress but we have strong evidence that one causes the other. It is exactly these connections that are essential for the progression of the science!

13 is another study not discussed by SCENIHR which is particularly important. It looks at cell phone radiation DNA damage produced in a mouse spermatocyte-derived cell line. What it finds is that DNA damage is particularly high when the cell phone is in the dialed or dialing mode, as opposed to a listen mode. They also state that the radiation levels in the three modes correspond, at least roughly, to the DNA damage effects seen. They also show that pretreatment with melatonin (which is known to have antioxidant effects) greatly lowers the DNA damage produced by the cell phone EMF exposures. This is similar to the study discussed immediately above because it again shows that one effect, DNA damage is produced by another effect, namely oxidative stress/free radical elevation. You will recall that as discussed in Chapter 2, cellular DNA damage following EMF exposure is produced by the attacks by on the DNA by peroxynitrite derived free radicals. This study provides confirmation for that mechanism.

#14 is another study not discussed by SCENIHR which is also particularly important. It looks at the impact of cell phone radiation on kidney structure of rats, using six different measures of kidney structure. There were two groups of rats that were exposed to cell phone radiation which were both compared with each other and with normal unexposed control rats. The two exposed groups differed from each other in one group the kidney structure was assessed immediately following the 20 day exposure period. The second exposure group was also exposed for 20 days but was given 20 days subsequently with no exposure to see if the kidney structure spontaneously recovered. There was no recovery seen in the second group, showing that the kidney damage was effectively irreversible. In Chapter 3, several tissue remodeling type effects produced by EMF exposure appeared to be irreversible. Study #14 may add an additional such effect to that list.

#15 is another study not discussed by SCENIHR which is also particularly important. In this study control (unexposed) rats were compared with rats exposed to cell phone radiation for: less than 15 minutes per day, 15 to 30 minutes per day, 31 to 45 minutes per day or 45 to 60 minutes per day. Rats exposed to over 15 minutes per day of cell phone radiation showed type 2 diabetes onset-like effects, with higher fasting glucose levels and higher serum insulin levels. This appears to be, therefore a study showing important hormone dysfunction. It should be noted that the same research group has found similar changes in people living near cell phone towers [101]. Consequently, this is still another situation where findings in experimental animal studies appear to be directly applicable to humans.

Of the papers that were discussed, it is my opinion that the Aldad et al paper (#12, Table 4) is perhaps the most important. The paper starts out discussing the very large increase in ADHD that we have had in recent years, an increase which suggests that one or more environmental changes must be involved. This paper is from a distinguished laboratory, Hugh Taylor's laboratory at Yale, and was published in one of the highly respected Nature journals and the paper, at this writing has been cited 89 times, showing a high level of scientific interest in it. The paper showed that prenatal exposure of pregnant mice to cell phone radiation produced three highly statistically significant changes in the adult mice. These were a decrease in measured memory function, increase in hyperactivity and increase in anxiety. They also showed that there was a dose dependent decrease in an important neurological parameter, the frequency of miniature

excitatory postsynaptic currents, allowing the authors to conclude "that these behavioral changes were due to altered neuronal developmental programming." SCENIHR states the following about this study: "Neurodevelopment from a functional point of view was studied by Aldad et al. (2012) who exposed mice in utero and investigated them as adults for certain behavioural traits and electrophysiological characteristics. Exposure is poorly described but is reported to be to a muted telephone (900-1800 MHz) during the entire gestation period. After blinded investigations, the authors concluded that exposed animals displayed hyperactivity, memory deficiencies, decreased anxiety, and impaired glutamatergic transmission. Although the study employs relevant biological end-points, it cannot be used for any conclusions regarding pre-natal mobile phone exposure and functional development of the brain." SCENIHR fails to tell us why they claim the exposures were poorly described nor do they provide any reasoning on why "it cannot be used for any conclusions regarding pre-natal mobile phone exposure and development of the brain." It is hard to see how such results could be found unless there are substantial effects of pre-natal exposure. Because the study used genuine cell phone radiation, the effects seen are disturbing. It would be reasonable for SCENIHR to call for more studies of this type to see if they can be replicated. Having said that there have been five subsequent studies that I found where pre-natal mouse exposure to non-thermal EMFs produced substantial and somewhat similar adult neurological effects and or behavioral effects [102-106]. These five included exposures to Wi-Fi and to DECT (cordless phone) EMFs. These studies provide, then, strong evidence that prenatal exposures to EMFs can in animals, produce ADHD-like effects even into adulthood. They also show that during the late prenatal period, the developing brain is particularly sensitive to the effects of microwave frequency EMFs and raise the issue of how long after birth such sensitivity is also seen. It is common for SCENIHR and other industry friendly organizations to treat experimental studies as if they had the weaknesses of epidemiological studies. They don't because they can and do in these cases, directly demonstrate causation. In epidemiology, causation can be inferred but not directly demonstrated. What about epidemiological evidence with regard to EMF causation of ADHD? There are two such studies that each provide evidence for an association between prenatal cell phone exposures and development of ADHD [107,108]. SCENIHR knew about both of these, since it discusses one of them which is, in turn, based on the earlier one. Why then did SCENIHR not make the connection of those two studies with at Aldad study (#12 in Table 4)? That is of course an important failure, given that the Aldad study greatly strengthens the argument for EMF causation of ADHD.

Given the current situation where there are a total of 6 studies showing that pre-natal EMF exposures, including cell phone, Wi-Fi and cordless phone EMFs can cause ADHD-like effects in mice and two human epidemiological studies suggesting a similar mechanism in humans and the parallel between the huge increase in ADHD in humans and the huge increase in microwave frequency EMF exposures, is there any other type of evidence that supports a causal role for EMFs? It turns out there is. EMFs act primarily via VGCC activation (Chapter 20. Genetic polymorphism studies show that elevated VGCC activity has a role in causing ADHD [109], acting to a substantial extent prenatally. This is the way real science works. It is not the way that SCENIHR works.

The Vecchio et al 2010 paper (#5, Table 4) was discussed in SCENIHR 2015 as follows: "A study by Vecchio et al. (2010) analysed age-dependent EMF effects on alpha activity in waking EEGs in 16 older (47-84 years) and 15 younger subjects (20-37 years). Participants were exposed to a GSM signal (902.40 MHz, modulation frequencies: 8.33 and 217 Hz) for 45 min with a maximum SAR of 0.5 W/kg emitted by a commercially available mobile phone which was set using a test card in a double-blind cross-over paradigm. EEG was recorded for 5 min prior to and following exposure at 19 electrodes. The authors found an increased inter-hemispheric coherence of frontal alpha EEG activity after GSM exposure which was statistically significant for the

elderly subjects but not for the young ones. This might point to a GSM-EMF related inter-hemispheric synchronization of alpha rhythms as a function of physiological aging." Another related study (#by the same research group was also cited and discussed SCENIHR 2015 [73] as follows: "Vecchio et al. (2012a) used the same study design to investigate an exposure effect in patients with epilepsy. Data from 10 patients were compared to results from 15 age- matched controls from previous studies. Patients showed a statistically significant higher inter-hemispheric coherence of temporal and frontal alpha-rhythms under exposure as compared to control subjects. According to the authors, these results might indicate a GSM exposure effect on inter-hemispheric synchronization of the dominant (alpha) EEG rhythms in epileptic patients."

What do I have to say about the two Vecchio studies? They are both based on an earlier 2007 study which showed that increased EEG coherence between the two hemispheres of the brain was produced by genuine cell phone EMF exposure. What the 2010 study (#5 in Table 4) shows is that the EMF-induced increased coherence is much higher in older adults than it is in younger adults. What the 2012 study (#10 in Table 4) shows is that the EMF-induced coherence seen in people with epilepsy is also much higher than in people without epilepsy. These three studies then provide large amounts of evidence for a neurological effect of cell phone radiation that is influenced by two variables, age and epilepsy. These findings should be looked at the context of the 23 reviews, listed in Chapter 1, each showing that EMFs produce both neurological and/or neuropsychiatric impacts on the brain. Here we have still another neurological effect, one that is influenced by age and epileptic condition. There are, then three important findings in these studies. One is that while we have had quite lot of evidence showing that children are more sensitive to EMF effects than adults, this is the first clear finding, to my knowledge, that suggests that older people may be more sensitive to a neurological effect. The linkage to epilepsy should not be surprising as some EHS people are reported to have seizures triggered by very low intensity EMF exposures. Finally, the communication between the two hemispheres of the brain has been known for over half a century to be through what is called the corpus callosum, a structure deeply buried in the middle of the brain, linking the two hemispheres. These effects increasing the coherence between the two hemispheres are probably produced, therefore, through the impact of the EMFs on the corpus callosum. That implies, in turn, that the EMFs act much more deeply in the brain than the industry claims is possible.

The problem with SCENIHR is that it lives in a totally fictional universe where none of those EMF effect reviews exist or at least none of them have any relevance to the SCENIHR world. Neither of the two Vecchio et al studies, discussed in the previous two paragraphs, are used by SCENIHR [73] to make any conclusions about EMF effects or lack thereof – they are only cited in the quote that I gave you. We know that because because the citations are by author's last name and are, therefore easily searchable. Similarly, the Aldad et al (#12) study discussed two paragraphs further up, was also never cited except in the quotation given. So none of these three papers are used to assess any effects of EMFs or lack of effects. The same thing is true of the two reviews from Table 3 that were cited and discussed in [73]. They also were only cited in the quoted section and are never used to assess EMF effects or the mechanism of EMF action. As previously noted, there are several statements in SCENIHR 2015 [73] regarding lack of any available mechanism to explain claimed EMF effects, something that is directly contradicted by one of those cited and discussed reviews [4]. The consequence of all of that is that we have two very large and very consequential bodies of literature, the reviews on EMF effects and the literature on genuine cell phone radiation effects, which are entirely missing from any SCENIHR 2015 [73] conclusion.

<u>Is There Another Systematic Effort by Industry to Corrupt the Literature that Has Been Followed to Some Extent by SCENIHR?</u>

The important roles of pulsation, window effects, frequency, cell type and polarization in determining biological activity of EMFs were discussed in Chapter 1, where it was noted that SCENIHR fails to pay attention to any of these roles. That failure shows up in many places in the document. In Tables 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 of SCENIHR 2015 [73], the discussion of each table centers on how many studies found apparent effects and how many did not. But these numbers are irrelevant to the issue of whether there are effects or not. In fact one can argue that the industry, knowing about the roles of each of these factors, could fund any number of studies designed to give apparent negative results just by manipulating these factors to minimize responses and by only studying tiny numbers of individuals to produce low statistical power. This approach closely describes the approach used in seven studies of what were claimed to be genuine Wi-Fi studies that were described by Foster and Moulder [110] in Table 4 of their paper. Those seven studies were shown [11] to all have used an EMF that was not genuine Wi-Fi, despite claims to the contrary. They each used one of two types of reverberation exposure chamber for their rodent exposures, with each type of chamber greatly lowering the polarization of the EMFs [11] and also generating some level of destructive interference from variable path lengths produced by the reverberations. Each of these changes from genuine Wi- Fi is predicted to lower effects. Foster and Moulder [110] concluded that there was no effect in any of these studies. However tiny numbers of rodents were studied, between 3 and 15 in each class, such that these studies have very low statistical power to conclude anything substantive.

It is not possible to conclude no effect even with large studies. At most one can claim that there is no statistically significant evidence of an effect. With tiny numbers, a claim of no effect is complete nonsense. This problem with "no effect" claims is documented in a section of Rothman et al., Modern Epidemiology, 3rd Edition, a highly respected source of information, cited over 19,000 times according to the Google Scholar database. It states (p. 151, bottom) that: "A common misinterpretation of significance tests is that there no difference between two observed groups because the null test is not statistically significant, in that P is greater that the cutoff for declaring statistical significance (again, usually 0.05). This interpretation confuses a descriptive issue (whether two observed groups differ) with an inference about the superpopulation. The significance test refers only to the superpopulation, not the observed groups. To say that the difference is not statistically significant means only that one cannot reject the null hypothesis that the superpopulation groups are the same; it does not imply that the two groups are the same." All such claims of "no effect" are, therefore flawed. When they are made regarding very small studies with very low statistical power, they are particularly deeply flawed.

Were these seven studies designed to fail? I don't think we can say for certain but they certainly *look* as if they may have been. They also raise the serious question about whether the industry may be corrupting the science, by using their knowledge of the roles of pulsation, window effects, frequency, cell type and polarization.

The SCENIHR 2015 document has 127 places in the 221 pages of text where the term "no effect" was found (these can be easily found by searching the document using "no effect" for the search terms (that also picks up "no effects" statements. The first two of these 127 places are used properly, to describe the null hypothesis. *Each of the other 125 should not be there*, with each of those 125 overstating the case and therefore, improperly supporting the industry propaganda case.

In any case, the only way to show that there are inconsistencies or conflicts in the EMF literature is to carefully repeat studies finding such effects, not to flood the literature with studies done under other conditions. The logic used throughout SCENIHR 2015 [73] of just counting numbers of studies is deeply flawed.

Summary of Flaws in SCENIHR 2015

The first set of flaws, is that SCENIHR is perfectly willing to make statements which they know or should have known are false. The most egregious example of this is the Speit/Schwarz controversy described at the beginning of this chapter where there are seven clear falsehoods *created by SCENIHR*, each of which greatly strengthens the telecommunications industry propaganda positions. There are many others, described in this chapter that are substantive, but less egregious than the Speit/Schwarz falsehoods.

There is a vast literature, both in the review literature and in the primary literature studies, that disagrees strongly with the SCENIHR positions and is completely ignored by SCENIHR. In a few cases, such studies are cited and very briefly discussed by SCENIHR but then they have no impact on the assessments that SCENIHR makes in the SCENIHR 2015 document [73]. In most cases, they are neither cited nor discussed. The situation here is similar to an organization that has two sets of books, the fake books that are used in public and then a genuine set of books that includes all of the data that are too inconvenient to be included in the fake set of books.

The finally, we have three additional considerations which interact with each other to produce the completely bogus logic used by SCENIHR and by other organizations that have taken positions similar those taken by SCENIHR. One of those considerations comes from our knowledge that pulsation pattern, cell type, polarization and frequency can all influence biological effects and that there are exposure windows that produce much larger effects than are seen with either lower or higher intensities. Our knowledge of these factors mean that it is possible for the telecommunications industry to foster any number of studies where it is unlikely that statistically significant evidence of effects will be seen. I have presented examples where this may have been done. One of the most bizarre things about the SCENIHR 2015 document [73] is that there is a sentence on p. 101 where they state "In some of these cases, the effect seemed to be dependent on the cell type investigated and by the electromagnetic parameters applied (frequency, modulation)." Modulation and pulsation are the same thing. They know about these three factors and therefore, they know that these factors may explain differences in results obtained by different studies. But they still falsely assume that such differences imply inconsistencies in results and falsely assume that it makes sense to simply count apparent positive and apparent negative studies as a way of assessing whether there are effects or not.

SCENIHR has often falsely stated that these studies show no effects as opposed to lack of statistical significance of any effects. SCENIHR 2015 document has 125 places where such bogus claims of "no effect" are found. They repeatedly claim the literature is inconsistent but studies done under different conditions are *not* inconsistent because they are more likely to be due to genuine biological heterogeneity of responses. The false logic described here is used, in turn, to support another highly pervasive false logic. I've documented where SCENIHR has simply counted numbers of studies showing so many findings of effects and some other number of findings of "no effect." But these numbers are meaningless, when the studies are done under different conditions and where the "no effect" numbers can easily be inflated by studies designed to produce such results. They are also, of course, meaningless, when large numbers of studies that show effects are eliminated by SCENIHR by the simple process of pretending they don't exist. You can see from this, that the entire logical framework behind the SCENIHR 2015 [73] document is completely bogus.

Lastly, before going on to the situation in the U.S. and with 5G, there is one other thing I want to state here. In 2005, Dr. Jared Diamond published a book [111] entitled "Collapse: How

Societies Choose to Fail or Succeed." In it he documents how each society that "chose to fail," chose paths that had some short term gains but also had much more severe longer-term consequences. This is exactly what we have been doing with the EMFs, except that the consequences are much more severe than the collapse of one society – here all of the advanced technology societies on earth are at great risk.

Chapter 6: The U.S. Early Role in Recognizing Non-Thermal EMF Effects and How This Was Abandoned Starting in 1986: U.S. Failure to Research Health Impacts of Cell Phone Towers, Cell Phones, Wi-Fi, Smart Meters and Now 5G. What Is the Current Position of U.S. Government Agencies?

We in the U.S. often take great pride in our scientific research. That is, of course, especially true of U.S. scientists, of which I am one. We have far more Nobel laureates than any other country so we think of ourselves as being the #1 science country in the world. But we have had, over the past 20 years, almost no scientific primary literature studies, either laboratory studies or epidemiological studies, on non-thermal microwave frequency EMF effects. We had much more such research in this area 35 years ago,

In terms of non-thermal effects of microwave frequency (sometimes called radiofrequency) EMFs, the U.S. government published documents acknowledging the existence of large numbers of such non-thermal effects. This included the 1971 U.S. Office of Naval Medical Research Institute Report [30] and the 1981 report from the National Aeronautics and Space Administration (NASA) [26]. The most recent such report acknowledging widespread non-thermal EMF effects was the NCRP report [112] published in 1986. It follows that for the past 32 years, the U.S.government has been in denial on what *had been* repeatedly recognized by our government and is of great importance to protecting our health. 1986 turns out to be a key year because in that year, the U.S. Environmental Protection Agency (EPA) shut down its in house research program studying non-thermal EMF effects. In 1986, the U.S. Office of Naval Research, which had been funding grants in this area, stopped funding any new grants – the already funded grants were funded to the end of the grant period but no new grants were funded past 1986. A few years later, I think it was in late 1994, a similar shutdown of grants went into effect at the NIEHS, the part of the National Institutes of Health (NIH) which supports environmental health research. In 1999, the last U.S. agency that had been funding some research in this area, The Department of Energy also shut down what little research it had been funding.

The consequences of those shutdowns is that of the 17 studies on people living near cell phone towers, not a single study has been done in the U.S. Of the 23 studies of effects of genuine Wi-Fi EMFs, each of them showing effects [11], not a single study was done in the U.S. Of the over 50 studies on genuine cell phone radiation effects, only single one was done in the U.S, the NTP cell phone cancer study required by the Congress. So we have a situation where the U.S. government is encouraging EMF exposures and, in many cases, making it impossible to avoid EMF exposures while doing nothing or almost nothing to ensure our safety. There are a tiny number of studies that somehow sneak through, such as the Aldad et al study (#12 in Table 4) discussed in the preceding chapter, which was funded through the Child and Human Development Institute of the NIH, but these are few and far between.

How did these shutdowns happen? I don't know about 1986 but have some useful information from 1994/1995.

Attacks by the Telecommunications Industry on Two U.S. Scientists

Dr. Henry Lai from the University of Washington and a collaborator, NP Singh were using the alkaline comet assay, discussed earlier in this document to measure single stranded breaks in cellular DNA. They found a substantial elevation of the levels following low level EMF exposure in late1994. Before that finding had even been published, they found that they were targets of a severe attack from the telecommunications industry. A key document providing evidence of this was what was called the "War-Gaming" memo [113], where an executive named Norm Sandler, head of the Corporate Communications Department of Motorola (at that time the largest cell phone company) sent the memo to Michael Kehs of a public relations campaign in Washington DC (dated Dec. 13, 1994), describing their planned response to these at that time, unpublished findings. The memo stated that "While this work raises some interesting questions about possible biological effects, it is our understanding that there are too many uncertainties—related to the methodology employed, the findings that have been reported and the science that underlies them—to draw any conclusions about its significance at this time. Without additional work in this field, there is absolutely no basis to determine whether the researchers found what they report finding—or that the results have anything at all to do with DNA damage or health risks, especially at the frequencies and power levels of power levels of wireless communication devices.

In discussing the frequency differentiation issue, we should be able to say that Lai-Singh and Sarkar were not conducted at cellular (that is cell phone) frequencies."

(My comments are as follows: It is true that Lai/Singh used a different frequency from that used by cell phones. So the industry was correct about that. But the findings also show that the industry claims that there cannot be any non-thermal effects are wrong, and that may be more important. Singh had a reputation of being a genuine international expert on comet assays, so I doubt that methodology was a problem. If this had nothing to do with DNA damage or health risks, Motorola would not be worrying about these findings. There were at that time (1994) previously published studies of EMF effects on cellular DNA including the concurrent Sarkar findings and including findings of chromosome breaks and rearrangements reported in [30]).

Further down, the memo: "I think we have sufficiently war-gamed the Lai-Singh issue, assuming that SAG (Scientific Advisory Group, a group linked to the telecom industry) and the CTIA (the umbrella telecom lobbying, publicity and legal organization) have done their homework. We want to run this by George Carlo and fill him in on contacts we have made."

Under Excerpts from Confidential Working Draft #3. Question and Response:

Q. How can Motorola downplay the significance of the Lai study when one of your own expert consultants is on record telling Microwave News that the results—if replicated—could throw previous notions of RF safety into question?
R. It is not a question of downplaying the significance of the Lai study. In his comments to Microwave News, Dr. Sheppard raised the key question: Can it be replicated and interpreted? We will wait and see."
(My comments: Replication needed to be done, so that was a valid point. The interpretation was and is clear – it is that EMF exposures produce large increases in the numbers of single strand breaks in the cellular DNA.)

"Action Planned: In addition to response materials prepared by SAG (see attached copies) we will work with SAG to identify appropriate experts to comment in general on the science of DNA research, in addition to any experts SAG may be able to recommend to publicly comment on one or both of these particular studies.

Then they talk about Media Strategy where Motorola stays in the background with SAG and CTIA in front."

Three important things happened to Dr. Henry Lai at about this time [114,115]. In November 1994, before the War-Gaming memo had been written, a representative of the industry called the NIH claiming that money had been misspent from the Henry Lai grant for the DNA studies. Dr. Lai faxed the NIH an explanation which was accepted. However, the cutoff of new NIEHS funding appears to have occurred at this time, such that the industry pressure is likely to have been important. Furthermore [114] "The industry made a full-court press to discredit the DNA break study. A consistent and coordinated message was put out to marginalize Lai and Singh. For instance, in November 1994 (note: this was also before the War-Gaming memo was written), Q. Balzano, then a senior Motorola executive, wrote to us (Microwave News) that "Even if it is validated, the effects it purports to show may be inconsequential." (My comment is that DNA breaks produced at intensity levels well below safety guidelines are *not* inconsequential. If they were, the industry would not be worrying so much about them). Ron Nessen, the CTIA's top spokesman told a Florida newspaper that "It's not very relevant." He also tried to cast doubt on the comet assay pioneered by Singh to measure DNA breaks. It "may not be scientifically valid." Quite a number of months later, the head of the WTR (successor organization to SAG) wrote a 6 page letter to the President of the University of Washington to try to get him to fire both Lai and Singh [114, 115]. Neither was fired, but this is what you face when you get results that the telecommunications industry does not like.

(My comments: The basic findings of the Lai and Singh studies have been replicated more than two dozen times, at this writing. There have also been many replicates of the findings of increased micronucleus formation and oxidized bases in the DNA following non-thermal EMF exposures. All of that replication and the 21 reviews that were listed in Chapter 1 each showing non-thermal cellular DNA damage have still not gotten the telecommunications industry to admit that these DNA effects are occurring. The industry apparently does not care about the replication but cares, rather, about having talking points. Furthermore, when the industry was trying to get Dr. Lai's research funding cut off or later was trying to get both Lai and Singh fired, they were trying to *prevent* replication rather than encouraging it).

So Dr. Henry Lai was the first major scientist who came under vicious attack from the telecommunications industry and their allies, but he was certainly not the last. There are many such scientists including Prof. Adlkofer in Germany and Prof. Rüdinger in Austria. I know of nine others who have been attacked in the U.S. or in Europe. But here is a situation where the U.S. instead of leading world science in the right direction has been leading it into corruption. There are others.

I want to talk about another especially important case of such an attack on a U.S. scientist, that of Professor Om Gandhi. Gandhi is a professor at the University of Utah who, for many years was doing modeling of cell phone EMF exposures on the brains of humans. He was modeling such exposures for a substantial period of time of time based on the head of what was called standard anthropomorphic man (SAM). SAM was modeled from a 6 foot 2 inch, 200 pound man, a man in the upper 10% of men for head size and estimated skull thickness. He was doing such cell phone modeling for the telecommunications industry and received an important honor for this research. Because the safety guidelines are based only on thermal effects, the modeling was aimed at determining heating of the human brain by cell phone radiation.

Prof. Gandhi became concerned about the fact that both the head size and skull thickness of SAM was greater than that of most men and essentially all women and children and consequently began modeling a typical woman and typical 10 year old child, When he did that he found that the cell phone EMF exposures to the brain were much too high, even based on their own standards, standards that were and are only based on heating. The timing of these events was from 1975 through 1996. I will be quoting on what occurred subsequently. I have received permission from Dr. Devra Davis to make these quotes from pages 81 through 88 of her book Disconnect [77]. I will use a different font for those quotes so that you can see them easily.

Based on the new work he had produced, Gandhi called for a revision of the safety standards that regulated cell phones. The industry was stunned. For years, Gandhi had been one of those on whom they had counted. If Gandhi's work went uncontested, it would mean that children, women and men with smaller heads could not safely use some electronic devices or that these devices would have to be redesigned to emit less radio frequency radiation. The industry's first response was to cut off all of Gandhi's funding.

Going to p. 86 from [77]:

Gandhi explained that something has gone very wrong with standard setting in the United States in the past few years.

"Starting in the late 1980s, I chaired the committee to set standards for radio-frequency exposures before all cell phones ever existed. About a decade ago, C.K. Chou, then at the City of Hope Hospital, replaced me. Within two years, Chou had moved. He became a senior executive with Motorola—a clear conflict of interest. The committee that advises as to cell phone standards is supposed to be independent and had never before been led by someone from the very industry it advises. Under Chou's leadership, the committee relaxed standards for cell phones as of 2005. Having spent my entire life developing models of the brain, I know how things work. I also know that what we have done here is to ratchet up exposures, without actually telling people we have done so. Today's standards for cell phones have more than doubled the amount of radio-frequency radiation allowed into the brain."

The next quote starts at 2002, before the more than doubling of those radiation standards (pp. 87-88 from [77]).

By 2002 the gloves were off and the industry made it clear to Gandhi that they would take him on directly. Gandhi remembers being told by an industry colleague who was once a student and friend, "If you insist on publishing these papers saying that children get more exposed than adults and saying our test procedure is not valid, you can expect that we will not fund you."

Gandhi replied, "I am a university professor. I don't need your money."

Next industry tried to place an article by Chou critiquing Gandhi's models in the journal of which Gandhi had been editor and chief and in which he had published dozens of articles, and asked that either his (that is Gandhi's) article criticizing the grounds for setting standards be removed, or that they be allowed to publish Chou's rejoinder.

Gandhi reports that four different peer reviews of Chou's critique of my work indicated that Chou's critique of my work was 'scientific junk.' Only when the editor of the journal balked did the industry finally relent. Despite this success in beating back one attempt to discredit Gandhi's work, the effort to increase allowable amounts of radio frequency radiation was won on a major front. As the new chief of the standard-setting committee, Chou masterminded changes in the standards, and the committee, which now included a large majority of industry experts, issued new recommendations, ignoring Gandhi's analysis showing that these would effectively double exposures.

(I want to comment on this. I've published three papers on the physics of EMF action [4,5,11]. In each of them, I have taken the industry arguments about the physics seriously. Even though it was clear that the industry arguments were wrong, because of the clear existence of so many effects that occur at non-thermal levels of exposure, the industry arguments claiming that there could only be thermal effects were substantive and therefore, had to be considered. What I find, in the previous six paragraph, is that the industry itself is ready to throw out its own arguments, when they conflict with their ability to make massive profits. The issues here are very simple. Anyone with the most elementary understanding of the geometry of the head and a high school knowledge or physics, will know that a person with a smaller head and thinner skull will be exposed to higher brain levels of radiation from cell phones.)

What is obvious about this is that the industry does not care about health impacts, as long as they can maintain some deniability. What is also obvious is that the telecommunications industry can act to systematically corrupt an organization that, in effect, regulates the telecommunications industry. That in turn means that other organizations that, in effect, regulate the industry must be scrutinized for possible corruption. Those include ICNIRP, SCENIHR, WHO, the FCC and the FDA.

When Have Somewhat Similar Things Happened in Other Situations in the U.S.?

Is this approach to obfuscating the science unusual? Not really, but it appears to be much more extreme than usual, with the telecommunications industry and EMF effects. I suggest looking at the book on "Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health" by Dr. David Michaels. I've cited a book review of that book here [116]. The review starts out with the statement that "Creating doubt – at least enough to derail government regulation – is an art form long practiced and highly perfected by some sectors of private industry. In the book, Professor David Michaels vividly demonstrates how each such industry channels some of its profit to 'product defense firms' and 'self interested scientists' who conduct research designed to cast doubt on the science that supports regulation." (I will add that it also casts doubt on the science that may support lawsuits, as well.) "As a result of the doubt created, regulation is long-delayed and thousands of people (or perhaps millions) suffer and die unnecessarily." The industries that are covered in the book include tobacco, lead, asbestos, Merck (the maker of Vioxx), global warming, chromium, beryllium, artificial butter flavoring (diacetyl, the cause of often fatal popcorn lung). I think you will see parallels with what went on with SCENIHR (Chapter 5) and with the telecommunications industry actions (this chapter). Part of the problem with these precedents, is that nobody went to prison, despite the many deaths and injuries that were perpetrated and in most of these cases, the industries involved ended up making more money than they lost in the subsequent lawsuits. The precedent has been set that you can get away with almost anything if you are big enough and powerful enough and rich enough. That

may have been sufficient to encourage the telecommunications industry to follow a similar, although, in my opinion, much more aggressive pathway.

One question that can be asked is whether there are any major international political figures who appear to have a good understanding of the EMF/health issue? When I was asked that question, I was able to come up with only one person. That person is President Vladimir Putin of Russia. This inference comes from an interview of Dr. Dietrich Klinghardt, who practices in Seattle, by Dr. Joseph Mercola, that occurred in December 2017, an interview that was entirely focused on EMF health effects [117]. In that context Dr. Klinghardt states that a lecture that Putin gave to the Russian assembly said, "We do not need to go to war with America. America is committing collective suicide by the way they are using electricity. We just have to wait until they are all in the psychiatric hospital." When I saw that, I asked myself whether it is plausible that Vladimir Putin has a deep understanding of the neuropsychiatric effects of the EMFs? And then I thought, of course, Vladimir Putin was the head of the KGB when the latter studies reviewed by Dr. Karl Hecht [28] were being done in the Soviet Union. The most important effects that were shown to be produced by the EMFs, in those studies, were the neuropsychiatric effects. Furthermore, the Putin statement apparently shows not only a substantial understanding of those effects but also the fact that they are cumulative and become irreversible, as shown in those studies [28] and in other studies discussed in Chapter 4. One thing that I would add is that President Putin apparently practices what he preaches. He avoids smart phones [118].

It is my opinion, that the CIA and other international intelligence agencies should examine these issues very carefully to assess whether they see the kinds of threats that I see. Those agencies are very good at obtaining information from various sources and determining probable threats to national and international security. It should not be difficult to come to an assessment, especially because some of us have done much of the work that needs to be done. The threat here is self-inflicted, it is not caused by any foreign power or set of powers. But it is the most serious national or international security threat that we have faced, in my opinion, with the exception of nuclear annihilation.

Propaganda:

In the initial days of the controversy regarding cell phones, in 1993, the industry developed a huge public relations effort in the face of lawsuits and adverse press reports impacting the industry. Paul Staiano, President of Motorola General Systems stated in a 1993 ABC 20/20 interview [119] that, “Forty years of research and more than ten thousand studies have proved that cellular phones are safe.” So I asked how many studies of cell phone safety or lack there of had been published by the end of 1993. The way I did that was to search in the PubMed database under (cell phones or cellular phones or mobile phones). I found about 11,000 hits, roughly 99% of them having nothing to do with health safety, and then looked at the few studies that had been published before the end of 1993. The only study I found that had any connection with health or safety, was one on driving safety while using a cellular phone, giving equivocal results with regard to driving safety. So there, were apparently no studies done on cell phone safety at that time. Furthermore, even if there had been any studies, they could not possibly show that “cellular phones are safe.” At most they might show that there was no statistically significant evidence of an effect but that only shows that you have not proven an effect, not that you have proven the opposite. It can be seen, therefore, that this propaganda statement is complete nonsense. Furthermore, we know that the Panagopoulos et al [100] review, showed that 46 out of 48 genuine cell phone studies that they reviewed showed effects. So the facts are exactly opposite of the industry propaganda on this. If this was the beginning of propaganda in the U.S. let’s look at something much more recent.

Berezow and Bloom Op-Ed Document: Recommendation to Limit Maryland School Wi-Fi Is Based on "Junk Science"

Berezow and Bloom, [120] start their 2017 op-ed with the claim that "The CEHPAC, an agency within Maryland's Department of Health and Mental Hygeine, has recommended that schools reduce or eliminate students' exposure to Wi-Fi because it believes wireless signals might cause cancer. *This is pure, unadulterated junk science. At least three separate, major areas of scientific knowledge can unambiguously confirm that wireless radiation is completely safe* (italics added)."

They continue with the physics [120], stating that "CEHPAC fails to realize that all radiation is not created equal. The energy of nuclear radiation, X-rays and UV light is high enough to damage our bodies and cause cancer. But other forms of radiation are energetically weak by comparison. They cannot cause cancer." This argument has validity with regard to individual photons, as I stated in my first paper on the activation of VGCCs by EMFs [4], but it is completely bogus with regard to EMFs as a whole. It has been known for 70 years that a person walking in front of a high powered radar machine will rapidly die, but Berezow and Bloom claim that cannot happen because the fields are "energetically weak." Furthermore, as discussed in Chapter 2 and elsewhere [5,11], the voltage sensor that controls the opening of the VGCCs is extraordinarily sensitive to electrical forces of EMFs, with the forces on the voltage sensor being approximately 7.2 million times greater than the forces on singly charged groups in the aqueous parts of our cells and tissues. It can be seen, therefore, that Berezow and Bloom [120] while claiming to be experts, are profoundly ignorant of the relevant physics.

Berezow and Bloom [120] state that "According to the NIH's National Cancer Institute [121], well performed studies that included over one million people showed no connection between cell phone use and cancer." There is no such statement in the NCI 2016 [121] document – I suggest the reader look it up – it differs substantially from the op-ed characterization of it. The NCI 2016 [121] document, states that "there is currently no consistent evidence that non-ionizing radiation increases cancer risk" (sole supporting citation in NCI 2016 [121] was SCENIHR 2015 [73]). It has been shown above in Chapter 5, that SCENIHR 2015 is not a credible source of information on this and as shown, in Chapter 1, there are 35 different reviews that each provide strong evidence that EMFs do cause cancer. So claiming, that EMF causation of cancer is, in Berezow & Bloom's words, "pure, unadulterated junk science" is nonsense. What is amazing here is that the U.S. NTP study, published by Wyde et al [122], clearly shows that cell phones do cause cancer but it was completely left out of the Berezow & Bloom statement.

Let's go to their third "major area of scientific knowledge" – Berezow and Bloom [120] state that "the only known health effects from Wi-Fi are due to psychosomatics." That is, "people who believe that something will make them sick will report feeling ill, even if nothing is happening externally." Some of the Wi-Fi studies (Table 1 in [11]) are cell culture studies, some are animal model studies where EMF exposures are compared with sham exposures. While there may be a very weak argument regarding some but not other human studies when they are not done blinded, there is no argument that effects in any of the other studies are caused by "psychosomatics." Berezow and Bloom do not look at any of the 23 studies of Wi-Fi reviewed in [11], each of which showed effects and it is clear that most of them cannot possibly be due to psychosomatics. What is surprising here, is that the trillion dollar set of telecommunication industries, having been working on their propaganda for over a quarter of a century, is unable to produce a more convincing argument.

Have There Been Individual Research Studies Designed to Fail and Therefore Corrupt the Scientific Literature?

The first example, that I am aware of, where false science has been produced to supposedly show that an important EMF observation was unrepeatable also came from the U.S. It was described in Dr. Davis' book [77]. Dr. Allen H. Frey (pronounced Fry) published a paper in 1975 in Annals of the New York Academy of Science showing that low intensity pulsed EMF exposures produced a breakdown of the blood-brain barrier, the barrier in the blood vessels in the brain and the brain tissue that protects the brain from toxic chemicals and also infectious agents. The methodology that he used was to inject the fluorescent dye fluorescein into the blood (IV) and then use its fluorescence to detect whether and to what extent it penetrates into the brain tissue from the blood. A subsequent paper was published in 1978 [123], using similar methodology *except* that the fluorescein instead of being injected into the blood, was injected by intraperitoneal (IP) injection. When a compound is injected IP, it enters the blood only slowly over a substantial period of time, so that when one does a short term experiment looking at penetration through the blood-brain barrier, essentially nothing is seen. This was a transparent attempt to claim that the studies of Dr. Frey had been repeated with negative results, but the Frey studies had not be replicated.

I am aware of many papers that were flawed like the seven studies of simulated Wi-Fi, discussed near the end of Chapter 5 that were each touted by Foster and Moulder [110]. Let me remind you of what the flaws were in those seven studies. Firstly, each of them used EMFs that were the correct frequency for Wi-Fi but differed in pulsation from genuine Wi-Fi. Each of these studies used a reverberation exposure chamber which is predicted to decrease effects by both decreasing the polarization of the EMFs and increasing the destructive interference of the EMFs. They also used tiny numbers of animals for each study group, such that any statistics would have very low power. Finally, Foster and Moulder claimed each of them showed "no effect" when one can only at best claim there was no statistically significant evidence of an effect. Given the tiny numbers, the lack of statistical significance is of very little importance. I find that this pattern has been followed in a substantial number of additional studies.

What I want to discuss here is a paper that had each of those four properties but had several additional flaws, as well. I am aware of three legal proceedings in the U.S., where the industry side of that case touted the paper to be discussed, as being a particularly strong one. This paper by Ziemann et al [124] is entitled "Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz (DCS) wireless communication signals: In vivo two-year bioassay in B6C3F1 mice. In other words, the title claims that the 902 MHz frequency, studied and the 1747 MHz frequency also studied in the paper cannot cause DNA damage or other types of genotoxicity."

On p. 456 of Ziemann et al [124], the authors make clear that they are studying the effects of simulated cell phone radiation, not actual cell phone radiation. You will recall that Panagopoulos et al [110] found that almost all studies of genuine cell phone radiation found effects whereas less than half of simulated cell phone studies showed effects. This raises an important question about why Ziemann et al [124] opted to study simulated cell phone radiation. Much of the funding of the Ziemann et al paper (see pp. 462-463) came from industry sources. Funding source is not a flaw but it is a reason to look at the paper particularly closely. 2. The Ziemann et al [124] study used a stainless steel exposure chamber similar to the reverberation chambers discussed in Chapter 5 of this document. The chamber is predicted, to produce lower effects because of lowered polarization and increased destructive interference 3. The study is described as being a two year study of radiation effects. However the cells examined for micronuclei (their marker for genotoxicity (cellular DNA damage)), were mouse erythrocytes (red blood cells), and such

erythrocytes have a lifespan of only about 30 days; because of the inherent instability of micronuclei in replicating cells, such micronuclei in erythrocytes may possibly be generated over at most a 30 day period. It is misleading to describe this as a two year study when only the last 30 days are relevant to generating the marker being studied. 4. In rats and humans, erythrocytes containing micronuclei are selectively removed from circulation very quickly (see p. 459 of Ziemann et al [124]). While Ziemann et al claim that mice do not have a similar mechanism for selective rapid removal, the only citation that they provide is a study published by Chaubey et al (1993) showing that this was apparently true with Swiss mice; Ziemann et al [124] chose to use B6C3F1/CrlBR mice, a different inbred mouse strain which may well behave quite differently from Swiss mice. It follows from this that we have no idea whether the strain studied is similar to Swiss mice with regard to selective removal of erythrocytes containing micronuclei.

5. Ziemann et al [124] show that male and female mice behave quite differently with regard to levels of micronuclei (Tables I and III in [124]); however in their experimental study (Figure 2), males and females were combined in doing the statistics. What that inevitably does is to produce greater variations in micronuclei levels within different animal groups, making it substantially more difficult to detect any statistical significance among different animal groups in the study. It also means that it is important to use similar ratios of males and females in the experimental groups and we have no idea whether this was done or not. 6. In section A of Figure 2, there were only 8 animals in each group studied. In section B of Figure 2, there are only 5 to 9 animals in each animal group studied. These tiny numbers mean that there is only extremely low statistical power to detect any effects of EMF exposure and therefore these tiny studies make it almost impossible to say anything at all about the results. 7. The Ziemann et al study [124] provide none of their raw data; consequently we are in a situation where we have no way of judging whether their statistical analysis was done properly. We also have no way to use any such data as part of a meta-analysis of multiple studies, which may have much more power than do any single study (particularly such a tiny one). Consequently, the lack of statistical significance they report, cannot be properly assessed by the reader. 8. When one does a study looking at the possible effects of some variables, in this case a couple of simulated cell phone radiation studies, the most you can say about an apparent negative result is that "we did not see any statistically significant effects." When you have tiny studies such a described under 7 above, then the lack of statistical significance tells you almost nothing. But even with a very large study such as with thousands of mice including hundreds in each experimental group, all you can say is that "we did not see any statistically significant effects." 9. What do Ziemann et al conclude? They state in their title that there is an "Absence of genotoxic potential of 902 MHz (GSM) and 1747 (DCS) wireless communication signals." Did they study these EMFs in all organisms and all cell types? No of course not. Did they study all possible pulsation patterns of these two frequency EMFs? No of course not. Did they study all types of genotoxicity found following low-intensity EMF exposures? No, just one, micronuclei in erythrocytes in an inbred strain of mice. This title alone should tell any competent scientist that the paper is deeply flawed, completely apart from the preceding 8 flaws, with each of the 8 adding substantially to the flaws in this paper.

<u>George Carlo Letter</u>

Dr. George Carlo is an interesting and controversial figure who has both a law degree (JD) and a PhD in, I believe, epidemiology. He had worked in the telecommunications industry for years as head of the SAG and then WTR research arms. Dr. Carlo wrote an important letter to the heads of the telecommunications companies on October 7, 1999. The letter he sent to the head of AT&T is available on the internet [125]. In his book [126] Carlo lists all of the people sent the letter and also provides the text of the letter.

Carlo was, at that time the soon to be retiring head of the WTR, which was the CTIA/telecommunications industry research arm. In the letters to the heads of the telecommunications industry companies, Carlo discusses the types of evidence arguing that cell phones do apparently cause cancer and that they do cause DNA damage to our cellular DNA. The DNA damage, suggested that the apparent cancer causation was real. Carlo continues the letter as follows [125]:

"Today, I sit here extremely frustrated and concerned that appropriate steps have not been taken by the wireless industry to protect consumers during this time of uncertainty about safety." Continuing further down, Carlo adds:

"Alarmingly, indications are that some segments of the industry have ignored the scientific findings suggesting potential health effects, have repeatedly and falsely claimed that wireless phones are safe for all consumers including children, and have created an illusion of responsible follow up by calling for and supporting more research. The most important measures of consumer protection are missing: complete and honest factual information to allow informed judgment by consumers about assumption of risk; the direct tracking and monitoring of what happens to consumers who use wireless phones; and, the monitoring of changes in the technology that could impact health.

I am especially concerned about what appear to be actions by a segment of the industry to conscript the FCC, the FDA and WHO with them in following a non-effectual course that will likely result in a regulatory and consumer backlash."

This is an important letter for several reasons. After October 7, 1999 the heads of the telecommunications companies or, for that matter anyone else at those companies, could no longer legitimately claim that they did not know there were serious health concerns with cell phones, with targeting cell phones to young children, or with increasing allowable cell phone exposure radiation. The last of these was done a few years later, as you have already seen.

The concerns Carlo expresses about the FCC (Federal Communications Commission) and the FDA (U.S. Food and Drug Adminstration) are particularly important in the U.S., because both the FCC and the FDA had already been given important regulatory roles when the Carlo letter was written. The FCC had been given the power of regulating the location of cell phone towers by the 1996 telecommunications act, which also *prohibited, as I understand it, any state or local government from protecting their people's health by regulating cell phone tower positioning*. In other words, the 1996 telecommunications act *de facto* stated that the U.S. Federal government valued telecommunication industry profits over every single health impact of microwave frequency radiation, *no matter how serious* it is, to the American people. There have been several subsequent pieces of legislation that have made the situation still worse. The FDA had been given the power to regulate radiation emissions from cell phones and other devices that emit microwave/radiofrequency radiation, with cell phone regulation apparently being shared with the FCC.

<u>What Can We Say About the FCC?</u>

There was a very informative document about the FCC published by the Safra Institute for Ethics at Harvard University [127] entititled "Captured Agency: How the Federal Communications Commission Is Dominated by the Industries It Presumably Regulates." One of the sections in that document shows why both the FCC role and the telecommunications industry role were so important with regard to the 1996 telecommunications act:

Section 332(c)(7)(B)(iv) of the Act remarkably, and that adverb seems inescapably best here, wrests zoning authority from local governments. Specifically, they cannot cite health concerns about the effects of tower radiation to deny tower licenses so long as the towers comply with FCC regulations.

Congress Silences Public

Section 322(c)(7)(B0(iv) of the Communications Act Provides:
No State or local government or instrumentality thereof may regulate the placement, construction of personal wireless service facilities on the basis of environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions.

In preempting local zoning authority – along with the public's right to guard its own safety and health, Congress unleashed an orgy of infrastructure build-out. Emboldened by the government green light and the vast consumer appetite for wireless technology, industry has had a free hand in installing more than 300,000 sites. Church steeples, schoolyards, school rooftops, even trees can house these facilities.

What, then are the consequences of all of this? The 17 studies that have been done on people living near cell phone towers show that many people within 300 meters (about 1000 feet) of a cell phone tower are afflicted by six of the health effects found in those many reviews listed in Chapter 1. Two of those effects have not been looked at. According to this literature, people living within 300 meters of cell phone towers suffer from widespread neuropsychiatric effects, cellular DNA damage, cancer, oxidative stress, elevated apoptosis (cell death), and hormonal effects. They also suffer from cardiac effects like those discussed in Chapter 3 and from hypertension and also anemia. The two extremely well documented EMF health effects that have not been looked at are the reproductive effects and the high levels of intracellular calcium. That does not tell us these are not also caused in people living near cell phone towers, just that no one has looked. Roughly 30% of the people in this country live within 300 meters of a cell phone tower so the impact on health is major. But few know about this and the media and our government, including especially the FCC and FDA are keeping it all a deep dark secret. Not a single one of these 17 studies have been done in the U.S. Consequently, when the U.S. has ensured that we are irradiated by well over 300,000 of these cell phone towers, it has done absolutely nothing to determine what the consequences of exposure are. Of course we are impacted not only by cell phone towers near where we live but also near where we work or go to school and to some extent, when we are driving around town. These high levels of exposure are not necessary. Switzerland has safety guidelines that are 100 times more stringent than ours, Russia has safety guidelines that are 1000 times more stringent than ours. The health effects we see now will no doubt rise much further in the future without any increasing exposure, because many of these effects are cumulative, eventually becoming irreversible.

I would encourage you to look at the whole FCC as a captured agency document [127] – it can be downloaded at no cost from the internet [127]. It is very interesting and adds considerably to my short comments here regarding corruption.

So what does the FCC have to say about EMF effects on its web site [128]? I have copied some relevant sections as follows:

At relatively low levels of exposure to RF radiation, i.e., levels lower than those that would produce significant heating, the evidence for production of harmful biological effects is ambiguous and unproven. Such effects, if they exist, have been referred to as "non-thermal" effects. A number of reports have appeared in the scientific literature describing the observation of a range of biological effects resulting from exposure to low levels of RF energy. However, in most cases, further experimental research has been unable to reproduce these effects. Furthermore, since much of the research is not done on whole bodies (in vivo), there has been no determination that such effects constitute a human health hazard. It is generally agreed that further research is needed to determine the generality of such effects and their possible relevance, if any, to human health. In the meantime, standards-setting organizations and government agencies continue to monitor the latest experimental findings to confirm their validity and determine whether changes in safety limits are needed to protect human health. (Back to Index)

CAN PEOPLE BE EXPOSED TO LEVELS OF RADIOFREQUENCY RADIATION THAT COULD BE HARMFUL?

Studies have shown that environmental levels of RF energy routinely encountered by the general public are typically far below levels necessary to produce significant heating and increased body temperature. However, there may be situations, particularly in workplace environments near high-powered RF sources, where the recommended limits for safe exposure of human beings to RF energy could be exceeded. In such cases, restrictive measures or mitigation actions may be necessary to ensure the safe use of RF energy. (Back to Index)

CAN RADIOFREQUENCY RADIATION CAUSE CANCER?

Some studies have also examined the possibility of a link between RF exposure and cancer. Results to date have been inconclusive. While some experimental data have suggested a possible link between exposure and tumor formation in animals exposed under certain specific conditions, the results have not been independently replicated. Many other studies have failed to find evidence for a link to cancer or any related condition. The Food and Drug Administration has further information on this topic with respect to RF exposure from mobile phones at the following Web site: FDA Radiation-Emitting Products Page . (Back to Index)

Let's look at the first paragraph. In the third and fourth sentence, they state that there have been non-thermal effects reported but then say that "in most cases they have not been reproduced." Is that true? No. The 79 reviews listed in Chapter 1 have each found repeated studies documenting one or more of the EMF effects. You can't get a review published without multiple studies. And the fact that so many of these effects have been repeatedly reviewed, over many years shows that similar patterns of evidence have been found over long periods of time. *The FCC provides not one iota of evidence on its claims, despite the fact that such a claim of inability to reproduce findings absolutely requires extensive documentation to be scientifically valid. This difference in documentation, means that any one of those 79 reviews listed in Chapter 1 is vastly more scientific in showing the falsity of the FCC statement than is the FCC statement itself, which is completely undocumented.*

Let's go on to the cancer claim at the bottom of the copied section. The FCC states that "A number of reports have appeared in the scientific literature describing the observation of a range of biological effects resulting from exposure to low levels of RF energy. However, in most cases, further experimental research has been unable to reproduce these effects. Furthermore, since much of the research is not done on whole bodies (in vivo), there has been no determination that such effects constitute a human health hazard." You will note here that there are no specifics, nor were there any specifics on the section discussed in the previous paragraph. What we have here are completely undocumented FCC claims, with no specifics whatsoever and claims that are clearly contradicted by each of the 35 reviews on cancer causation by EMF exposure. They are also clearly contradicted by the 21 reviews on cellular DNA damage following EMF exposures, something that the FCC says nothing about. It has been known for decades, that the process of carcinogenesis (cancer causation) usually starts with one or more mutations in the cellular DNA, mutations that can be caused by each of the three types of cellular DNA damage known to be caused by EMF exposure.

The sort of pattern seen here, where we have gross generalizations followed by no or completely inadequate documentation goes on with the industry propaganda [119,120] as discussed earlier, as well as in the Speit/Schwarz discussion from early in Chapter 5. What you see in each of those cases is everything falls apart when you look carefully at the facts. The situation with the FCC statements is very similar. There can be little doubt that the FCC is acting as a propaganda organization here, as strongly suggested by the George Carlo letter [125,126] and the FCC as a captured agency [127] document.

Three questions: Does the FCC know that these statements that it has made are not factual? Does it know how non-thermal EMF effects actually are produced? Does it know that its safety guidelines do not protect our health? That answer to all three of these questions is yes. How do I know? I know because I did a PowerPoint presentation to the FCC in September 2016 which presented findings in each of these important areas. My account of that presentation, written two days after it occurred, follows:

Professor Emeritus Martin L. Pall presented Powerpoint presentation on the main mechanism of action of non-thermal microwave frequency EMFs to the FCC

I met with Julius Knapp, Chief of OET, Martin Doczkat, Branch Chief, OET/Technical Analysis Branch, and Ed Mantiply Engineer OET/Associate Chief at the Federal Communications Commission on September 21, 2016 to present a Powerpoint presentation and answer questions. The presentation showed that non-thermal microwave and lower frequency EMFs act via voltage-gated calcium channel (VGCC) activation. The most important findings demonstrating this mechanism are that various effects produced by such non-thermal exposures can be blocked or greatly lowered by calcium channel blockers, drugs that are highly specific for blocking VGCCs. The reason why such low intensity non-thermal exposures activate the VGCCs is because the voltage sensor of the VGCCs is exquisitely sensitive to the electrical forces produced by these EMFs. The forces on the voltage sensor are calculated to be about 7.2 million times higher than are the forces on singly charged chemical groups in the aqueous phases of the cell. This very high level sensitivity also predicts that the safety guidelines allow us to be exposed to EMF intensities that are approximately 7.2 million times too high.

The actions produced by such VGCC activation go mainly through the excessive intracellular calcium levels produced by such activation. Excessive calcium acts via three main pathways to produce effects in the body. Therapeutic effects are produced through the nitric oxide signaling pathway whereas many pathophysiological effects are produced by the peroxynitrite/oxidative stress pathway. Excessive calcium signaling also produces pathophysiological effects. Numerous effects produced following non-thermal EMF exposures can be produced by these pathways including oxidative stress, cellular DNA damage, cancer, widespread neuropsychiatric effects, breakdown of the blood brain barrier, lowered male and female fertility and various endocrine (that is hormonal) changes.

It has long been known that pulsed EMFs are usually much more biologically active than are non-pulsed (or continuous wave) EMFs and this difference appears to be consistent with the VGCC mechanism. Because all wireless communication devices communicate via pulsations, such devices may be of special concern.

Three concerns were expressed with regard to 5G: 1. The stronger absorption of the very high frequencies involved require the setting up of vast numbers of antennae, making it essentially impossible to avoid damaging exposures. 2. The stronger absorption suggests that these EMFs may be particularly active in activating the VGCC voltage sensor. 3. The very high level and complexity of pulsations also may make for much more biological damage via VGCC activation.

There was substantial discussion of the need for biological safety testing. That discussion focused on the using cells in culture that have high densities and different types of VGCCs. Responses can be monitored by either monitoring intracellular calcium levels or by measuring nitric oxide production using a nitric oxide electrode.

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We had what would be considered in diplomatic circles a good and productive meeting, but since that time the FCC has doubled down on their positions, pushed much further on 5G, leading us to the mega-crisis situation which we are faced with now. Instead of actually testing 5G radiation biologically for safety, using the methods that were discussed in that meeting, the FCC has instead opted to put out tens of millions of 5G antennae without any biological safety testing of genuine 5G radiation. That is the insanity that we are in.

What About the FDA?

The Food and Drug Administration (FDA) was given the power to regulate devices that emit microwave frequency EMFs. This was not an unreasonable decision, given that the FDA was already regulating the safety of medical devices, where one can argue that there are similar challenges involved. The FDA was given this responsibility without any additional funding. So obviously, it was and is distinctly limited in what it can do.

What the FDA did was to issue a Letter of Intent for Proposed Collaboration in Mobile Phone Research between the Food and Drug Administration and the Cellular Telecommunications

Industry Association (CTIA), [129] Dated October 20, 1999. This would involve a Cooperative Research and Development Agreement (CRADA). Later in their Letter of Intent, it states under Initial Research Under the CRADA [129]: "The first study to be conducted would follow up on the findings of studies previously conducted by WTR but not yet published using the micronucleus assay, a test which detects structural effects on genetic material. Research data in the literature from RF exposure studies using the micronucleus assay are conflicting, and warrant follow-up study." You will see here that the FDA is accepting the industry claim that these studies are conflicting even though, having been done under different circumstances, they are not.

The basic approach of the CRADA was that the industry would fund any research to be done and decide what research should be done by whom and how and what information would be published subsequently.

You may recall that Dr. George Carlo wrote a very important letter to the heads of the telecommunications companies, described earlier. That letter was dated two weeks before the date of the letter or intent. Carlo's letter stated: "I am especially concerned about what appear to be actions by a segment of the industry to conscript the FCC, the FDA and WHO… ." Carlo who had been up to that point, an industry insider, and apparently had reason to think that the FDA had been corrupted, or what he called conscripted by parts of the telecommunications industry two weeks before the letter of intent was written. I don't think this is definitive evidence that the FDA has been corrupted, and it can even be argued that it is not evidence at all. But it does suggest, however, that we need to look further into this issue.

Let's go on to the results of this CRADA [130]. The FDA reports the following findings from the CRADA: "FDA's cooperative research and development agreement (CRADA) with the Cellular Communication & Internet Association (CTIA) has resulted in research projects focused on two topics - mechanistic studies related to genotoxicity and exposure assessment studies. All studies funded through the CRADA have been completed, and no association was found between exposure to radiofrequency (RF) radiation from cell phones and adverse health effects." I have been unable to get copies of these studies and therefore cannot comment on them.

The CRADA also lead to a National Academy of Sciences (NAS) workshop on EMFs that lead, in turn, to a 2008 NAS report. That 2008 NAS report can be accessed from [130]. It is a useful report, in my view, albeit one that leaves out much of what was already known in 2008. It does ***not*** say that there are no clear non-thermal effects and specifically calls for study of the neurological effects, suggesting that "that neural networks are a sensitive biological target." It also calls for much research on biophysical or biochemical molecular mechanism(s) that may lead to the non-thermal effects. It also calls for much more study on cancer. There has been a large amount of progress in each of these three areas since 2008, including of course the identification of VGCC activation as the most important but not necessarily the only biophysical mechanism. The problem with regard to the FDA is that as far as one can tell, the FDA has paid no attention to either the 2008 report or to the subsequent progress we have had in these several areas.

Let's shift our attention to what the FDA currently says about the impacts of these EMFs? On their web site [131], the FDA states the following:

Is there a connection between certain health problems and exposure to radiofrequency fields via cell phone use?

The results of most studies conducted to date indicate that there is not. In addition, attempts to replicate and confirm the few studies that did show a connection have failed.

According to current data, the FDA believes that the weight of scientific evidence does not show an association between exposure to radiofrequency from cell phones and adverse health outcomes. Still, there is a consensus that additional research is warranted to address gaps in knowledge, such as the effects of cell phone use over the long-term and on pediatric populations.

There was a similar statement made by the FCC, in previous section, and also similar statement was made by Samsung, one of world's largest producers of cell phones which reads a follows [132]:

Over the past 15 years, scientists have conducted hundreds of studies looking at the biological effects of radio frequency energy emitted by cell phones. While some researchers have reported biological changes associated with RF energy, these studies have failed to be replicated. The majority of studies published have failed to show an association between between exposure to radio frequency from a cell phone and health problems.

Neither the FDA statement nor the Samsung statement give us any idea what possible effects are being considered here, what literature was used for such a consideration. These statements are completely undocumented and therefore must be viewed as being unscientific. In Chapter 1, 79 reviews were given that each showed the existence of one or more effects. Eignt different of effects were each documented in from 12 to 35 reviews. Such reviews must be extensively documented or one cannot get them published. Any one of those reviews provides, therefore, a much stronger argument for presence of one or more effects than do the FDA, FCC and Samsung statements put together arguing for the opposite. One thing that is strange about the FDA statement is that they are talking specifically about cell phones even though they are tasked with regulating safety on all such microwave/radiofrequency devices. What I have done below is to put together the 16 reviews which are completely or largely focused on cell phone radiation effects so that we can see what specific effects have been found to be caused by cell phone radiation. I will summarize those effects below.

Table 5: Reviews on Cell Phone Effects and the Effects Found in Each

Review on Cell Phone Effects	Effects Found
La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. 2012 Effects of the exposure to mobile phones on male reproduction: a review of the literature. J Androl 33:350-356.	Multiple effects on male reproduction
Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.	Cellular DNA damage, neurological/neuropsychiatric effects, apoptosis
Yakymenko IL, Sidorik EP, Tsybulin AS. 1999 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999), 2011 Mar-Apr:20-28.	Apoptosis, increased oxidative stress, increased intracellular calcium
K Sri N. 2015 Mobile phone radiation: physiological & pathophysiological considerations. Indian J Physiol Pharmacol 59:125-135.	Male infertility, cellular DNA damage, lowered melatonin, increased stress protein expression
Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. 2013 Recent reports of Wi-Fi and mobile phone-induced	Oxidative stress, male and female reproductive signaling dysfunction

radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol 246:869-875.	
Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.	Cancer, cellular DNA damage, apoptosis; higher cancer incidence on ipsilateral side of the head, not contralateral
Zhang J, Sumich A, Wang GY. 2017 Acute effects of radiofrequency electromagnetic field emitted by mobile phone on brain function. Bioelectromagnetics 38:329-338. doi: 10.1002/bem.22052.	Neurological dysfunction
Kundi M, Mild K, Hardell L, Mattsson M. 2004 Mobile telephones and cancer – a review of the epidemiological evidence. J Toxicol Env Health, Part B 7:351-384.	Cancer – epidemiological review
Hardell L, Carlberg M, Soderqvist F, Hansson Mild K. 2008 Meta-analysis of long-term mobile phone use and the association with brain tumors. Int J Oncol 32:1097-1103.	Cancer – meta-analysis on long-term cell phone use and brain tumors
Hardell L, Carlberg M. 2013 Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. Rev Environ Health 28:97-106. doi: 10.1515/reveh-2013-0006.	Mobile and cordless phone radiation caused brain cancer based on the Hill criteria for causation (most important criteria for causation in epidemiology)
Hardell L, Carlberg M, Hansson Mild K. 2013 Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. Pathophysiology 2013;20(2):85-110.	Mobile and cordless phone exposures associated with increased risk of glioma and acoustic neuroma; higher cancer increase on ipsilateral side of the head
Davis DL, Kesari S, Soskolne CL, Miller AB, Stein Y. 2013 Swedish review strengthens grounds for concluding that radiation from cellular and cordless phones is a probable human carcinogen. Pathophysiology 20:123-129.	Cell phone and cordless phone radiation are a probable carcinogens; cancer increase on ipsilateral side of the head, not contralateral side
Morgan LL, Miller AB, Sasco A, Davis DL. 2015 Mobile phone radiation causes brain tumors and should be classified as a probable human carcinogen (2A). Int J Oncol 46(5): 1865-1871.	Mobile phone radiation causes brain tumors and should be classified as a probable human carcinogen
Bielsa-Fernández P, Rodríguez-Martín B. 2017 [Association between radiation from mobile phones and tumour risk in adults]. Gac Sanit. 2017 Apr 12. pii: S0213-9111(17)30083-3. doi: 10.1016/j.gaceta.2016.10.014.	Association between mobile phone risk and tumor risk
Prasad M, Kathuria P, Nair P, Kumar A, Prasad K. 2017 Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes. Neurol Sci. 2017 Feb 17. doi: 10.1007/s10072-017-2850-8.	The association between mobile phone use and brain cancer is higher in independently funded studies than in industry funded studies
Miller A. 2017 References on cell phone radiation and cancer. https://ehtrust.org/references-cell-phone-radio-	This is a bibliography of studies on cell phone radiation and cancer – most

frequency-radiation-cancer/ (Accessed Sept. 9, 2017)	support the view that cell phones do cause cancer

The effects of specifically cell phone radiation that have been found in these reviews (Table 5) include: lowered male reproductive function, lowered female reproductive function, increased cellular DNA damage, neurological/neuropsychiatric effects, increased stress protein synthesis, increased intracellular calcium, apoptosis, lowered melatonin, oxidative stress, cancer (10 reviews) and specifically increased ipsilateral cancer (3 reviews). So there are 11 different cell phone effects where there is substantial enough evidence to warrant publication in one or more review articles. Each of these effects has been shown to occur in response to other microwave frequency EMFs and therefore should be considered to be caused by EMFs more broadly.

The summary of Table 4, Chapter 5, the genuine cell phone primary literature studies that fell into the 2009-2013 time frame, started as follows: "If you look through the studies described in Table 4, you will see multiple studies in oxidative stress/free radical damage, on changes in tissue structure (sometimes called remodeling), on cellular DNA damage, on male fertility (and also one on female fertility), on behavioral changes and on neurological changes. There is also one study on insulin/type 2 diabetes (hormonal effect). It follows from this that five of the effects that were extensively documented in large numbers of reviews (Chapter 1) are further demonstrated to be produced by cell phone radiation in these studies. In addition the tissue remodeling and proteomic changes discussed in Chapter 3 are also further demonstrated here."

It can be seen from Tables 4 & 5 and the preceding two paragraphs, that there is a vast amount of literature on repeatedly found effects of cell phone radiation, effects which make a mockery of the *completely undocumented and non-specific* FDA claims to the contrary.

Let's look at another part of the FDA statement which also shows similarities to statements made elsewhere [131]:

The biological effects of radiofrequency energy should not be confused with the effects from other types of electromagnetic energy.

Very high levels of electromagnetic energy, such as is found in X-rays and gamma rays can ionize biological tissues. Ionization is a process where electrons are stripped away from their normal locations in atoms and molecules. It can permanently damage biological tissues including DNA, the genetic material.

The energy levels associated with radiofrequency energy, including both radio waves and microwaves, are not great enough to cause the ionization of atoms and molecules. Therefore, RF energy is a type of non-ionizing radiation. Other types of non-ionizing radiation include visible light, infrared radiation (heat) and other forms of electromagnetic radiation with relatively low frequencies.

This is almost identical to another Samsung statement and also to an FCC statement that I have not copied. Here is the Samsung statement [133]:

The biological effects of RF energy should not be confused with the effects from other types of electromagnetic energy.

Very high levels of electromagnetic energy, such as is found in X-rays and gamma rays, can ionize biological tissues. Ionization is a process where electrons are stripped away from their normal locations in atoms and molecules. It can permanently damage biological tissues including DNA, the genetic material.

The energy levels associated with radio frequency energy, including both radio waves and microwaves, are not great enough to cause ionization of atoms and molecules. Therefore, RF energy is a type of non-ionizing radiation. Other types of non-ionizing radiation include visible light, infrared radiation (heat), and other forms of electromagnetic radiation with relatively low frequencies.

While RF energy does not ionize particles, large amounts can increase body temperatures and cause tissue damage. Two areas of the body, the eyes and the testes, are particularly vulnerable to RF heating because there is relatively little blood flow in them to carry away excess heat.

The three paragraphs from the FDA statement are word for word identical to the first three paragraphs of the Samsung statement. The last paragraph in the Samsung statement was deleted from the FDA statement. It is clear from this that either the FDA statement is derived from the earlier industry statement rather than the other way around or both are derived from a previous statement similar to the Samsung statement.

These types of statements have given rise to shorter statements that are all something like the following:

Non-ionizing radiation consists of photons that do not have enough energy to break chemical bonds including the chemical bonds of DNA.

All of these statements are technically correct. They are also highly misleading. They are often falsely interpreted as meaning that there cannot be any effects of non-ionizing, non-thermal EMF exposures ***including indirect effects***. There are many possible indirect effects that may occur, given the complexity of biology. But our situation goes way beyond that, because we know that most of the effects are produced via VGCC activation which produces, as downstream effects, the free radical breakdown products of peroxynitrite (Fig. 1, Chapter 2). Those free radical breakdown products attack DNA, proteins and other biological constituents in ways that are very similar to the ways in which ionizing radiation attack these same molecules. Ionizing radiation was shown by Arthur Compton, who won the Nobel prize in physics in 1927, for showing that ionizing radiation produces large numbers of free radicals through what has become known as Compton scattering, with those free radicals being responsible for most of the biological effects of ionizing radiation. So the often repeated industry claim that ionizing radiation is dangerous but non-ionizing radiation is not, <u>is wrong</u> – both of them produce similar effects mediated through free radical generation. However the dangers of non-ionizing radiation may eclipse the dangers of ionizing radiation under some conditions because of something that is discussed early in Chapter 5, at the end of the Speit/Schwarz discussion. There are three processes which occur in the sequence by which EMF activation leads to peroxynitrite breakdown product radicals, each of which have high levels of amplification (each discussed on p. 29 in Chapter 5). Thus potentially and I believe actually microwave frequency EMFs can produce under suitable conditions, much more efficient free radical production than occurs from a similar energy level of ionizing radiation.

The FDA may have had a long history of playing fast and loose with the truth. For example, Microwave News article published in 2003, provides this account of what occurred at the FDA in 1993 [134]:

1993 FDA Memo Data "Strongly Suggest" Microwaves Can Promote Cancer.

In the spring of 1993 at the height of the public concern over cell phone brain tumor risks, the Food and Drug Adminstration (FDA) biologists concluded [134] that the available data "strongly suggest" that microwaves can "accelerate the development of cancer." This assessment is from an internal agency memo recently obtained by Microwave News under the Freedom of Information Act.

"Of approximately eight chronic animal experiments known to us, five resulted in increased numbers of malignancies, accelerated progression of tumors, or both" wrote Drs. Mays Swicord and Larry Cress of FDA's Center for Devices and Radiological Health (CDRH) in Rockville, MD. They also pointed to other evidence from laboratory (in vitro) studies which supported cancer risk.

Yet in its public statements at that time, the agency played down these findings [134]. For instance in a Talk Paper issued in early February, the FDA stated that there was "limited evidence that suggests that lower levels (of microwaves) might cause adverse effects."

"A few studies suggest that (microwave) levels (from cellular phones) can accelerate the development of cancer in laboratory animals," the FDA added [134], "but there is much uncertainty among scientists about whether these results apply to the use of cellular phones."

I have three comments. Firstly, if you look at the 35 citations in the list on cancer causation in Chapter 1, you will see that there are 8 citations (#s 2-7 & 15 & 19) which provide similar evidence of stimulation of tumor promotion, four of which (#s 3-6) were published around 1993, the time of the FDA memo and public statement described above. Therefore, there was a substantial literature including peer-reviewed primary literature and review articles which produced similar conclusions to those of the FDA internal memo. The importance of the memo is that the FDA knew about these findings and opted to cover them up.

Secondly if you compare the rhetoric in the 1993 memo with the first quote from the current FDA web site quoted in this section, you will see some striking similarities. They both first refer to "a few studies" which are not identified, followed by raising uncertainties and then finally raising doubt as to whether these findings apply to cell phone radiation. The pattern of the FDA rhetoric has not changed much in 25 years.

If one includes the middle statement also quoted from the FDA web site, we have three FDA statements each of which downplays any biological effects and each of which are strongly rebutted by extensive peer-reviewed independent scientific literature. I'm not sure we can say the FDA has been corrupted by the industry, but what we can say is that it has been functioning as if it has been corrupted for 25 years.

In mid-2009 Margaret A. Hamburg, the new commissioner of the FDA, and Joshua M. Sharfstein, her principal deputy commissioner, published a commentary article in the New England Journal of Medicine [135] which included the following:

"One of the greatest challenges facing any public health agency is that of risk communication. … The FDA's job is to minimize risks through education, regulation, and enforcement. To be credible in all these tasks, the agency must communicate frequently and clearly about risks and benefits—and about what organizations and individuals can do to minimize risk. When, like the FDA, Americans must make choices about medication, devices, foods, or nutrition in the absence of perfect information, the FDA cannot delay in providing reasonable guidance —guidance that informs rather than causes unnecessary anxiety. For these communications to have credibility, the public must trust the agency to base its decisions on science."

These were and are laudable goals. As far as I can tell, with regard to EMF effects, the FDA has failed to base either its communications or its decisions on science.

Summary of Chapter 6

In the areas discussed in Chapter 6 what used to be the primacy of U.S. science has completely disintegrated. It has disintegrated because of the cessation of U.S. government funding for either experimental studies or epidemiological studies. It has disintegrated due to attacks on U.S. and International scientists, attacks that started in the U.S. with the attacks on Dr. Henry Lai. It has disintegrated because of aggressive industry propaganda, propaganda that has no connection with the real science. It has disintegrated because of the outright corruption of the committee to set standards for radio-frequency exposures and the FCC and the possible and *de facto* corruption of the FDA. The telecommunications industry has been aware of much of the problems with their approach since the 1999 letter to them from George Carlo. The FCC has been aware of much more of the science since my presentation to them in September 2016. The FDA has been aware of contrary findings since 1993. Each of them has, if anything, doubled down on their fictions since those respective times.

Many of these things are going on internationally; however the U.S. has often been leading the world in these processes. All of the actions we have seen to corrupt the science and public understanding of the science have the effect of making it vastly more difficult for individuals impacted by the EMFs to protect themselves from further harm. We have many effects that are cumulative and become irreversible as they become more severe, effects that impact at a minimum, tens of millions of Americans and hundreds of millions of people elsewhere in the world. *Industrial and regulatory organizations make it difficult or impossible for people to have scientifically valid information also make it difficult or impossible for people to protect themselves from the accumulation of these effects, leading to severe irreversible effects. Each of the organizations involved, both U.S. and international that collaborate in this process, have important responsibility for the consequences.* I think damage goes way beyond tens and hundreds of millions of people, because I think we are looking at cumulative severe impact on our brain function, on our reproductive function and on our DNA, and that these, in turn will lead to the crash of every single technologically advanced country on earth, barring a major change in course. That will happen fairly quickly, in my opinion, even without 5G but 5G will greatly speed up the process and perhaps even add new egregious effects

Chapter 7: The Great Risks of 5G: What We Know and What We Don't Know

We have already discussed two issues that are essential to understanding 5G. One is that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (often called

continuous wave) EMFs. A second is that the EMFs act by putting forces on the voltage sensor of the VGCCs, opening these calcium channels and allowing excessive calcium ions to flow into the cell. The voltage sensor is extraordinarily sensitive to those electrical forces, such that the safety guidelines are allowing us to be exposed to EMFs that are something like 7.2 million times too high.

The reason that the industry has decided to go to the extremely high frequencies of 5G is that with such extremely high frequencies, it is possible to carry much more information via much more pulsation than it is possible to carry with lower frequencies even in the microwave range. We can be assured, therefore, that 5G will involve vastly more pulsation than do EMFs that we are currently exposed to. It follows from that, that any biological safety test of 5G must use the very rapid pulsations including whatever very short term spikes may be present, that are to be present in genuine 5G. There is an additional process that is planned to be used in 5G: phased arrays (https://en.wikipedia.org/wiki/Phased_array). Here multiple antenna elements act together to produce highly pulsed fields which are designed for 5G, to produce increased penetration. 5G will entail particularly powerful pulsations to be used, which may, therefore, be particularly hazardous.

The only data we have, to my knowledge, on millimeter wave frequencies of 5G used *non-pulsed EMFs in the millimeter frequency range of 5G, not genuine 5G*. Such millimeter waves have been shown to produce a number of downstream effects of VGCC activation. One millimeter wave study showed that it activated both the VGCCs and also the voltage-gated potassium channels, suggesting that it worked via the voltage sensor, as do other EMFs [136]. Any such data tells us almost nothing about how biologically active genuine very highly pulsed 5G will be. I take it that from their statements, that both Mr. Ryan and Dr. Vinciūnas are ready to put out 10s of millions of 5G antennae to afflict every single person in the EU with 5G radiation without even a single biological test of safety of genuine 5G. In the U.S., the FCC has taken a much worse position. The FCC is not only willing to allow such completely untested exposures but has also been has been aggressively pushing to promote installation of 5G antennae, such that antennae are already being installed in parts of the U.S. In a world where shocking behavior has become less and less shocking, I consider EU and U.S. views and actions to be shocking. The U.S. situation is mass insanity. I would have hoped that the Europeans, who think of themselves as being much more thoughtful than Americans, would have been genuinely more thoughtful.

Why does 5G need such high numbers of antennae? It is because the 5G radiation is much more absorbed as it enters various materials. The approach is to use many more antennae with one found every few houses, such that 5G can sufficiently penetrate local walls. Such absorption usually involves the interaction with electrically charged groups, such that such high absorption is likely to involve placing forces on electrically charged groups. Because such forces are the way in which EMFs activate the VGCCs, it seems highly likely, therefore, that 5G radiation will be particularly active in VGCC activation.

In summary, then, 5G is predicted to be particularly dangerous for each of four different reasons: 1. The extraordinarily high numbers of antennae that are planned. 2. The very high energy outputs which will be used to ensure penetration. 3. The extraordinarily high pulsation levels. 4. The apparent high level interactions of the 5G frequency on charged groups presumably including the voltage sensor charged groups.

Now what the telecommunications industry argues is that 5G radiation will be mostly absorbed in the outer 1 or 2 mm of the body, such that they claim that we don't have to worry about the effects. There is some truth to that, but there are also some caveats that make any conclusions

made from that, much more suspect. In any case, these surface effects of 5G will have especially strong impact on organisms with much higher surface to volume ratios. Consequently, I predict that many organisms will be much more impacted than we will. This includes insects and other arthropods, birds and small mammals and amphibia. It includes plants including even large trees, because trees have leaves and reproductive organs that are highly exposed. I predict there will be major ecological disasters as a consequence of 5G. This will include vast conflagrations because EMF exposures make plants much more flammable.

But let's get back to humans. The industry has also made claims that more conventional microwave frequency EMFs are limited in effect to the outer 1 cm of the body. We know that is not true, however because of the effects deep in the human brain, on the heart and on hormone systems. Perhaps the most important two studies demonstrating effects deep within the body are the studies of Professor Hässig and his colleagues in Switzerland on cataract formation in newborn calves [137,138]. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (also called cell phone towers), the calves are born with very greatly increased incidences of cataracts. It follows from these findings that even though the developing fetuses are very deep in the body of the mother and should be highly protected from the EMF exposures, they are not so protected. And because the EMF safety guidelines in Switzerland are 100 times more stringent than are the safety guidelines in most of the rest of Europe, in the U.S., Canada and most of the rest of the world, the more general safety guidelines allow greatly excessive exposures and penetration of effects. The claims of industry that microwave frequency EMFs only act in the outer centimeter of the body are clearly false.

How then can both conventional microwave frequency EMFs and 5G radiation act deeply within the body? You may correctly observe that the electrical effects of the EMFs activate the voltage sensor and that the direct electrical forces are rapidly attenuated in the body. So how can we get deep effects? I think the answer is that the magnetic parts of the EMFs have been known for decades to penetrate much more deeply than do the electrical parts. The magnetic fields put forces on mobile electrically charged groups dissolved in the aqueous phases of the body and small individual movements of the charged groups can regenerate electric fields that are essentially identical to the electric fields of the original EMFs, carrying the same frequency and same pulsation pattern, although with lower intensity. An example of this is given in the Lu and Ueno [139] study. Because the voltage sensor is so stunningly sensitive to electrical forces and part of the reason for that is the very high level of amplification of the electrical field across the plasma membrane, we have an almost perfect way in which to produce EMF effects deeply within our bodies.

I am very concerned that 5G may produce effects like those we already see produced from lower frequency EMFs but are much more severe. I am also concerned that we will also see responses that are qualitatively different. Let me give you three possible examples of the latter type and one quantitative example. Each of the four types of blindness, have downstream effects of VGCC activation as causal factors: cataracts, detached retinas, glaucoma and macular degeneration. The aqueous and vitreous humors in the eye may be an ideal environment for the regeneration of the electrical fields within the eye. We may, therefore have a gigantic epidemic of each of the four types of blindness. Another concern focuses on kidney dysfunction, which was shown in Chapter 5 to be impacted by EMFs. The kidneys have much fluid, both blood and also what will become urine, which may allow efficient the regeneration of electrical fields. Such regeneration may be expected to impact both the glomerular filtration and also the reabsorption, both essential to kidney function. Does this mean that 5G will produce very large increases in kidney failure? The only way to find out is to do biological safety testing of genuine 5G radiation. Let me give you a third example. Fetuses and very young babies have much more water in their bodies than do

adults. Therefore, they may be a special risk for impacts of 5G, because of great increases in the regeneration of the electrical fields. Here one can think of all kinds of possibilities. Let me suggest two. We may have a gigantic (sorry about using that word again) epidemic of spontaneous abortion due the teratogenic effects. Another possibility is that instead of autism being one birth in 38, however horrendous that is, it could be one out of two, or even a majority of births. I don't know that these will happen, but these are the kinds of risks we are taking and there are many others one can think of. Putting in tens of millions of 5G antennae without a single biological test of safety has got to be about the stupidest idea anyone has had in the history of the world.

This brings us back to the earlier point. The only way to do 5G safety testing is to do genuine 5G biological safety testing. I have published on how this can be done relatively easily at relatively low cost and have, as you saw in the Chapter 6, told the FCC how this can be done. Those tests must be done by organizations completely independent of industry and that leaves out both ICNIRP and SCENIHR and a lot of other organizations.

Now we will get into the precautionary principle which is specially relevant to the EU but may have lessons for all of us.

Dr. Vinciūnas' last full paragraph reads as follows: "The recourse to the EU's precautionary principle to stop distribution of 5G products appears too drastic a measure. We need first to see how this technology will be applied and how the scientific evidence will evolve. Please be assured that the Commission will keep abreast of the scientific evidence in view of safeguarding the health of European citizens at the highest level possible and in line with its mandate."

Article 191 defines the **Precautionary Principle** as follows:

"According to the European Commission the precautionary principle may be invoked when **a phenomenon, product or process may have a dangerous effect**, identified by a **scientific and objective evaluation**, **if this evaluation does not allow the risk to be determined with sufficient certainty**.

Recourse to the principle belongs in the general framework of **risk analysis** (which, besides risk evaluation, includes risk management and risk communication), and more particularly in the context of **risk management** which corresponds to the decision-making phase.

The Commission stresses that the precautionary principle may only be invoked in the event of a potential risk and that it can never justify arbitrary decisions.
The precautionary principle may only be invoked when the **three preliminary conditions** are met:

identification of potentially adverse effects;
evaluation of the scientific data available;
the extent of scientific uncertainty."

The question now is what about 5G? We have with 5G strong suspicions of similar or much more severe risk of effects documented elsewhere in this document. We have no biological safety testing of genuine 5G radiation. Therefore, we have no risk analysis or risk management because we have no risk assessment whatsoever on 5G. So here we have Dr. Vinciūnas arguing that the request for precautionary principle application is premature. But it is not the request for

the use of the precautionary principle that is premature, it is the Commission's claim that it has done the required risk analysis and risk assessment. This is the bizarre world that we live in.

The European Commission has done nothing to protect European citizens from the very serious health hazards and the U.S. FDA, EPA and National Cancer Institute have done nothing to protect U.S. citizens. The U.S. FCC has been worse than that, acting in wanton disregard for our health.

Let me close, as follows. There have been certain points in our history where people have stood up to strong destructive forces against what often appeared to be insurmountable odds. Those people are THE most honored people in our history. The people who failed to do so are among the most despised people in our history. I am not at all sure we will have historians to record us 100 years from now or even 30 years from now, given the direction in which we are heading. But if we do, rest assured that these are the standards by which we will all be judged.

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Response to 2018 ICNIRP Draft Guidelines and Appendices on Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (100 kHz to 300 GHz)

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8 October 2018

Comments from signatories

I have EHS. Life has become horrible because of all the cell phones and WiFi everywhere. Life will become intolerable if 5G rolls out. I may decide to end my life because life will not be worth living if there is no safe place to live. We are living in a technological insane world where health is not considered in the roll-outs of new technology.

My husband had epileptic seizures only when exposed to Wi-Fi, mobile phones and cell phone towers. He died in February 2018 as we did not have enough money to shield the house completely from rising radiation from Grand Mal and subsequent brain bleeding.

After installation of a smart meter, I began to experience debilitating muscle weakness. The condition reversed with the removal of the smart meter.

Current levels of electrosmog are preventing some children from sleeping, speaking and learning. Increasing levels of wireless radiation further with 5G is a serious mistake.

I have been suffering with EMR-Interference Syndrome, beginning around 1985 for 7 years (Wi-Fi hearing, which would go away when out of the city) and then 2009 to present (the same Wi-Fi hearing - 1 pure tone 90% of the time, other frequencies here & there for a few seconds at a time & the HUM, heard round the world when people are using natural gas!!!!????? A total of 15 years!!! PLEASE HELP!!!!!

People in the U.S. have more environmentally induced diseases than any nation, including our children! Corporations knowingly allow harm via unconscionable deceit. No studies support 5G! Many studies demonstrate the life-altering damage from our daily bombardment by unseen waves. We must limit exposure. We must protect our brains, our bodies, our DNA. Moratorium on all 5G and limit and reduce our current exposures for the good of our living earth and its inhabitants.

Health damaged by RFR/EMR in my own home due to two smart meters on my property installed without my knowledge or consent. Now that my utility has been made aware that their meters caused me to become electromagnetically hypersensitive, they refuse to remove and replace with safer analog meters. I have been sleeping in my vehicle each night for nearly two years. I am very concerned about 5G and feel that it MUST be tested for safety before it is unleashed on an uninformed public. The science is clear, there are cumulative negative health effects caused by non-ionizing RF radiation and we should have some say to whether we want to be radiated 24/7 inside our own home. Enough already how this is going to be great for the economy; public health matters more.

The guidelines must be set this time without ignoring the thousands of papers that demonstrate harm, otherwise we may reach a point where the human race becomes unviable. Never has such an important decision been in the hands of so few people.

Since a cellular telephony base station was built outside my house I have suffered increasing sensitivity to EMF, which has become almost entirely debilitating. This is NOT nocebo, as I began suffering the symptoms several months before I knew about the base station. When the medical report came back clear, I began looking for other reasons for my condition, and discovered the research on EMF sensitivity, which matched my symptoms. Biomarkers tests have confirmed this diagnosis.

I developed EHS after an exterminator used a banned commercial fungicide Calo-Clor (mercuric chloride) to kill carpenter ants in 1997. My body can't take any more trauma. Please let me heal!

I am a very concerned mother and grandmother. I want my son, daughter-in-law, and their children to live long, healthy lives. I have suffered from an invisible illness called Multiple Chemical

Sensitivity (MCS) for 26 years. It cost me my career and most of my personal freedom. I do not want to add a second severe illness, electrohypersensitivity (EHS) to my already very limited life.

Is there really any data showing safety or subjective "absence of harm", which is not the same thing?

Massachusetts is leading the U.S. with nine bills to address man-made radiation and public health: https://sites.google.com/site/understandingemfs/ma-emf-bills. Please ensure non-thermal, biologically-based public radiation exposure limits established in the non-industry-funded scientific literature.

Risk assessment for radio frequency exposure must include toxicology and medical sciences as part of the evaluation process.

These safety guidelines are a rational and necessary first step toward recognizing the clear and present dangers of, and regulating an out-of-control, beyond hazardous, profit-driven industry.

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Response to 2018 ICNIRP Draft Guidelines and Appendices on Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (100 kHz to 300 GHz)

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Contents

I. Introduction

Scientific documents such as this ICNIRP draft document and its two associated appendices must:

- Be shown to be science-based on several widely accepted principles
- Provide an objective assessment of the scientific literature
- Use clear logic in making inferences or coming to conclusions
- Contain statements supported by citations or provide information, such that the reader can assess whether or not those statements are likely to be valid
- Contain scientific statements that are testable and falsifiable, such that it should be obvious how such statements can be falsified by the reader.

When we have documents where the health and safety of essentially every single human being on earth may be at risk and the health and safety of many other living beings and whole ecosystems may be at risk, such as in this ICNIRP draft document and its appendices, it is especially important that these principles be followed. Accordingly, the following must be viewed as very serious flaws in the ICNIRP draft document and its two appendices.

II. Serious flaws in 2018 ICNIRP draft guidelines and appendix B

1. The biological portions of these ICNIRP drafts (see appendix 1) have 64 different claims for which no evidence is provided. Each of these 64 claims should be documented in terms of the larger scientific literature, not just by cherry picking one or a few studies that can be claimed to support the ICNIRP position. This is particularly important because there is a very large literature contradicting many of these claims.

2. Among the most egregious claims are the undocumented claims that certain EMF effects have no demonstrated health impacts. It is our belief that most, if not all, EMF effects have demonstrated health impacts, as shown by the biomedical scientific literature. Claims of no demonstrated health impacts must, therefore, be based on an extensive review of the biomedical literature on what health effects, if any, are produced by each EMF effect.

3. The conditions used in a study determine what results are obtained. Therefore, a study done under one set of conditions cannot conflict with or show inconsistencies with another done under another set of conditions. The only way to show conflicts or inconsistencies is to do identical studies and produce different results. ICNIRP and other similar organizations often suggest that there are conflicts or inconsistencies based on some superficial similarities, while providing no evidence whatsoever that any such inconsistencies actually exist. This is, therefore, a fundamental logical flaw that needs to be corrected in the ICNIRP draft.

4. A number of specific issues derived from appendix 1 of this document are dealt with below. These include both the biological parts of the ICNIRP draft and various critiques of it. The following 14 critiques are considered particularly important and are therefore singled out for comment here.

III. Critiques of biological parts of ICNIRP draft

1. Neurological and/or neuropsychiatric effects that occur at microwave frequencies

ICNIRP claims that frequencies above 10 MHz are not known to stimulate nerves. However, 27 different reviews listed in appendix 2 show that there are neurological and/or neuropsychiatric effects that occur at microwave frequencies. This claim is therefore false and must be deleted.

2. Non-thermal effects of microwave frequency electromagnetic fields (EMFs)

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation):

> "For very low exposure levels (such as within the ICNIRP (1998) basic restrictions), there is extensive evidence that the amount of heat generated is not sufficient to cause harm, but for exposure levels above those of the ICNIRP (1998) basic restriction levels, yet below those shown to produce harm, there is still uncertainty."

ICNIRP provides no evidence for this claim, which is falsified by each of the 89 reviews listed in appendix 2. If ICNIRP wishes to argue against those findings, it should first cite each review, discuss in detail the findings reported and then attempt to rebut each of those 89 bodies of evidence.

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation):

> "Where there is good reason to expect health impairment at temperatures lower than those shown to impair health via radiofrequency EMF exposure, ICNIRP uses those lower temperatures to base limits on."

No evidence is provided to support this claim. Again, this statement clearly appears to be false based on those same 89 bodies of evidence.

3. Electromagnetic hypersensitivity or EHS

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "A small portion of the population attributes non-specific symptoms to various types of radiofrequency EMF exposure; this is referred to as Idiopathic Environmental Intolerance attributed to EMF (IEI-EMF). Double-blind experimental studies have consistently failed to identify a relation between radiofrequency EMF exposure and such symptoms in the IEI-EMF population, as well as in healthy population samples. These human experimental studies provided evidence that 'belief about exposure' (e.g. the so-called 'nocebo' effect), and not exposure itself, is the relevant symptom determinant."

No evidence is provided in support of these assertions. The accepted name for what ICNIRP calls "IEI-EMF" is "electromagnetic hypersensitivity" or EHS and there is much information about it in the scientific literature. It has been shown in four studies that it is possible to identify people with apparent EHS and show that they can be tested in blinded fashion using objectively measurable responses, showing that they are genuinely hypersensitive when compared with normal controls. The four studies are:

1. Rea WR, Pan Y, Yenyves EJ, Sujisawa I, Suyama N, Ross GH. 1991. Electromagnetic field sensitivity. J Bioelectr 10:241-256.
2. Havas M. 2006 Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. Electromagn Biol Med 2006;25(4):259–68.
3. Havas M, et al. 2010 Provocation study using heart rate variability shows microwave radiation from DECT phone affects autonomic nervous system. In: Giuliani L, Soffritti M, editors. "Non-thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter", European J Oncology — Library. National Institute for the Study and Control of Cancer and Environmental Disease Bologna: Mattioli; 2010. pp. 273–300. 2010.
4. McCarty DE, et al. 2011 Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. www.ncbi.nlm.nih.gov/pubmed/21793784. 2011 Sep 5.

There are other studies that show that there are genuine physiological changes occurring in EHS. Two studies have shown that EHS people have high levels of oxidative stress:

1. De Luca C, Raskovic D, Pacifico V, Thai JC, Korkina L. 2011 The search for reliable biomarkers of disease in multiple chemical sensitivity and other environmental intolerances. Int J Environ Res Public Health. 2011 Jul;8(7):2770-97. doi: 10.3390/ijerph8072770.
2. Irigaray P, Caccamo D, Belpomme D. 2018 Oxidative stress in electrohypersensitivity self-reporting patients: Results of a prospective *in vivo* investigation with comprehensive molecular analysis. Int J Mol Med. 2018 Oct;42(4):1885-1898. doi: 10.3892/ijmm.2018.3774.

The De Luca et al. citation also showed that genetic polymorphisms in genes encoding enzymes for glutathione utilization produce increased susceptibility to EHS. These findings show that oxidative stress and lowered chemical metabolism have roles in causing EHS and that the ICNIRP claim that it is caused by a nocebo effect is again falsified.

Furthermore, it has been shown using fMRI that there are regions of the brain in EHS people who are especially sensitive to EMF stimulation:

> Heuser G, Heuser SA. 2017 Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 2017 Sep 26;32(3):291-299. doi: 10.1515/reveh-2017-0014.

It can be seen from this that EHS is a genuine hypersensitivity condition with major sensitivity responses in the brain. Consequently, not only is what ICNIRP says in this area undocumented, but also each of the ICNIRP claims is also false.

4. Associations between exposure and symptoms or well-being

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "In studies on transmitters, no consistent associations between exposure and symptoms or well-being were observed when objective measurements of exposure were made, or when exposure information was collected prospectively."

No evidence is provided in support of this assertion.

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "In studies on mobile phone use, associations with symptoms and problematic behavior have been observed. However, these studies can generally not differentiate between potential effects from radiofrequency EMF exposure and other consequences of mobile phone use, such as sleep deprivation in adolescents using the mobile phone at night."

No evidence is provided in support of this claim.

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "Overall, the epidemiological research does not provide evidence of a causal effect of radiofrequency EMF exposure on symptoms or well-being."

No evidence is provided in support of this claim. The same 26 reviews on neurological/neuropsychiatric effects that were referred to above also falsify these ICNIRP claims regarding cell phone effects. Similar effects were found, including sleep disruption, fatigue, headache, memory dysfunction, depression, lack of concentration, anxiety, sensory dysfunction and several others. These were found to be produced by many different types of EMF exposures. These included radar, other occupational exposures, three types of broadcast radiation, heavy cell phone use, living near cell phone towers and microwave radiation of the US

embassy in Moscow. Clearly these are not caused by behavioral changes specific for cell phone use, as ICNIRP argues here. When these problems are becoming almost universal in every single technologically advanced country on earth, surely it is time for ICNIRP to start protecting us from them.

5. High frequency EMF exposure affects symptoms

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "There is thus no evidence that high frequency EMF exposure affects symptoms, except for pain (and potentially tissue damage) at high exposure levels."

No evidence is provided in support of this claim. It is shown to be completely untrue by the 27 reviews on neurological/neuropsychiatric effects previously discussed.

6. Physiological functions and adverse health effects

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions):

> "A number of studies of physiological functions that could in principle lead to adverse health effects have been conducted, primarily using *in vitro* techniques. These have included multiple cell lines and assessed such functions as intra- and intercellular signaling, membrane ion channel currents and input resistance, Ca^{2+} dynamics, signal transduction pathways, cytokine expression, biomarkers of neurodegeneration, heat shock proteins, and oxidative stress-related processes. Some of these studies also tested for effects of co-exposure of radiofrequency EMF with known toxins. Although some effects have been reported for some of these endpoints, there is currently no evidence of effects relevant to human health."

No evidence is provided in support of these claims. Is ICNIRP really trying to argue that important signaling pathways, excessive intracellular calcium, inflammation including inflammatory cytokines, neurodegeneration, heat shock responses and oxidative stress have "no relevance to human health"? If so, ICNIRP needs to debunk hundreds of thousands of studies in the PubMed database.

7. Evidence of eye damage

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions):

> "Some evidence of superficial eye damage has been shown in rabbits at exposures of at least 1.4 kW m^{-2}, although the relevance of this to humans has not been demonstrated."

Why does ICNIRP state that there is no evidence of human relevance but never tells us if there is any evidence that the findings are not relevant to humans? If there is simply a lack of evidence, then the way ICNIRP describes this speaks to an unconscionable bias on the part of ICNIRP. With human relevance, as with all things, absence of evidence is not evidence of absence.

8. Endocrine, including neuroendocrine systems, impacted by non-thermal EMF exposures

In contrast with the many ICNIRP statements with no evidence provided, the endocrine, including neuroendocrine systems, have been widely found to be impacted by non-thermal EMF exposures as shown by the following 12 reviews:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised.

https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
2. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by B Haigh. Consultants Bureau, New York/London, 146 pages.
3. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.
4. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
5. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
6. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1
7. Pall, M. L. 2015. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116.
8. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
9. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
10. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.
11. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
12. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to disagree with the findings in these reviews, it should cite each of these reviews and describe what findings were documented in each of them. Only then could ICNIRP feel free to disagree with any conclusions reached. Ignoring vast amounts of contrary data and opinion undercuts any claim that ICNIRP may make to providing unbiased science.

9. Neuronal cell death following non-thermal EMF exposures

2018 ICNIRP draft guidelines, appendix B, chap. 5 (Neurodegenerative Diseases):

> "Although one group has reported that exposure to pulsed radiofrequency EMF fields increased neuronal death in rats, which might contribute to an increased risk of neurodegenerative disease, two studies have failed to confirm these results."

No evidence is provided in support of this claim. This is completely inaccurate: approximately a dozen studies found elevated levels of neuronal cell death following non-thermal EMF exposures reviewed in the Tolgaskya and Gordon 1973 review. The two studies by Zhang et al. in rats showed that repeated pulsed microwave/RF radiation in young rats caused them to develop Alzheimer's-like effects as middle-aged rats, including elevated levels of amyloid beta protein and oxidative stress in their brains and including Alzheimer's-like behavioral and memory deficiencies. Other studies have found increased levels of amyloid beta protein following EMF exposures. Why is ICNIRP ignoring such evidence?

10. Link between radiofrequency EMF exposure and measures of cardiovascular health

2018 ICNIRP draft guidelines, appendix B, chap. 6 (Cardiovascular System, Autonomic Nervous System, and Thermoregulation):

> "Numerous human studies have investigated indices of cardiovascular, autonomic nervous system, and thermoregulatory function, including measures of heart rate and heart rate variability, blood pressure, body, skin and finger temperatures, and skin conductance. Most studies indicate there are no effects on endpoints regulated by the autonomic nervous system."

No evidence is provided in support of this claim.

> "The relatively few reported effects of exposure were small and would not have an impact on health."

No evidence is provided in support of this claim.

> "The changes were also inconsistent and may be due to methodological limitations or chance."

No evidence is provided in support of this claim. Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used. When ICNIRP claims there are methodological problems, these need to be clearly stated and clearly documented.

11. Non-thermal radiofrequency EMF exposures produce autoimmune responses

2018 ICNIRP draft guidelines, appendix B, chap. 7 (Immune System and Haematology):

> "There have been inconsistent reports of transient changes in immune function and haematology following radiofrequency EMF exposures."

No evidence is provided in support of this claim.

> "These have primarily been from *in vitro* studies, although some *in vivo* animal studies have also been conducted."

No evidence is provided in support of this claim.

> "There is currently no evidence that such reported effects, if real, are relevant to human health."

A total of 11 animal studies in the EMF Portal database show that non-thermal radiofrequency EMF exposures produce autoimmune responses. These can be easily found by searching that database for *autoimmune* or *autoimmunity for EMFs over 10 MHz*. If ICNIRP wishes to argue that these findings are irrelevant to the large increases in autoimmune incidence and prevalence we have seen in recent years in humans, it should make whatever argument it feels is appropriate. To have ICNIRP ignoring this pattern of evidence is unacceptable.

12. Effects of radiofrequency EMF exposure on reproduction and development

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

> "There is very little human experimental research addressing possible effects of radiofrequency EMF exposure on reproduction and development. What is available has focused on hormones that are

relevant to reproduction and development, and as described in the Neuroendocrine System section above, there is no evidence that they are affected by radiofrequency EMF exposure."

This is completely untrue. There are 13 studies showing that such EMFs impact human male reproduction, including sperm motility and aberrations in sperm structure; long-term exposures produce decreases in sperm count. These impacts are shown in the following studies:

1. Avendaño, Mata AM, Sanchez Sarmiento CA. 2012 Use of laptop computers connected to the internet through Wi-Fi deceases human sperm motility and increases sperm DNA fragmentation. Fertil Steril 97: No. 1, January 2012 0015-8282.
2. Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. 2008 Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92: 1318-1325.
3. Erogul O, Oztas E, Yildirim U, Kir T, Emin A, Komeski G, Irkilata, HC, Irmak MK, Peker AF. 2006 Effects of electromagnetic radiation from cellular phone on human sperm motility. Arch Med Res 37:840-843.
4. Wdowiak A, Wdowiak L, Wiktor H. 2007 Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med 2007, 14: 169-172

The following additional nine studies can all be accessed in the EMF Portal database:

Oni et al., 2011; Iuliis et al., 2009; Zalata et al., 2015; Gorpinchenko et al., 2014; Wang et al., 2015; Baste et al., 2008; Davoudi et al., 2002; Kilgallon and Simmons, 2005; Fejes et al., 2005.

Therefore, the claim by ICNIRP that there are few studies of the effects of EMFs on human reproduction are clearly false. There is also concern about EMF causation of increased spontaneous abortion in humans from an earlier review and from four recent primary literature citations:

1. Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect. 1997 Dec;105 Suppl 6:1579-87.
2. Mahmoudabadi FS, Ziaei S, Firoozabadi M, Kazemnejad A. 2015 Use of mobile phone during pregnancy and the risk of spontaneous abortion. J Environ Health Sci Eng. 2015 Apr 21;13:34. doi: 10.1186/s40201-015-0193-z.
3. Mortazavi SMJ, Mortazavi SA, Paknahad M. 2012 Association between electromagnetic field exposure and abortion in pregnant women living in Tehran. Int J Reprod Biomed (Yazd) 2017 Feb;15(2):115-116.
4. Liu XY, Bian XM, Han JX, Cao ZJ, Fan GS, Zhang C, Zhang WL, Zhang SZ, Sun XG. 2007 [Risk factors in the living environment of early spontaneous abortion pregnant women]. Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 2007 Oct;29(5):661-4.
5. Zhou LY, Zhang HX, Lan YL, Li Y, Liang Y, Yu L, Ma YM, Jia CW, Wang SY. Epidemiological investigation of risk factors of the pregnant women with early spontaneous abortion in Beijing. Chin J Integr Med. 2017 May;23(5):345-349. doi: 10.1007/s11655-015-2144-z. Epub 2015 Apr 14.

ICNIRP can, if it wishes, argue against these findings, but it cannot simply ignore them and have any sustainable claim that it is protecting our health from EMF effects.

13. Prenatal exposure to EMF non-thermal radiation can produce neurological effects

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

"Other research has addressed this issue by looking at different stages of development (on endpoints such as cognition and brain electrical activity), in order to determine whether there may be greater sensitivity to radiofrequency fields during these stages."

No evidence is provided in support of this claim.

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

> "There is currently no evidence that developmental phase is relevant to this issue."

No evidence is provided in support of this claim. Six studies have found that late prenatal EMF non-thermal exposures in rodents produce long-term neurological changes that are maintained as adults, changes similar to those found in ADHD or autism. No similar changes are produced in adults. These changes were found to be produced by cell phone radiation, cordless phone radiation and by Wi-Fi, suggesting that prenatal exposure to a broad range of such radiation can produce these effects. These studies are as follows:

1. Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.
2. Othman, H., Ammari, M., Rtibi, K., Bensaid, N., Sakly, M., Abdelmelek, H. 2017. Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices. Environ. Toxicol. Pharmacol. 52:239-247. doi: 10.1016/j.etap.2017.04.016.
3. Bas O, Sönmez OF, Aslan A, Ikinci A, Hanci H, Yildirim M, Kaya H, Akca M, Odaci E. 2013 Pyramidal Cell Loss in the Cornu Ammonis of 32-day-old Female Rats Following Exposure to a 900 Megahertz Electromagnetic Field During Prenatal Days 13-21. Neuroquantology 11: 591-599.
4. Kumari K, Koivisto H, Myles C, Jonne N, Matti V, Heikki T, Jukka J. 2017 Behavioural phenotypes in mice after prenatal and early postnatal exposure to intermediate frequency magnetic fields. Environ Res 162: 27-34.
5. Othman H, Ammari M, Sakly M, Abdelmelek H. 2017 Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. Behav Brain Res 326: 291-302 doi: 10.1016/j.bbr.2017.03.011.
6. Stasinopoulou M, Fragopoulou AF, Stamatakis A, Mantziaras G, Skouroliakou K, Papassideri IS, Stylianopoulou F, Lai H, Kostomitsopoulos N, Margaritis LH. 2016 Effects of pre- and postnatal exposure to 1880-1900 MHz DECT base radiation on development in the rat. Reprod Toxicol 2016; 65: 248-262.

There is a second type of study that also produces clear evidence of fetal effects not seen in adults. These are the two studies in cattle that clearly show high sensitivity of the fetus to EMFs. Conducted by Professor Hässig and his colleagues in Switzerland, they demonstrate effects deep within the body, on cataract formation in newborn calves where the mothers were grazing near a cell phone tower:

1. Hässig M, Jud F, Naegeli H, Kupper J, Spiess BM. 2009 Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. Schweiz Arch Tierheilkd 151:471-478.
2. Hässig M, Jud F, Spiess B. 2012 [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd 154:82-86.

The Swiss safety guidelines are 100 times more stringent than are the ICNIRP safety guidelines, emphasizing the complete inadequacy of the ICNIRP safety guidelines. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (also called cell phone towers), the calves are born with very greatly increased incidences of cataracts. It follows from these findings that, even though the developing fetuses are very deep in the body of the mother and should be highly protected from the EMF exposures, they are not so protected. Furthermore, because the mothers do not develop cataracts despite their eyes being much more exposed to cell phone tower radiation, this clearly argues

that the fetal eye tissue is vastly more sensitive to EMF effects than is adult eye tissue. When ICNIRP claims there is no evidence but there clearly is evidence, this destroys whatever credibility ICNIRP may have had.

14. EMF exposure has important role in cancer causation

2018 ICNIRP draft guidelines, appendix B, chap. 9 (Cancer):

> "There is a large body of literature concerning cellular and molecular processes that are of particular relevance to cancer. This includes studies of cell proliferation, differentiation and apoptosis-related processes, proto-oncogene expression, genotoxicity, increased oxidative stress, and DNA strand breaks. Although there are reports of effects of radiofrequency EMF on a number of these endpoints, there is no substantiated evidence of health-relevant effects."

No evidence is provided in support of this claim. What ICNIRP is apparently claiming is that these effects of EMF exposure, each of which has been shown in an extraordinarily large scientific literature to have an important role in cancer causation, are—inexplicably—not relevant to health! We are relying on the Melnick critique to provide a much broader-ranging assessment of the many flaws in this cancer section of the ICNIRP draft. We urge ICNIRP to pay close attention to the Melnick critique.

5. Appendix 2 contains reviews documenting each of eight different non-thermal EMF effects. These effects are as follows:

1. Effects on cellular DNA including single-strand and double-strand breaks in cellular DNA and on oxidized bases in cellular DNA; also evidence for chromosomal mutations produced by double strand DNA breaks (23 reviews).
2. Lowered fertility, including tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovarian remodeling, oocyte (follicle) loss, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, lowered libido (19 reviews).
3. Widespread neurological/neuropsychiatric effects (27 reviews).
4. Apoptosis/cell death (an important process in production of neurodegenerative diseases that is also important in producing infertility responses) (13 reviews).
5. Oxidative stress/free radical damage (important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage) (21 reviews).
6. Endocrine, that is hormonal effects, including neuroendocrine, peptide and other non-steroid hormones; also steroid hormones (12 reviews).
7. Increased intracellular calcium: intracellular calcium is maintained at very low levels (typically about 2×10^{-9} M) except for brief increases used to produce regulatory responses, such that sustained elevation of intracellular calcium levels produces many pathophysiological (that is disease-causing) responses) (16 reviews).
8. Cancer causation by EMF exposures (36 reviews).

ICNIRP appears to be systematically avoiding citing and discussing review articles that discuss contrary findings and express contrary opinions to those expressed by ICNIRP. That is not acceptable. If ICNIRP wishes to take a position contrary to those taken in these reviews, at a minimum, ICNIRP must cite each contrary review, discuss its main findings and only then can ICNIRP argue against the positions taken in these reviews.

6. Appendix 3 contains reviews showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity (13 reviews). This is important because all wireless communication devices communicate via pulsations and because the "smarter" the device, the more it pulses because the pulsations convey the information. This raises the issue that such "smarter" devices may, in fact, be much more dangerous than are less "smart" devices, even if the "smart" devices have lower intensity radiation.

What should be obvious is that *you could not study such pulsation roles if there were no biological effects produced by such EMFs*. The pulsation studies alone tell us that there are many such EMF effects, despite ICNIRP's claims to the contrary.

There is an additional complication here. There have been shown to be intensity windows of exposure, where exposures within a window produce maximum biological effects, but either lower or higher exposures produce much lower effects:

1. Belyaev, I., 2005. Non-thermal biological effects of microwaves. Microwave Rev. 11, 13-29.
2. Belyaev, I., 2015. Biophysical mechanisms for nonthermal microwave effects. In: Markov M.S. (Ed), Electromagnetic Fields in Biology and Medicine, CRC Press, New York, pp 49-67.
3. Pall, M. L. 2015 Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116. doi: 10.1515/reveh-2015-0001.

Each of these issues seriously threatens the whole structure advocated by ICNIRP and must, therefore, be seriously considered by ICNIRP in order to produce a scientifically valid document. They threaten the ICNIRP claim that:

1. Effects are only seen if intensities are above some level but are not seen at lower intensities.
2. Average intensities are all that need to be considered, when in fact average intensities are often irrelevant to biological effects seen.
3. Pulsations can be ignored.
4. Dose response curves are linear or, at least, monotone.

IV. Conclusion

It is our opinion that safety can only be assessed biologically and that the whole structure that ICNIRP proposes is deeply flawed.

Signed:

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Rainer Nyberg, EdD, Professor Emeritus. Vassa, Finland. Co-author§ of the EU Appeal asking for a moratorium on 5G until research on health harm is done

Appendix 1

Consideration of biological aspects in ICNIRP 2018 draft and ICNIRP Appendix B

2018 ICNIRP draft guidelines, subsect. 4.3.1 (Nerve stimulation)

Exposure to EMF can induce electric fields within the body, which for frequencies up to 10 MHz can stimulate nerves (Saunders and Jeffreys, 2007); this is not known to occur in vivo at frequencies higher than approximately 10 MHz. The Saunders and Jeffreys article does not test this, so no evidence is provided by ICNIRP supporting this statement. Furthermore each of the 27 reviews on neurological/neuropsychiatric effects listed in appendix 2 provides clear evidence that this is not true. Each provides a body of evidence showing that microwave frequency EMFs do cause neurological and/or neuropsychiatric effects. *The effect of this stimulation varies as a function of frequency, and is typically reported as a 'tingling' sensation for frequencies around 100 kHz (where peak field is most relevant)* **[no evidence provided**]. *As frequency increases, heating effects predominate and the likelihood of nerve stimulation decreases; at 10 MHz the electric field is typically described as 'warmth'* **[no evidence provided]**. *Nerve stimulation by induced electric fields is protected by the ICNIRP low frequency guidelines (2010)* **[no evidence provided; massively contradicted by the 27 reviews]**, *and is not discussed further here.* We have here multiple claims by ICNIRP that are both undocumented by them and are contradicted by very large amounts of evidence that have been reviewed earlier. This raises the question of why ICNIRP did not cite and discuss this very large literature that opposes their position.

2018 ICNIRP draft guidelines, subsect. 4.3.2 (Membrane permeabilization)

When (low frequency) EMF is pulsed, the power is distributed across a range of frequencies, which can include radiofrequency EMF (Joshi and Schoenbach, 2010). If the pulse is sufficiently intense and brief, exposure to the resultant EMF may cause cell membranes to become permeable, which in turn can lead to other cellular changes. However, there is no evidence that the radiofrequency spectral component from an EMF pulse (without the low- frequency component) is sufficient to cause this permeability. **Joshi and Schoenbach did not test this, so no evidence is provided.** *The restrictions on nerve stimulation in the ICNIRP (2010) guidelines provide adequate protection against the low frequency components* **[no evidence provided]**, *so additional protection from the resultant radiofrequency EMF is not necessary* **[no evidence provided]**. *Membrane permeability has also been shown to occur with 18 GHz continuous wave exposure (e.g. Nguyen et al., 2015). This has only been demonstrated in vitro, and requires very high exposure levels (circa 5 kW kg^{-1}) that far exceed those required to cause thermally-induced harm (see Section 4.3.3).* (**Nguyen et al. was a study of bacteria and there is no evidence provided here on mammalian cells, let alone human cells**). *Therefore there is also no need to specifically protect against this effect, as restrictions designed to protect against smaller temperature elevations will also protect against this.* **Logic does not follow**. The genuine membrane permeabilization that is produced by low intensity, non-thermal effects of EMFs, is through activation of voltage-gated ion channels, with the voltage-gated calcium channels (VGCCs) being particularly important. It has been shown that there are 28 published studies which showed that low-intensity EMF effects can be blocked or greatly lowered by calcium channel blockers [Pall ML, 2013 and 2018; J Cell Mol Med. 2013 Aug;17(8):958-65; Environ Res. 2018 Jul;164:405-416.], drugs that are specific for blocking the VGCCs. Microwave frequency EMF exposures lead, in turn, to excessive calcium signaling via increased levels of [Ca2+]i, as shown in many of the reviews listed above on increased calcium levels.

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation)

Radiofrequency EMFs can generate heat in the body. As heat can affect health, it is important that heat generated by EMF is kept to a safe level. However, as can be seen from appendix B, there is a dearth of radiofrequency exposure research using sufficient power to cause heat- induced health effects. Of particular note is that although exposures (and resultant temperature rises) have occasionally been shown to cause severe harm, the literature lacks concomitant evidence of the highest exposures that do not cause harm. For very low exposure levels (such as within the ICNIRP (1998) basic restrictions) there is extensive evidence that the amount of heat generated is not sufficient to cause harm, but for exposure levels above those of the ICNIRP (1998) basic restriction levels, yet below those shown to produce harm, there is still uncertainty **[no evidence provided]**. **Each of the 89 reviews listed in appendix 2 falsifies this claim.** If ICNIRP wishes to argue against those findings, ICNIRP should cite each of those reviews, discuss in detail what findings they report and only then can ICNIRP attempt to rebut each of those 89 bodies of evidence. *Where there is good reason to expect health impairment at temperatures lower than those shown to impair health via radiofrequency EMF exposure, ICNIRP uses those lower temperatures to base limits on* **[no evidence provided. Again, this statement clearly appears to be false based on those same 89 bodies of evidence]**.

2018 ICNIRP draft guidelines, appendix B, sect. 2.1 (Brain electrical activity and cognitive performance)

Human research addressing higher cognitive function has primarily been conducted within the ICNIRP (1998) basic restriction values, with very limited research at levels high-enough to provide health-effect threshold information. This has primarily been assessed via performance measures, and derivations of the electroencephalogram (EEG) and cerebral blood flow (CBF) measures (sensitive measures of brain electrical activity and blood flow/metabolism, respectively). Most double-blind human experimental studies on cognitive performance, CBF or event-related potential (a derivative of the EEG) measures of cognitive function did not report an association with radiofrequency EMF **[no evidence provided]***. A number of sporadic findings have been reported, but these do not show a consistent or meaningful pattern* **[no evidence provided]***. This may be a result of the large number of (uncontrolled-for) statistical comparisons, a possibility consistent with the lack of replication of such reports* [**no evidence provided].** The only way to show lack of replication is to do identical studies and obtain different results. If ICNIRP has many examples of such identical studies, then it needs to document them. If it does not, then it needs to stop making false claims of lack of replication. *Of particular importance is that the larger, more methodologically rigorous studies have failed to identify effects of radiofrequency EMF exposure on these cognitive domains* **[no evidence provided**]*. There are therefore no substantiated reports of radiofrequency EMF negatively affecting performance, CBF or event-related potential measures of cognitive function* **[no evidence provided]***. Studies analyzing frequency components of the EEG have reliably shown that the 8–13 Hz alpha band in waking EEG and the 10–14 Hz 'sleep spindle' frequency range in sleep EEG, are affected by radiofrequency EMF exposure with SARs <2 W kg^{-1}, but there is no evidence that these relate to adverse health effects* **[no evidence provided]***. Both rodents and non-human primates have shown a decrease in food-reinforced memory performance with exposures to radiofrequency EMF at a whole body average SAR >5 W kg^{-1} for rats, and a whole body average SAR >4 W kg^{-1} for non-human primates, exposures which correspond to increases in body core temperatures of approximately 1 °C. However, there is no indication that these changes were due to reduced cognitive ability, rather than the normal temperature-induced*

reduction of motivation (hunger) [no evidence provided]. *Such changes in motivation are considered normal and reversible thermoregulatory responses, and do not in themselves represent an adverse health effect* [**no evidence provided]**. Having an interpretation, however plausible or implausible it may be, does not provide compelling evidence to the issue of whether this is a health effect. *Similarly, although not considered an adverse health effect, behavioral changes to reduce body temperature have also been observed in non-human primates at a whole body average SARs of 1 W kg^{-1}, with the threshold the same for acute, repeated exposures and for long-term exposures* **[no evidence provided]**. *There is limited epidemiological research on higher cognitive function* **[no evidence provided]**. *There have been reports of subtle changes to performance measures with radiofrequency EMF, but findings have been contradictory and alternative explanations for observed effects are plausible* **(no evidence provided]**. Again only identical studies that produce widely different findings can provide evidence of contradictory findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop making false claims of contradictory findings. *Further details concerning the term 'substantiated' can be found in the main guidelines document. In summary, there is no substantiated experimental or epidemiological evidence that exposure to radiofrequency EMF affects higher cognitive functions relevant to health* **[no evidence provided].**

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing)

There is research addressing the potential for radiofrequency EMF to influence mood, behavior characteristics and symptoms. A number of human experimental studies testing for acute changes to wellbeing or symptoms are available, and these have failed to identify any substantiated effects of exposure **[no evidence provided]**. See next section for discussion. *A small portion of the population attributes non-specific symptoms to various types of radiofrequency EMF exposure; this is referred to as Idiopathic Environmental Intolerance attributed to EMF (IEI-EMF). Double-blind experimental studies have consistently failed to identify a relation between radiofrequency EMF exposure and such symptoms in the IEI-EMF population, as well as in healthy population samples* [no evidence provided]. *These human experimental studies provided evidence that 'belief about exposure' (e.g. the so-called 'nocebo' effect), and not exposure itself, is the relevant symptom determinant* [**no evidence provided]**. The accepted name for what ICNIRP calls IEI-EMF is electromagnetic hypersensitivity or EHS and there is much information about it in the scientific literature. It has been shown in four studies, that it is possible to identify people with apparent EHS and show that they can be tested in blinded fashion using objectively measurable responses, showing that they are genuinely hypersensitive when compared with normal controls. The four studies are: Rea WR, Pan Y, Yenyves EJ, Sujisawa I, Suyama N, Ross GH. 1991. Electromagnetic field sensitivity. J Bioelectr 10:241-256; Havas M. 2006 Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. Electromagn Biol Med 2006;25(4):259–68; Havas M, et al. 2010 Provocation study using heart rate variability shows microwave radiation from DECT phone affects autonomic nervous system. In: Giuliani L, Soffritti M, editors. "Non-thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter", European J Oncology — Library. National Institute for the Study and Control of Cancer and Environmental DiseaseBologna: Mattioli; 2010. p. 273–300. 2010; McCarty DE, et al. 2011 Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. bhttp://www.ncbi.nlm.nih.gov/pubmed/21793784> 2011 Sep 5. There are other studies that show that there are genuine physiological changes occurring in EHS. Two studies have shown that EHS people have high levels of oxidative stress: De Luca C, Raskovic D, Pacifico V, Thai JC, Korkina L. 2011 The search for reliable biomarkers of disease in multiple chemical sensitivity and other environmental intolerances. Int J Environ Res Public Health. 2011 Jul;8(7):2770-97. doi:

10.3390/ijerph8072770. Irigaray P, Caccamo D, Belpomme D. 2018 Oxidative stress in electrohypersensitivity self-reporting patients: Results of a prospective in vivo investigation with comprehensive molecular analysis. Int J Mol Med. 2018 Oct;42(4):1885-1898. doi: 10.3892/ijmm.2018.3774.k; Furthermore it has been shown using fMRI that there are regions of the brain in EJHS people who are especially sensitive to EMF stimulation: Heuser G, Heuser SA. 2017 Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 2017 Sep 26;32(3):291-299. doi: 10.1515/reveh-2017-0014. It can be seen from this that EHS is a genuine hypersensitivity condition with major sensitivity responses in the brain. Consequently not only is what ICNIRP says in this area undocumented, but also each of the ICNIRP claims is also false).

Epidemiological research has addressed potential long-term effects of radiofrequency EMF exposure from fixed site transmitters and devices used close to the body on both symptoms and well-being, but with a few exceptions these are cross-sectional studies with self-reported information about symptoms and exposure **[no evidence provided]***. Selection bias, reporting bias, and nocebo effects are of concern in these* studies **[no evidence provided]**. Most of the scientific literature calls what ICNIRP calls IEI-EMF, electromagnetic hypersensitivity or EHS. The ICNIRP statements here are both undocumented and contradicted by a substantial scientific literature, as shown immediately above. *In studies on transmitters, no consistent associations between exposure and symptoms or well-being were observed when objective measurements of exposure were made, or when exposure information was collected prospectively* **[no evidence provided]***. In studies on mobile phone use, associations with symptoms and problematic behavior have been observed. However, these studies can generally not differentiate between potential effects from radiofrequency EMF exposure and other consequences of mobile phone use, such as sleep deprivation in adolescents using the mobile phone at night* **[no evidence provided]***. Overall, the epidemiological research does not provide evidence of a causal effect of radiofrequency EMF exposure on symptoms or well-being* **[no evidence provided]**. The same 27 reviews on neurological/neuropsychiatric effects, which were referred to above, also falsify these ICNIRP claims regarding cell phone effects. Similar effects were found including sleep disruption, fatigue, headache, memory dysfunction, depression, lack of concentration, anxiety, sensory dysfunction and several others were found to be produced by many different types of EMF exposures. These included radar, other occupational exposures, three types of broadcast radiation, heavy cell phone use, living near cell phone towers and microwave radiation of the US embassy in Moscow. Clearly these are not caused by behavioral changes specific for cell phone use, as ICNIRP argues here. When these problems are becoming almost universal in every single technologically advanced country on earth, surely it is time for ICNIRP to start protecting us from them. *However, there is evidence that radiofrequency EMF, at sufficiently high levels, can cause pain. Walters et al. (2000) reported a pain threshold of 12.5 kW m^{-2} for 94 GHz, 3-second exposure to the back, which raised temperature at a rate of 3.3 °C per second (from 34 °C to 43.9 °C). This is similar to that found for heating due to sources other than EMF, where 'weak to moderate' pain was reported for smaller temperature elevations (+4 °C) but with a similar rate of temperature elevation (4 °C per second; Green & Akirav, 2010). However, as Walters et al. used an exposure scenario more relevant to radiofrequency EMF, and as Green and Akirav (2010) has not been replicated (which is particularly important here due to the methodological difficulties associated with self-report measures)* **[no evidence provided]***, it is difficult to determine the relevance of 'rate of temperature elevation' to human health at present. Another instance of pain induced by radiofrequency EMF is due to 'indirect' exposure via contact currents, where radiofrequency EMF in the environment is redirected via a conducting object to a person, and the resultant current flow, dependent on frequency, can stimulate nerves, cause pain and/or damage tissue* **[no evidence provided]***.*

Thresholds are very difficult to determine, with the best estimates of thresholds for health effects being for pain, which is approximately 10 and 20 mA for children and adults respectively (extrapolated from Chatterjee et al., 1986). There is thus no evidence that high frequency EMF exposure affects symptoms, except for pain (and potentially tissue damage) at high exposure levels **[no evidence provided]. Shown by the 27 reviews on neurological/neuropsychiatric effects previously discussed to be completely untrue.** *In summary, no reports of adverse effects on symptoms and wellbeing have been substantiated, except for pain, which is related to elevated temperature at high exposure levels* **[logically flawed statement based on a biased assessment of the literature]**. *Thresholds for these have not been clearly identified, but the best estimate is within the vicinity of 10 and 20 mA for indirect contact currents, for children and adults respectively, and 12.5 kW* m^{-2} *for direct millimeter-wave exposure* **[no evidence provided].**

Sections 2.1 and 2.3 are wildly contradicted by 27 reviews on neurological and neuropsychiatric effects of non-thermal EMF exposures both in animals and in humans. Those reviews are as follows:

1. Marha K. 1966 Biological Effects of High-Frequency Electromagnetic Fields (Translation). ATD Report 66-92. July 13, 1966 (ATD Work Assignment No. 78, Task 11). http://www.dtic.mil/docs/citations/AD0642029 (accessed March 12, 2018)
2. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
3. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by by Haigh. Consultants Bureau, New York/London, 146 pages.
4. Bawin SM, Kaczmarek LK, Adey WR. 1975 . Effects of modulated VHF fields on the central nervous system. Ann NY Acad Sci 247:74-81.
5. Bise W. 1978 Low power radio-frequency and microwave effects on human electroencephalogram and behavior. Physiol Chem Phys 10:387-398.
6. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.
7. Frey AH. 1993 Electromagnetic field interactions with biological systems. FASEB J 7:272-281.
8. Lai H. 1994 Neurological effects of radiofrequency electromagnetic radiation. In: Advances in Electromagnetic Fields in Living Systems, Vol. 1, J.C. Lin, Ed., Plenum Press, New York, pp. 27-88.
9. Grigor'ev IuG. 1996 [Role of modulation in biological effects of electromagnetic radiation]. Radiats Biol Radioecol 36:659-670.
10. Lai, H 1998 Neurological effects of radiofrequency electromagnetic radiation. http://www.mapcruzin.com/radiofrequency/henry_lai2.htm.
11. Valentini E, Curcio G, Moroni F, Ferrara M, De Gennaro L, M. Bertini M. 2007 Neurophysiological Effects of Mobile Phone Electromagnetic Fields on Humans: A Comprehensive Review. Bioelectromagnetics 28:415-432.
12. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
13. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
14. Kundi M, Hutter H-P. 2009 Mobile phone base stations—Effects on wellbeing and health. Pathophysiology 16:123-135.

15. Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M, Ahonen M. 2010 Epidemiological evidence for a health risk from mobile phone base stations. Int J Occup Environ Health 16:263-267.
16. Levitt, B. B., Lai, H. 2010. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18, 369-395. doi.org/10.1139/A10-018
17. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.
18. Politański P, Bortkiewicz A, Zmyślony M. 2016 [Effects of radio- and microwaves emitted by wireless communication devices on the functions of the nervous system selected elements]. Med Pr 67:411-421.
19. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
20. Pall ML. 2016 Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75(Pt B):43-51. doi: 10.1016/j.jchemneu.2015.08.001.
21. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
22. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
23. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. 2016 EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health DOI 10.1515/reveh-2016-0011.
24. Zhang J, Sumich A, Wang GY. 2017 Acute effects of radiofrequency electromagnetic field emitted by mobile phone on brain function. Bioelectromagnetics 38:329-338. doi: 10.1002/bem.22052.
25. Lai H. 2018. A Summary of Recent Literature (2007–2017) on Neurological Effects of Radio Frequency Radiation. Chapter 8 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 185-220.
26. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
27. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to argue about these many findings, it should cite each of these reviews, present the important, relevant findings of each of them and only then should ICNIRP make whatever arguments it may have in disagreeing with them. Pretending that vast amounts of contrary evidence and opinion do not exist simply destroys whatever credibility ICNIRP may have.

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions)

A number of studies of physiological functions that could in principle lead to adverse health effects have been conducted, primarily using in vitro *techniques. These have included multiple cell lines and assessed such functions as intra- and intercellular signaling, membrane ion channel currents and input resistance, Ca2+ dynamics, signal transduction pathways, cytokine expression, biomarkers of neurodegeneration, heat shock proteins, and oxidative stress-related processes. Some of these studies also tested for effects of co-exposure of radiofrequency EMF with known*

toxins. Although some effects have been reported for some of these endpoints, there is currently no evidence of effects relevant to human health **[No evidence provided]**. Is ICNIRP really trying to argue that important signaling pathways, excessive intracellular calcium, inflammation including inflammatory cytokines, neurodegeneration, heat shock responses and oxidative stress have "no relevance to human health?" If so, ICNIRP needs to debunk hundreds of thousands of studies in the PubMed database. *There have been some reports of morphological changes to cells, but these have not been replicated, and their relevance to health has not been demonstrated* **[no evidence provided]**. *There have also been reports of radiofrequency fields inducing leakage of albumin across the blood-brain barrier, but due to methodological limitations of the studies and failed attempts to independently replicate the results, there remains no evidence of an effect* **[no evidence provided]**. *Intense pulsed low frequency electric fields (with radiofrequency components) can cause cell membranes to become permeable, allowing exchange of intra- and extra-cellular materials (Joshi and Schoenbach, 2010); this is referred to as electroporation. 18 GHz continuous wave exposure can result in a similar effect (Nguyen et al., 2017). These require very high field strengths (e.g. 10 kV m^{-1} (peak) in tissue in terms of the former, and 5 kW kg^{-1} for the latter). These levels have not been shown to adversely affect health in realistic exposure scenarios in humans, and given their very high thresholds, are protected against by limits based on effects with lower thresholds and are not discussed further. Animal studies have also reported that the heating that results from radiofrequency EMF exposure may lead to formation of cataract in rabbits. In order for this to occur, very high local SAR levels (100 – 140 W kg^{-1}) at low frequencies (< 6 GHz) are needed, with increases of several degrees centigrade maintained for several hours* **[no evidence provided]**. *However, the rabbit model is more susceptible to cataract formation than primates (with primates more relevant to human health), and cataracts have not been found in primates exposed to radiofrequency fields* **[no evidence provided]**. *No substantiated effects on other deep structures of the eye have been found (e.g. retina, lens or iris)* **[no evidence provided]**. *However, rabbits can be a good model for damage to superficial structures of the eye at higher frequencies (30-300 GHz), because the shape of the facial structure is less relevant to exposure in the more superficial tissue that receives the highest exposure at higher frequencies. However, as the baseline temperature of the anterior portion of the eye (including the cornea) is relatively low (compared with the posterior portion of the eye that would be exposed at lower frequencies), very high exposure levels are required to cause harm superficially* **[no evidence provided]**. *For example, Kojima et al. (2018) reported that adverse health effects to the cornea can occur at > 1.4 kW m^{-2} across frequencies from 40 to 95 GHz, and no effects were found below 500 W m^{-2}; the authors concluded that the blink rates in humans would preclude such effects in humans. In summary, there is no evidence of effects of radiofrequency EMF on physiological processes or eye pathology that impair health in humans* **[no evidence provided]**. *Some evidence of superficial eye damage has been shown in rabbits at exposures of at least 1.4 kW m^{-2}, although the relevance of this to humans has not been demonstrated* Why does ICNIRP state that there is no evidence of human relevance but never tells us if there is any evidence that the findings are not relevant to humans. If there is simply a lack of evidence, then the way ICNIRP describes this speaks to an unconscionable bias on the part of ICNIRP. With human relevance as with all things, absence of evidence is not evidence of absence.

2018 ICNIRP draft guidelines, appendix B, chap. 3 (Auditory, vestibular, and ocular function)

A number of animal and some human studies have tested for potential effects of radiofrequency EMF on function and pathology of these systems. Sub-millisecond pulses of radiofrequency EMF can result in audible sound. Specifically, within the 200-3000 MHz range the microwave hearing effect can result from brief (approximately 100 µS) radiofrequency pulses to the head, which cause

thermoelastic expansion that is detected by sensory cells in the cochlea via the same processes involved in normal hearing [**no evidence provided that this is the actual mechanism]**. *This effect is perceived as a brief low-level noise, often described as a 'click' or 'buzzing'. The most recent report has provided a specific absorption (SA) value of 4.5 mJ 190 kg^{-1} per pulse to reach the 20 mPa auditory sound pressure threshold at the cochlea for 10 and 20 µS pulses at 2.45 GHz, which by definition is barely audible (Roschmann, 1991). This equates to a temperature rise of approximately 1 x 10-6 °C per pulse. There is no evidence that the microwave hearing effect can affect health, and so the present Guidelines do not provide a restriction to specifically account for microwave hearing* **[no evidence provided; there have been reports that exposures which produce microwave hearing also produce tinnitus, which is a human health effect].** *A few studies reported effects of mobile phone emissions on auditory function and cellular structure in animal models* **[no evidence provided]**. *However, results are inconsistent, and no association of radiofrequency EMF exposure with risk of tinnitus, hearing impairment or vestibular dysfunction has been substantiated in epidemiological studies* [**no evidence provided; any epidemiological assessment should be extensively documented and should be assessed by professional epidemiologists that have no vested interests here].** *Human laboratory studies also failed to identify any adverse health effects of exposure* **[no evidence provided]**. *A number of experimental human studies have tested for changes to normal sensory processing due to radiofrequency EMF exposure. These have largely been conducted at exposure level within the ICNIRP (1998) basic restriction levels, and although there are some reports of effects in both categories of research, the results are highly variable, with the larger and more methodologically rigorous studies failing to find such effects* **[no evidence provided; where ICNIRP claims there are methodological problems, these need to be extensively documented. Failing that ICNIRP cannot claim to be protecting us from radiation effects.]** *There is very little epidemiological research addressing sensory effects of devices that emit radiofrequency EMF* **[no evidence provided]**. *The available research has focused on mobile phone use and does not provide substantiated evidence that this is associated with increased risk of tinnitus, hearing impairment, vestibular or ocular function* **[no evidence provided]**.

In summary, no effects on auditory, vestibular, or ocular function relevant to human health have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 4 (Neuroendocrine system)

A small number of human studies have tested whether indices of endocrine system function are affected by radiofrequency EMF exposure. Several hormones, including melatonin, growth hormone, luteinising hormone, cortisol, epinephrine and norepinephrine have been assessed, but no consistent evidence of effects of exposure has been observed **[no evidence provided]**. *In animal studies, robust changes have only been reported from acute exposures with whole body SARs in the order of 4 W kg^{-1}, which result in core temperature rises of 1 °C or more* **[no evidence provided]**. *However, there is no evidence that this corresponds to an impact on health* **[Is there evidence against such an impact? If so, it should be presented.]** *Although there have been a few studies reporting field-dependent changes in some neuroendocrine measures, these have also not been substantiated* **[no evidence provided]**. *The literature as a whole reports that repeated, daily exposure to mobile phone signals does not impact on plasma levels of melatonin or on melatonin metabolism, oestrogen or testosterone, or on corticosterone or adrenocorticotropin in rodents under a variety of conditions* **[no evidence provided]**. *The two epidemiological studies on potential effects of exposure to radiofrequency EMF on melatonin levels had conflicting results, and both had methodological limitations, including possible nocebo effects* **[no evidence provided]**. *For*

other hormonal endpoints no epidemiological studies of sufficient scientific quality have been identified **[no evidence provided]**. *In summary, the lowest level at which an effect of radiofrequency EMF on the neuroendocrine system has been observed is 4 W kg^{-1} (in rodents and primates), but there is no evidence that this translates to humans or is relevant to human health* **[no evidence provided]**. *No other effects have been substantiated* **[no evidence provided]**.

In contrast with the many statements with no evidence provided, the endocrine including neuroendocrine systems have been widely found to be impacted by non-thermal EMF exposures as shown by the following reviews:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
2. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by B Haigh. Consultants Bureau, New York/London, 146 pages.
3. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.
4. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
5. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
6. Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1
7. Pall, M. L. 2015. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116.
8. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
9. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
10. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.
11. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
12. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to disagree with the findings in these reviews, what it needs to do is cite each of these reviews, describe what findings were documented in each of them, and only then should ICNIRP feel free to disagree with any conclusions reached. Ignoring vast amounts of contrary data and opinion just undercuts any claim that ICNIRP may have to providing unbiased science.

2018 ICNIRP draft guidelines, appendix B, chap. 5 (Neurodegenerative diseases)

No human experimental studies exist for neurodegenerative diseases **[Of course not. Such studies are not allowable for ethical reasons. Why is ICNIRP starting with this when this is totally irrelevant?]**. *Although one group has reported that exposure to pulsed radiofrequency EMF fields increased neuronal death in rats, which might contribute to an increased risk of neurodegenerative disease, two studies have failed to confirm these results* **[no evidence provided].** This is completely inaccurate; there were approximately a dozen studies finding elevated levels of neuronal cell death following non-thermal EMF exposures reviewed in the Tolgaskya and Gordon 1973 review; The two studies by Zhang et al. in rats showed that repeated pulsed microwave/RF radiation in young rats caused them to develop Alzheimer's-like effects as middle aged rats, including elevated levels of amyloid beta protein and oxidative stress in their brains and including Alzheimer's-like behavioral and memory deficiencies Other studies have found increased levels of amyloid beta protein following EMF exposures. Why is ICNIRP ignoring such evidence? *Some other effects have been reported (e.g. changes to neurotransmitter release in the cortex of the brain, protein expression in the hippocampus, and autophagy in neurons which was not accompanied by apoptosis), but such changes have not been shown to lead to neurodegenerative disease* **[no evidence provided]**. *Other studies investigating effects on neurodegeneration are not informative due to methodological or other shortcomings* **[no evidence provided]**. It is unacceptable for ICNIRP to make a claim of methodological shortcoming without documenting such a claim. *A Danish epidemiological cohort study has investigated potential effects of mobile phone use on neurodegenerative disorders, and reported reduced risk estimates for Alzheimer disease, vascular and other dementia, and Parkinson disease. These findings are likely to be the result of reverse causation, as prodromal symptoms of the disease may prevent persons with early symptoms to start using a mobile phone* **[no evidence provided]**. *Results for multiple sclerosis are inconsistent, with no effect observed among men, and a borderline increased risk in women, but with no consistent exposure-response pattern* **[no evidence provided].** Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used.

In summary, no adverse effects on neurodegenerative diseases have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 6 (Cardiovascular system, autonomic nervous system, and thermoregulation)

As described above, radiofrequency EMF can induce heating in the body. Although humans have a very efficient thermoregulatory system, too much heat puts the cardiovascular system under stress and may lead to adverse health effects.

Numerous human studies have investigated indices of cardiovascular, autonomic nervous system, and thermoregulatory function, including measures of heart rate and heart rate variability, blood pressure, body, skin and finger temperatures, and skin conductance. Most studies indicate there are no effects on endpoints regulated by the autonomic nervous system **[no evidence provided]**. *The relatively few reported effects of exposure were small and would not have an impact on health* **[no evidence provided]**. *The changes were also inconsistent and may be due to methodological limitations or chance* **[no evidence provided].** Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it

should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used. When ICNIRP claims there are methodological problems, these need to be clearly stated and clearly documented.

With exposures at higher intensities, up to a whole body SAR of about 1 W/kg (Adair, Mylacraine and Cobb, 2001b), sweating and cardiovascular responses occurred similar to that observed under increased heat load from other sources. The body core temperature increase was generally less than 0.2 °C. The maximal increase in skin temperature of the exposed area observed with 2450 MHz was less than 4 °C at a whole body SAR of approximately 1 W kg^{-1}, which again does not represent an adverse health effect. With exposures to 100 and 250 MHz leading to a whole body average SAR of 0.68 W kg^{-1}, hot spots occurred in the skin of the ankles with an average temperature increase of up to 4 °C (Adair et al., 2005). However, reports of effects that are sufficient to impact on health have not been substantiated **[no evidence provided]**. *The situation is different for animal research, in that far higher levels of exposure have been used, often to the point where thermoregulation is overwhelmed and temperature increases to the point where death occurs. For example, Frei et al. (1995) exposed rats to 13 W kg^{-1} 35 GHz fields, which raised body core temperature by 8 °C (to 45 °C), resulting in death. Similarly, Jauchem and Frei (1997) exposed rats to 13.2 W kg^{-1} 350 MHz fields, and reported that thermal breakdown (i.e. where the thermoregulatory system cannot cope with the increased body core temperature) occurred at approximately 42 °C. These are serious adverse health effects that need to be avoided, however there is not sufficient research using lower exposures to evaluate the threshold for health effects in rodents* **[no evidence provided]**. *It is also difficult to relate these animal findings to humans, as humans are more-efficient thermoregulators than rodents, and thus their thermoregulatory systems can deal effectively with higher exposure levels than rodents. Taberski et al. (2014) reported that in hamsters, no body core temperature elevation is seen at 4 W kg^{-1}, with the only detectable effect a reduction on food intake (which is consistent with reduced eating in humans when warmer).* This is, of course, circular reasoning. ICNIRP is assuming that the effects must be thermal and is then making false conclusions based on that assumption.

Few epidemiological studies on cardiovascular, autonomic nervous system, or thermoregulation outcomes are available **[no evidence provided]**. *Those that are have not demonstrated a link between radiofrequency EMF exposure and measures of cardiovascular health* **[no evidence provided]**. *In summary, no effects on the cardiovascular system, autonomic nervous system, or thermoregulation that compromise health have been substantiated for exposures with whole body average SARs below approximately 1 W kg^{-1}, and there is some evidence that 4 W kg-1 is not sufficient to alter body core temperature in hamsters* **[no evidence provided]**. *However, there is strong evidence that whole body exposures in rats that are sufficient to increase body core temperature by several degrees centigrade can cause serious adverse health effects in rats.*

2018 ICNIRP draft guidelines, appendix B, chap. 7 (Immune system and haematology)

There have been inconsistent reports of transient changes in immune function and haematology following radiofrequency EMF exposures **[no evidence provided]**. *These have primarily been from* in vitro *studies, although some in vivo animal studies have also been conducted* **[no evidence provided]**. *There is currently no evidence that such reported effects, if real, are relevant to human health.* There are 11 animal studies in the EMF Portal database each showing that non-thermal radiofrequency EMF exposures produce autoimmune responses. If ICNIRP wishes to argue that these findings are irrelevant to the large increases in autoimmune incidence and prevalence we have seen in recent years in humans, it should make whatever argument it feels is appropriate. To

have ICNIRP ignoring this pattern of evidence is unacceptable. *The few human studies have not indicated any evidence that radiofrequency EMF affects health in humans via the immune system or haematology* **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, reproduction, and childhood development)

There is very little human experimental research addressing possible effects of radiofrequency EMF exposure on reproduction and development. What is available has focused on hormones that are relevant to reproduction and development, and as described in the Neuroendocrine System section above, there is no evidence that they are affected by radiofrequency EMF exposure. **This is completely untrue.** There are 13 studies showing that such EMFs impact human male reproduction including sperm motility and aberrations in sperm structure; long-term exposures produce decreases in sperm count. These are shown in the following studies:

Avendaño, Mata AM, Sanchez Sarmiento CA. 2012 Use of laptop computers connected to the internet through Wi-Fi deceases human sperm motility and increases sperm DNA fragmentation. Fertil Steril 97: No. 1, January 2012 0015-8282.
Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. 2008 Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92: 1318-1325.
Erogul O, Oztas E, Yildirim U, Kir T, Emin A, Komeski G, Irkilata, HC, Irmak MK, Peker AF. 2006 Effects of electromagnetic radiation from cellular phone on human sperm motility. Arch Med Res 37:840-843.
Wdowiak A, Wdowiak L, Wiktor H. 2007 Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med 2007, 14: 169-172
The following additional studies can all be accessed in the EMF Portal database: Oni et al., 2011; Iuliis et al., 2009; Zalata et al., 2015; Gorpinchenko et al., 2014; Wang et al., 2015; Baste et al., 2008; Davoudi et al., 2002; Kilgallon and Simmons, 2005; Fejes et al., 2005.

So these claims by ICNIRP are clearly false. There is also concern about EMF causation of increased spontaneous abortion in humans from an earlier review and from four recent primary literature citations:

Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect. 1997 Dec;105 Suppl 6:1579-87.
Mahmoudabadi FS, Ziaei S, Firoozabadi M, Kazemnejad A. 2015 Use of mobile phone during pregnancy and the risk of spontaneous abortion. J Environ Health Sci Eng. 2015 Apr 21;13:34. doi: 10.1186/s40201-015-0193-z.
Mortazavi SMJ, Mortazavi SA, Paknahad M. 2012 Association between electromagnetic field exposure and abortion in pregnant women living in Tehran. Int J Reprod Biomed (Yazd) 2017 Feb;15(2):115-116.
Liu XY, Bian XM, Han JX, Cao ZJ, Fan GS, Zhang C, Zhang WL, Zhang SZ, Sun XG. 2007 [Risk factors in the living environment of early spontaneous abortion pregnant women]. Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 2007 Oct;29(5):661-4.
Zhou LY, Zhang HX, Lan YL, Li Y, Liang Y, Yu L, Ma YM, Jia CW, Wang SY.
Epidemiological investigation of risk factors of the pregnant women with early spontaneous abortion in Beijing. Chin J Integr Med. 2017 May;23(5):345-349. doi: 10.1007/s11655-015-2144-z. Epub 2015 Apr 14.

ICNIRP can, if it wishes, argue against these findings, but it cannot simply ignore them and have any sustainable claim that it is protecting our health from EMF effects. Other research has addressed this issue by looking at different stages of development (on endpoints such as cognition *and brain electrical activity), in order to determine whether there may be greater sensitivity to radiofrequency fields during these stages* **[no evidence provided]***. There is currently no evidence that developmental phase is relevant to this issue.* **[No evidence provided].** There are six studies that have each found that late prenatal EMF exposures in rodents produce long-term neurological changes which are maintained as adults, changes similar to those found in ADHD or autism. No similar changes are produced in adults. These changes were found to be produced by cell phone radiation, cordless phone radiation and by Wi-Fi, suggesting that prenatal exposure to a broad range of such radiation can produce these effects. These studies are as follows:

Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.
Othman, H., Ammari, M., Rtibi, K., Bensaid, N., Sakly, M., Abdelmelek, H. 2017. Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices. Environ. Toxicol. Pharmacol. 52:239-247. doi: 10.1016/j.etap.2017.04.016.
Bas O, Sönmez OF, Aslan A, Ikinci A, Hanci H, Yildirim M, Kaya H, Akca M, Odaci E. 2013 Pyramidal Cell Loss in the Cornu Ammonis of 32-day-old Female Rats Following Exposure to a 900 Megahertz Electromagnetic Field During Prenatal Days 13-21. Neuroquantology 11: 591-599.
Kumari K, Koivisto H, Myles C, Jonne N, Matti V, Heikki T, Jukka J. 2017 Behavioural phenotypes in mice after prenatal and early postnatal exposure to intermediate frequency magnetic fields. Environ Res 162: 27-34
Othman H, Ammari M, Sakly M, Abdelmelek H. 2017 Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. Behav Brain Res 326: 291-302.
Stasinopoulou M, Fragopoulou AF, Stamatakis A, Mantziaras G, Skouroliakou K, Papassideri IS, Stylianopoulou F, Lai H, Kostomitsopoulos N, Margaritis LH. 2016 Effects of pre- and postnatal exposure to 1880-1900 MHz DECT base radiation on development in the rat. Reprod Toxicol 2016; 65: 248-262.

There is a second type of study that also produces clear evidence of fetal effects not seen in adults. These are the two studies in cattle that clearly show high sensitivity of the fetus to EMFs. Conducted by Professor Hässig and his colleagues in Switzerland, they demonstrate effects deep within the body, on cataract formation in newborn calves where the mothers were grazing near a cell phone tower. [Hässig M, Jud F, Naegeli H, Kupper J, Spiess BM. 2009 Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. Schweiz Arch Tierheilkd 151:471-478. Hässig M, Jud F, Spiess B. 2012 [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd 154:82-86]. The Swiss safety guidelines are 100 times more stringent than are the ICNIRP safety guidelines, emphasizing the complete inadequacy of the ICNIRP safety guidelines. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (also called cell phone towers), the calves are born with very greatly increased incidences of cataracts. It follows from these findings that, even though the developing fetuses are very deep in the body of the mother and should be highly protected from the EMF exposures, they are not so protected. Furthermore, because the mothers do not develop cataracts despite their eyes being much more exposed to cell phone tower radiation, this clearly argues that the fetal eye tissue is

vastly more sensitive to EMF effects than is adult eye tissue. When ICNIRP claims there is no evidence but there clearly is evidence, this destroys whatever credibility ICNIRP may have had.

However, extensive, well-performed studies have failed to identify developmental effects at whole body average SAR levels up to 4 W kg^{-1}. In particular, a large four-generation study on fertility and development using SAR levels up to 2.34 W kg^{-1} found no evidence of adverse effects (Sommer et al., 2009) **(This claim is shown to be false in the previous paragraph).** *Some studies have reported effects on male fertility at exposure levels below this value, but these studies have had methodological limitations, and reported effects have not been substantiated* **[no evidence provided]**. Completely false as shown in previous paragraph. *Epidemiological studies have investigated various aspects of male and female infertility and pregnancy outcomes in relation to radiofrequency EMF exposure. Some epidemiological studies found associations between radiofrequency EMF and sperm quality or male infertility, but taken together, the available studies do not provide strong evidence for an association with radiofrequency EMF exposure as they all suffer from limitations in study design or exposure assessment* **(no evidence provided].** Untrue as shown above*. A few epidemiological studies are available on maternal mobile phone use during pregnancy and potential effects on child neurodevelopment. There is no substantiated evidence that radiofrequency EMF exposure from maternal mobile phone use affects child cognitive and psychomotor development, or causes developmental milestone delays* **[no evidence provided]**.

In summary, no adverse effects of radiofrequency EMF exposure on fertility, reproduction or development relevant to human health have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 9 (Cancer)

There is a large body of literature concerning cellular and molecular processes that are of particular relevance to cancer. This includes studies of cell proliferation, differentiation and apoptosis-related processes, proto-oncogene expression, genotoxicity, increased oxidative stress, and DNA strand breaks. Although there are reports of effects of radiofrequency EMF on a number of these endpoints, there is no substantiated evidence of health-relevant effects. **[No evidence provided]**. What ICNIRP is apparently claiming is that these effects of EMF exposure, each of which has been shown in an extraordinarily large scientific literature to have an important role in cancer causation, are—inexplicably—not relevant to health! We are relying on the Melnick critique to provide a much broader ranging assessment of the many flaws in this cancer section of the ICNIRP draft. We urge ICNIRP to pay close attention to the Melnick critique.

A few animal studies on the effect of radiofrequency EMF exposure on carcinogenesis have reported positive effects, but in general, these studies either have shortcomings in methodology or dosimetry, or the results have not been replicated in independent studies. Indeed, the great majority of studies have reported a lack of carcinogenic effects in a variety of animal models. A replication of a study in which exposure to radiofrequency EMF increased the incidence of liver and lung tumors in an animal model with prenatal exposure to the carcinogen ENU (ethylnitrosourea) indicates a possible promoting effect (Lerchl et al., 2015; Tillmann et al., 2010). The lack of a dose-response relationship, as well as the use of an untested mouse model for liver and lung tumors whose relevance to humans is uncertain (Nesslany et al., 2015), makes interpretation of these results and their applicability to human health difficult, and therefore there is a need for further research to better understand these results.

A recent, large animal study, performed by the US National Toxicology Program (NTP) reported an increased rate of cardiac schwannoma in male rats exposed to radiofrequency EMF, but not in female rats or either male or female mice (NTP 2018). As the exposure was approximately 75 times higher than the ICNIRP (1998) whole body average general public limit, the results are not directly relevant to radiofrequency EMF levels that humans would typically be exposed to. Further, humans are far more efficient at diminishing the resultant body core temperature rise than rats. As noted by the internal NTP review (NTP 2018), there are also a number of methodological issues that limit the usefulness of the results for EMF health assessment. Of particular note is that the statistics were not able to determine whether the higher number of cardiac schwannomas that were reported was more than what would be expected by chance alone (given that no control for multiple comparisons was applied). This is particularly important given that a graded dose-response relation was not found, no consistency across rodent species or genders was found, and the results are not consistent with the radiofrequency EMF cancer literature more generally. A similar study that was conducted concurrently with the NTP study reported that they had replicated these NTP results on cardiac schwannoma (Falcioni et al., 2018). However, similar to the NTP study, the statistics were also not designed to determine whether the increase was higher than would be expected by chance alone (due to uncorrected multiple statistical comparisons). The schwannoma findings in these two studies are inconsistent in terms of the exposure-response association as the Italian study observed an 'increased' number of schwannomas at low exposure levels where no increase in schwannoma was observed in the NTP study. These studies therefore do not provide sufficient evidence to conclude that radiofrequency EMF can cause cancer.

A large number of epidemiological studies of mobile phone use and cancer risk have also been performed. Most have focused on brain tumors, acoustic neuroma and parotid gland tumors, as these occur in close proximity to the typical exposure source from mobile phones. However, some studies have also been conducted on other types of tumors, such as leukaemia, lymphoma, uveal melanoma, pituitary gland tumors, testicular cancer, and malignant melanoma. With a few exceptions, the studies have used a case-control design and have relied on retrospectively collected self-reported information about mobile phone use history.

Only two cohort studies with prospective exposure information are available. Several studies have had follow-ups that were too short to allow assessment of a potential effect of long-term exposure, and results from case-control studies with longer follow-up are not consistent. The large, IARC coordinated, Interphone study did not provide evidence of a raised risk of brain tumors, acoustic neuroma or parotid gland tumors among regular mobile phone users, and the risk estimates did not increase with longer time since first mobile phone use (Interphone, 2010; 2011). It should be noted that although somewhat elevated odds ratios were observed at the highest level of cumulative call time for acoustic neuroma and glioma, there were no trends observed for any of the lower cumulative call time groups, with among the lowest risk estimates in the penultimate exposure category. This, combined with the inherent recall bias of such studies, does not provide evidence of an increased risk. Similar results were observed in a Swedish case-control study of acoustic neuroma (Pettersson et al., 2014). Contrary to this, a set of case-control studies from the Hardell group in Sweden report significantly increased risks of both acoustic neuroma and malignant brain tumors already after less than five years since the start of mobile phone use, and at quite low levels of cumulative call time. However, they are not consistent with trends in brain cancer incidence rates from a large number of countries or regions, which have not found any increase in the incidence since mobile phones were introduced. Furthermore, no cohort studies (which, unlike case-control studies, are not affected by recall or selection bias) report a higher risk of glioma, meningioma or acoustic neuroma among mobile phone subscribers, or when estimating

mobile phone use through prospectively collected questionnaires. Studies of other types of tumors have also not provided evidence of an increased tumor risk in relation to mobile phone use. Only one study is available on mobile phone use in children and brain tumor risk. No increased risk of brain tumors was observed. Studies of exposure to environmental radiofrequency EMF fields, for example from radio and television transmitters, have not provided evidence of an increased cancer risk either in children or in adults. Studies of cancer in relation to occupational radiofrequency EMF exposure have suffered substantial methodological limitations and do not provide sufficient information for the assessment of carcinogenicity of radiofrequency EMF fields. Taken together, the epidemiological studies do not provide evidence of a carcinogenic effect of radiofrequency EMF exposure at levels encountered in the general population. In summary, no effects of radiofrequency EMF on cancer have been substantiated.

Appendix 2

Reviews showing important health-related non-thermal effects of microwave frequency electromagnetic fields (EMFs)

Specific effects and reviews, each reporting the effect in multiple primary literature studies

Effects on cellular DNA including single-strand and double-strand breaks in cellular DNA and on oxidized bases in cellular DNA; also evidence for chromosomal mutations produced by double-strand DNA breaks

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Lowered fertility, including tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovarian remodeling, oocyte (follicle) loss, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, lowered libido

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Apoptosis/cell death

Apoptosis is an important process in the production of neurodegenerative diseases that is also important in producing infertility responses.

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Oxidative stress/free radical damage (important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage)

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Endocrine, that is hormonal effects

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Increased intracellular calcium

Intracellular calcium is maintained at very low levels (typically about 2 X 10^{-9} M) except for brief increases used to produce regulatory responses, such that sustained elevation of intracellular calcium levels produces many pathophysiological (that is disease-causing) responses.

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Cancer causation by EMF exposures

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Appendix 3

Reviews showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity

Pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity. This is important because all wireless communication devices communicate via pulsations and because the "smarter" the device, the more it pulses because the pulsations convey the information. What should be obvious is that you cannot study such pulsation roles if there were no biological effects produced by such EMFs. The pulsation studies alone tell us that there are many such EMF effects.

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La « Drôle de guerre» de la 5G contre l'humanité

Claire Edwards, 19 janvier 2019

Les premiers huit mois quasi sans combat de la deuxième guerre mondiale ont été appelés la « Drôle de guerre ». L'utilisation des ondes millimétriques comme technologie de communication sans fil de cinquième génération (5G) est une autre forme de drôle de guerre. C'est une drôle de guerre silencieuse où des tirs ont bien lieu cette fois – sous la forme de faisceaux d'ondes, comme des lasers, en provenance de rangées de minuscules antennes[1] – et pourtant nul sur la ligne de feu ne se rend compte que des blessures sérieuses et irréparables sont en train de se produire.[2,3]

Dans un premier temps, la 5G risque de rendre tout le monde électrohypersensible (EHS).[4] C'est peut-être par le fait d'être assise devant deux grands écrans d'ordinateur pendant bon nombre des 18 années où j'ai travaillé à l'ONU que je suis devenue électrohypersensible. Lorsque l'ONU a installé, en décembre 2015, des points d'accès permettant d'amplifier le signal wifi (des équipements prévus pour de vastes espaces publics!) dans tous les couloirs étroits dotés de murs en métal du Centre international de Vienne, j'ai été malade sans arrêt pendant sept mois de suite.

Je fis alors de mon mieux, pendant deux ans et demi, pour alerter le syndicat du personnel et les services administratif et médicaux de l'ONU de Vienne quant aux risques pour la santé du rayonnement électromagnétique venant de ces points d'accès sans-fil, mais ce fut en vain. Cette absence de réaction m'a finalement poussée, en mai 2018, à m'adresser directement au secrétaire général de l'ONU, António Guterres [transcription]. Physicien et ingénieur électricien, il a donné des conférences sur les signaux de télécommunication au début de sa carrière. Pourtant, il m'a affirmé qu'il ne s'y connaissait guère sur le sujet. Il s'est engagé à demander à l'Organisation mondiale de la santé de se pencher sur mes questions et pourtant, alors que sept mois se sont écoulés, ces points d'accès publics restent en place. Je n'ai reçu aucune réponse à mes nombreux courriels de suivi.

Suite à ces événements, j'ai eu l'occasion de m'investir pour la publication de l'**Appel international demandant l'arrêt du déploiement de la 5G sur terre et dans l'espace** et c'est avec plaisir que j'ai relevé le défi. J'avais bien compris que, malgré la publication des 43 appels scientifiques précédents, presqu'aucune personne lambda n'était consciente des dangers des ondes électromagnétiques. Je me suis dit que mon expérience de rédactrice pouvait contribuer à assurer qu'un nouvel appel – ledit appel censé cette fois inclure la question de la 5G de l'espace – permette au lecteur non spécialiste de lire un texte clair, détaillé, explicatif et accessible. C'est maintenant chose faite et le résultat est un **Appel** entièrement référencé, citant plus de cent documents scientifiques parmi les dizaines de milliers qui confirment les effets biologiques des ondes électromagnétiques publiés au cours des derniers quatre-vingt ans.[5]

J'ai passé des années à corriger des textes de l'ONU concernant les affaires spatiales et suis donc bien placée pour savoir que l'espace est un haut lieu de géostratégie fortement visé et convoité ! Tout événement suspect relatif aux satellites militaires est susceptible de mettre le feu aux poudres.[6]

Le droit spatial a tellement de zones d'ombre – prenez par exemple la question complexe de la législation spatiale en matière de responsabilité[7,8] : en fait, l'espace peut être considéré comme le nouveau Far West ! La Chine a provoqué la consternation de la communauté internationale en 2007 quand elle a montré qu'elle possédait des missiles antisatellites en détruisant son propre satellite dans l'espace. Les débris spatiaux sont au centre des préoccupations des pays ayant un programme spatial. Il faut savoir que selon le scénario envisagé par le syndrome de Kessler, une réaction en chaîne par effet de cascade de débris spatiaux (se heurtant de plus en plus vite et devenant de plus en plus petits), pourrait rendre les orbites terrestres inutilisables pendant mille ans ![9] Vous semble-t-il rationnel de lancer dans l'espace plus de 20 000 satellites commerciaux sous ces conditions ?

J'habite à Vienne, en Autriche, où du jour au lendemain le déploiement de la 5G semble chose faite ou presque. L'équipement est quasi déjà en place : au cours des cinq dernières semaines on a fait l'annonce officielle de la pré-5G à l'aéroport de Vienne et même de la 5G (qui reste en fait encore au stade de la pré-5G) sur le *Rathausplatz* de Vienne, soit la place de l'hôtel de ville. Cette place est un lieu festif qui attire des milliers de visiteurs tous les ans, notamment à son populaire marché de Noël, un endroit particulièrement féérique pour les enfants en novembre et décembre ! Or, tout comme les oiseaux et les insectes, les enfants sont les plus vulnérables aux dommages causés par la 5G en raison de leurs petits corps.[10]

Des personnes de mon cercle d'amis et de mon cercle de connaissances, ici à Vienne, me décrivent des symptômes classiques d'exposition aux CEM.[11] Ce qui m'a été rapporté, ce sont des saignements de nez, des maux de tête, des douleurs aux yeux, des douleurs thoraciques, des nausées, de la fatigue, des vomissements, des acouphènes, des étourdissements, des symptômes pseudo-grippaux, des douleurs cardiaques ainsi qu'une sensation de bande serrée autour de la tête, de la pression sur le dessus de la tête, des courtes douleurs lancinantes à différents endroits du corps et une sensation de vibration interne. Il faut habituellement du temps avant que certains des effets biologiques établis par la science se manifestent, par exemple pour les tumeurs et la démence. Mais qui sait dans le cas de la 5G, puisque l'impact sur la santé et la sécurité n'a jamais été testé ?[12]

Depuis le lancement de l'infrastructure pré-5G un peu partout en Autriche, en seulement trois semaines, une amie chère à mon cœur, de robuste constitution depuis toujours, a dû prendre la fuite précipitamment d'un pays où elle a habité pendant presque 30 ans ! Chaque personne réagit différemment aux CEM. Pour elle, c'était une torture extrême et nous avons donc passé ses dernières deux nuits en Autriche à dormir dans la forêt. Elle a quitté le pays en voiture et a trouvé que la situation RF au sud de l'Allemagne est encore pire que celle de l'Autriche, tandis qu'au nord de l'Allemagne elle n'a plus ressenti aucun symptôme et s'est senti tout à fait normale.

Ceci peut sembler incroyable mais aucune limite réglementaire d'exposition au CEM n'existe légalement. C'est bien commode pour l'industrie des télécommunications. Il n'existe que de vagues lignes directrices n'ayant aucune valeur légale produites par une toute petite ONG en Allemagne, solennellement appelée « Commission internationale pour la protection contre les rayonnements non ionisants » (International Commission on Non-Ionising Radiation Protection ou ICNIRP). Cette ONG, l'ICNIRP, quasiment inconnue du grand public a des pouvoirs magiques

comme le magicien d'Oz. Elle désigne en son sein ses propres membres, parmi lesquels on ne trouve aucun médecin ni expert en environnement.[13]

Comme le magicien d'Oz, l'ICNIRP fait disparaître d'un coup de baguette tout effet non thermique (non chauffant) des CEM. La prise en compte des dizaines de milliers d'études qui démontrent les effets biologiques des rayons non ionisants remettrait en cause les soi-disantes lignes directrices de sécurité ! [14] D'un autre coup de baguette apparemment, toutes les recommandations de l'ICNIRP sont adoptées mot pour mot par l'Union Internationale des Télécommunications, organisation faisant partie de la famille des organisations de l'ONU.[15] Et un seul petit courriel envoyé à l'ICNIRP en octobre 2018 pour lui faire part des commentaires du professeur Martin Pall sur le nouveau projet de lignes directrices de l'ICNIRP a suscité une explosion d'intérêt immédiat pour la présence en ligne de l'expéditeur - qui n'avait attiré jusque-là l'intérêt de personne – des entreprises du monde entier, des autorités de l'immigration d'un pays, le bureau du chancelier autrichien (le chef du gouvernement), un cabinet d'avocats à Vienne et même Interpol ![16,17]

J'espère que les gens liront et partageront notre **Appel Stop 5G Terre et Espace** pour prendre conscience et éveiller la conscience d'autrui. J'espère que les gens pourront s'en servir pour agir contre le déploiement de la 5G, dont la valeur pour l'économie mondiale est estimée à plusieurs milliards de dollars.

Comme la drôle de guerre, il suffirait certainement de huit mois pour jeter la Terre et la vie qui l'habite dans une situation inédite et catastrophique. Elon Musk entend lancer les premiers 4 425 satellites 5G au mois de juin 2019 et recouvrir la Terre de radiation 5G, en violation à d'innombrables traités internationaux. Son action risque de déclencher la dernière grande extinction, cadeau empoisonné de l'ambitieux projet 5G, l'expérience biologique à l'échelle la plus grande de toute l'histoire de l'humanité. C'est aussi la manifestation de l'arrogance et de l'appât du gain poussé à son plus grand paroxysme ![10]

La première réaction à l'idée que la 5G est une menace existentielle à toute vie sur Terre est l'incrédulité ou la dissonance cognitive. Une fois les faits examinés, pourtant, la deuxième réaction, c'est la terreur. Il faut transcender la peur pour voir la 5G en tant qu'opportunité de nous responsabiliser et d'agir. Il se peut que nous ayons déjà perdu 80 pour cent de nos insectes aux CEM pendant les derniers 20 ans.[18] Nos arbres risquent d'être abattus par millions pour assurer que les signaux des voitures autonomes, des bus et trains sans chauffeurs demeurent fiables et continus. Va-t-on rester les bras croisés pendant que nous-mêmes et nos enfants sommes irradiés, que nos systèmes alimentaires sont détruits, que notre nature est décimée ?[19,20]

Les journaux vulgarisent nonchalamment la doxa fataliste que nous mériterons bien notre mort ou déclin programmé,[21,22] mais lorsque la question devient non plus rhétorique mais réelle, lorsqu'il s'agit de *votre* vie, *votre* enfant, *votre* communauté, *votre* milieu naturel qui sont réellement menacés, êtes-vous d'accord avec une telle proposition ? Si vous répondez « Non ! », veuillez signer **l'Appel Stop 5G Terre et Espace** et prenez un rôle actif. Contactez tous ceux qui, à votre avis, ont le pouvoir ou la possibilité d'arrêter le déploiement de la 5G, surtout Elon Musk[23] et les PDG de toutes les autres sociétés qui prévoient lancer des satellites 5G, commençant d'ici

seulement 20 semaines. Votre aide immédiate est indispensable pour la Vie sur Terre.

La transcription qui suit restitue par écrit ma conversation avec le Secrétaire général de l'ONU, qui a eu lieu le 14 mai 2018:

[Début de la transcription]

Employée: *Monsieur le secrétaire général, on répète régulièrement au personnel de l'ONU qu'il est la plus importante richesse de cette organisation.*

Or, depuis le mois de décembre 2015, le personnel en poste au Centre international de Vienne est exposé à des champs électromagnétiques d'un niveau inédit émanant des amplificateurs wifi et des répéteurs de signal mobile qui ont été suspendus aux plafonds très bas des couloirs de tous nos bâtiments.

Les doses d'exposition du public sont actuellement d'au moins un milliard de milliards de fois – un chiffre à 18 zéros – au-dessus du rayonnement naturel normal selon le professeur Olle Johansson de l'Institut Karolinska de Suède.

Les effets biologiques extrêmement néfastes des champs électromagnétiques (CEM) ont été documentés par des milliers d'études depuis 1932, indiquant que nous sommes peut-être confrontés à une catastrophe sanitaire mondiale d'une envergure plus grande encore que celles causées par le tabac et l'amiante.

Monsieur le secrétaire général, en vertu du principe de précaution, je vous demande de faire retirer immédiatement ces appareils à hyperfréquences de nos bâtiments et de stopper tout déploiement de la 5G (cinquième génération) sur tous les lieux d'affectation de l'ONU, car la 5G est conçue pour utiliser tant les hyperfréquences que les micro-ondes millimétriques par faisceaux focalisés et concentrés, dépassant d'au moins cent fois nos seuils actuels, comme le font les armes à faisceau d'énergie dirigée.

Conformément aux Principes directeurs relatifs aux entreprises et aux droits de l'homme: mise en œuvre du cadre de référence « protéger, respecter et réparer », il est impératif que la technologie 5G soit soumise à une évaluation indépendante de santé et de sécurité avant qu'elle ne soit déployée dans le monde entier.

À l'heure actuelle, un Appel international qui a été signé par 237 scientifiques CEM de 41 pays demande à l'ONU, et particulièrement à l'OMS, de se mobiliser afin d'élaborer des directives CEM plus protectrices, de favoriser l'adoption de mesures préventives et de sensibiliser le public aux risques sanitaires considérables, notamment pour le développement du fœtus et pour l'enfant.

Monsieur le Secrétaire général, je pense que nous avons la possibilité, exceptionnelle, ici, à l'Office des Nations Unies de Vienne, puisque tous nos dossiers médicaux sont numérisés : la possibilité vous est offerte, et vous pouvez faire ce choix, d'analyser les données d'une population contingentée soumise à des niveaux hors normes de rayonnement électromagnétique dans un édifice aux murs de métal – ce qui aggrave la situation – et vous pourrez évaluer s'il y a déjà eu des effets néfastes pour le personnel de l'ONU, ici, au cours des derniers 28 mois.

S'il-vous-plaît, vous pouvez faire cela et demander l'arrêt de tout déploiement de la 5G dans ces bâtiments !

Je vous remercie.

Secrétaire général de l'ONU : *Je dois m'excuser, car vous parlez à quelqu'un qui est un peu ignorant de ces choses-là. Vous parlez des systèmes wifi ?*

Employée : *Il y a aux plafonds de ces bâtiments, des répéteurs wifi et des amplificateurs de réseau pour les portables qui ont été installés sans concertation, sans en informer le personnel, au mois de décembre 2015. J'ai entendu parler de nombreuses personnes qui ont eu des ennuis de santé. Je ne sais pas s'il y a un lien mais, en vertu du principe de précaution, il serait judicieux de notre part de vérifier nos dossiers médicaux et aussi de retirer immédiatement tous ces dangereux appareils. Je vous remercie.*

Secrétaire général de l'ONU : *Eh bien, je suis inquiet parce que j'ai mis ces appareils dans ma maison.* [rires et applaudissements]

Employée : *Mauvaise idée !*

Secrétaire général de l'ONU : *Il faudra que je… Je veux dire… J'avoue mon ignorance là-dessus. Je vais soulever cette question avec l'OMS – car c'est l'organisation qui selon moi pourrait peut-être donner une suite adéquate à ceci. Ils pourront s'adresser à quelqu'un, à des membres du personnel ou bien à des organisations qui se pencheront là-dessus car je dois avouer que je n'étais pas au courant de ce danger* [avec humour] *au point que j'ai même mis ces trucs dans les pièces de ma maison – au plafond.*

Employée : *Je propose que tout le monde commence à se renseigner sur la question et notamment sur la 5G, ce que 237 scientifiques de 41 pays considèrent comme une menace beaucoup plus grave que les menaces du tabac et de l'amiante du passé.*

Secrétaire général de l'ONU : *Bien. J'ai peut-être appris quelque chose d'entièrement nouveau et j'espère que cela me sera utile, mais j'avoue que c'est la première fois que j'en entends parler.*

[Fin de la transcription]

Les opinions exprimées dans cet article appartiennent à l'auteur et ne représentent pas forcément les opinions des autres auteurs de ***l'Appel international demandant l'arrêt du déploiement de la 5G sur terre et dans l'espace****.*

Claire Edwards est titulaire d'une licence avec mention et d'une maîtrise ès arts. Elle a travaillé de 1999 à 2017 pour les Nations Unies comme rédactrice et coach en rédaction interculturelle. Depuis le mois de mai 2018, elle collabore avec Arthur Firstenberg afin de publier le texte collectif de ***l'Appel international demandant l'arrêt du déploiement de la 5G sur terre et dans l'espace***

*(www.5gspaceappeal.org). L'**Appel** a réuni jusqu'à maintenant plus de 31 000 signataires de 108 pays, mais il importe de le diffuser bien davantage.*

*Un appel aux dons a été lancé pour aider à une plus grande diffusion de l'**Appel** et pour informer la population sur la menace existentielle de la 5G, particulièrement la 5G de l'espace. Si les plans de l'industrie se concrétisent, les satellites 5G seront mis en opération à partir de juin 2019 et couvriront la terre entière de rayonnement 5G. Il n'y aura aucune issue de secours pour aucun organisme vivant, nulle part sur la planète (www.5gspaceappeal.org/donate/).*

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www.5gspaceappeal.org/contact/.

*L'Appel est disponible en chinois (**中文**), japonais (**日本語**), croate (Hrvatski), tchèque (Český), danois (Dansk), finlandais (suomi), français (Français), allemand (Deutsch), grec (Ελληνική), hongrois (Magyar), italien (Italiano), norvégien (Norsk), polonais (Polski), portugais (Português), roumain (Română), russe (Русскuй), serbe (Српски), espagnol (Español) et en turc (Türkçe). Il sera bientôt disponible en hollandais, en macédonien, en mongol et en suédois (www.5gspaceappeal.org/the-appeal/). Nous cherchons des traducteurs bénévoles pour d'autres langues.*

[1] Pour visualiser des antennes à balayage électronique: présentation de 2003 par Nicolas Burlet, consulté le 9 décembre 2018. http://nicolas.burlet.free.fr/tipe/balayage_electronique.html
Voir également (anglais seulement): Delos, Peter. "La voie vers une nouvelle architecture radar par balayage électronique." TechTime: Electronics & Technology News. Le 15 janvier 2018, vu le 1er janvier 2019. https://techtime.news/2018/01/ 15/analog-devices-phased-array-radar/. “Bien que l’on parle beaucoup des entrées et sorties multiples (MIMO massive) et des radars de courte portée pour les automobiles, il ne faut pas oublier que l’essentiel du développement radar et de la R & D en matière de formation de faisceaux concerne l’industrie de la défense et que ces travaux sont en cours d’adaptation pour les applications commerciales. Alors que le balayage électronique et la formation de faisceaux passaient des efforts de R & D à la réalité dans les années 2000, on s’attend maintenant à une nouvelle vague d’antennes militaire par réseau focalisés, rendus possibles par la technologie industrielle offrant des solutions auparavant inabordables.”

[2] *Être Connecté Peut Nuire Gravement à La Santé*. Radio Télévision Suisse (RTS). Temps présent : Magazine de Reportages. 31 mai 2017. Consulté le 19 janvier 2019. https://www.youtube.com/watch?v=PnnUbWRGJz8.

[3] *La 5G Risquée Pour La Santé* ? TV5Monde. 6 décembre, 2018. Consulté le 9 janvier 2019. https://www.youtube.com/watch?v=rDwsWqJCYqI.

[4] Pour mieux connaître ce qu'est l'électrohypersensisibilité, voir: les "Témoignages de personnes hypersensibles" (EHS). Robin des Toits, consulté le 9 janvier 2018.
https://www.youtube.com/user/electrosensible
"L'Association Robin des Toits lutte pour la sécurité sanitaire dans la technologie sans fil et cherche à comprendre et démontrer les dangers du téléphone portable et des antenne-relais.”

[5] La recherche existe effectivement depuis au moins 80 ans. Pour s'en convaincre, voir la liste exhaustive du lieutenant Zorach Glaser (anglais seulement), "Index cumulatif portant sur la bibliographie des phénomènes biologiques ("effets") signalés et des manifestations cliniques attribuées aux rayonnements hyperfréquences et radiofréquences: Rapport, suppléments (n°1-9)." Bulletin BEMS B-1 à B-464 (1984). Consulté le 1er janvier 2019.
http://www.cellphonetaskforce.org/wp-content/uploads/2018/06/Zory-Glasers-index.pdf
Le lieutenant Glaser, PhD, a catalogué 5 083 études, livres et rapports de conférence pour la marine américaine jusqu’en 1981.

[6] En savoir plus sur les enjeux dans: "Durabilité de l’espace: Un guide pratique (anglais seulement)" *Secure World Foundation*, 2014, p. 21. Consulté le 1er janvier 2019.
https://swfound.org/media/206289/swf_space_sustainability-a_practical_guide_2018__1.pdf.
“Au fur et à mesure du temps, de plus en plus de pays intègrent l'espace dans leur capacité militaire et s'appuient sur des informations spatiales pour la sécurité nationale. De ce fait, il est de plus en plus probable que toute ingérence (réelle ou perçue) sur les satellites pourrait provoquer ou aggraver des tensions et des conflits dans l’espace ou sur la terre. Cela est complexifié d’autant plus par le défi posé pour trouver la cause exacte d'un dysfonctionnement de satellite: s'agit-il d'un événement météorologique, d'un impact causé par des débris spatiaux, d'une ingérence involontaire ou d'un acte d'agression délibéré ?"

[7] "Droit spatial: responsabilité à l’égard des débris spatiaux". Texte publié en anglais par la Société à responsabilité limitée Panish, Shea & Boyle. 2018. Consulté le 1er janvier 2019. https://www.aviationdisasterlaw.com/liability-for-space-debris/
" Poursuivre SpaceX en justice pour les débris spatiaux est un peu différent d’une poursuite contre la société commerciale ou le fait que le lancement soit financé par l’État. Étant donné que SpaceX est une société privée, les victimes peuvent déposer des réclamations directement contre l’établissement, conformément aux lois de l’État relatives aux dommages corporels. Le demandeur devra prouver que SpaceX a été négligent d'une manière qui a provoqué la collision de débris spatiaux. Le droit de l'espace est notoirement complexe et il est très difficile pour les parties lésées de récupérer leurs dommages en Californie."

[8] Travaux de Von Der Dunk, Frans G. " Droit de l'espace: Responsabilité légale versus responsabilité tout court, incompréhension ou erreur ?" (anglais seulement) Collège de droit de l'Université du Nebraska et de Lincoln: Publication 21 de la faculté de droit de l'espace, de cyber droit et des télécommunications (1992). Consulté le 1er janvier 2019.
http://digitalcommons.unl.edu/spacelaw/21/?utm_source=digitalcommons.unl.edu/spacelaw/21&utm_medium=PDF&utm_campaign=PDFCoverPages.

[9] Pour en savoir plus sur le syndrome de Kessler, voir:
https://www.universalis.fr/encyclopedie/syndrome-de-kessler/
Voir aussi (en anglais seulement) Kessler, D.J., P.M. Landry, B.G. Cour-Palais et R.E. Taylor. "Aérospatiale: prévention des collisions dans l'espace: prolifération des charges utiles et action rapide pour prévenir les accidents des débris spatiaux" IEEE Spectrum 17, no. 6 (1980): pages 37-41.

[10] Morgan, L. Lloyd, Santosh Kesari et Devra Lee Davis. "Pourquoi les enfants absorbent plus de radiations hyperfréquences que les adultes: les conséquences (anglais seulement)" *Journal of Microscopy and*

Ultrastructure 2, no. 4 (décembre 2014): pages 197-204. Consulté le 1er janvier 2019.
https://www.sciencedirect.com/science/article/pii/S2213879X14000583
Faits saillants:
(1) Les enfants absorbent plus de rayonnement hyperfréquence que les adultes.
(2) Le rayonnement hyperfréquence est un cancérogène (possible) de la classe 2B.
(3) Le fœtus est plus en danger que les enfants du fait de son exposition au rayonnement hyperfréquence.
(4) Les limites d'exposition légales ne sont pas modifiées depuis des décennies.
(5) Les avertissements aux manuels des téléphones portables et la règle des 20 cm pour les tablettes / ordinateurs portables violent le règlement de la «position de fonctionnement normal».

[11] *Hypersensibilité électro: Parler à votre médecin (anglais seulement).* PDF. Initiative canadienne contre la pollution sans fil, électrique et électromagnétique.
http://weepinitiative.org/talkingtoyourdoctor.pdf

[12] *Président de la FCC sur la 5G: «Nous n'étudierons pas, ne réglementerons pas, n'aurons pas de normes pour cela.»* (anglais seulement) Youtube. 20 juin 2016. Consulté le 1er janvier 2019. www.youtube.com/watch?v=Bwgwe01SIMc
Notes extraites de la vidéo: Rayonnement ultra haute fréquence (24 à 100 GHz ou plus); signaux dirigés et amplifiés; déploiement massif de stations de bases 5G; vaut des milliards de dollars; pas de normes, pas de tests; partage avec les satellites et les opérations militaires; toutes les zones (y compris les zones rurales) doivent être saturées de radiations; tous les déploiements locaux doivent être accélérés; toute chose sera micropucée.

[13] Dariusz Leszczynski, PhD. "L'ICNIRP est-elle suffisamment fiable pour dicter le sens de la science aux responsables gouvernementaux de la réglementation du risque? (anglais seulement)" Tiré du blog *Between a Rock and a Hard Place*, 4 avril 2016. Consulté le 2 janvier 2019.
https://betweenrockandhardplace.wordpress.com/2016/04/04/icnirp-did-it-again/
«Les principaux problèmes de l'ICNIRP sont les suivants:
(1) il s'agit d'un« club privé » dans lequel les membres élisent de nouveaux membres sans avoir à justifier leur choix;
(2) le manque de responsabilité devant quiconque;
(3) le manque de transparence de leurs activités;
(4) absence totale de supervision de ses activités;
(5) une évaluation scientifique biaisée en raison de l'étroite similitude des opinions de tous les membres de la commission principale et de tous les autres scientifiques choisis comme conseillers de la commission principale. ”

[14] Matthes, Rüdiger."Consignes de sécurité des CEM: le point de vue d'ICNIRP (anglais seulement)" *Atelier de l'Union internationale des télécommunications sur l'exposition humaine aux champs électromagnétiques*, 9 mai 2013. Consulté le 1er janvier 2019.
https://www.itu.int/en/ITU-T/climatechange/emf-1305/Documents/Presentations/s2part1p1-RuedigerMatthes.pdf

[15] Commission d'études 2 du Secteur du développement des télécommunications de l'UIT: Session sur les politiques, directives, réglementations et évaluations modernes concernant l'exposition des individus aux RF-EMF. *Session 1: Activités récentes sur l'exposition humaine aux RF-EMF à l'UIT et à l'ICNIRP (anglais seulement)*, Genève, Suisse. 10 octobre 2018. Consulté le 2 janvier 2019.
https://www.itu.int/en/ITU-D/Study-Groups/2018-2021/Pages/meetings/session-Q7-2-oct18.aspx
"La session 1 traitera de certaines des activités récentes organisées à l'UIT et décrira les dernières mises à jour des directives de l'ICNIRP (Commission internationale de la protection contre les rayonnements non ionisants)."

[16] Martin L. Pall, PhD, professeur émérite de biochimie et de sciences médicales de base de la Washington State University. *Réponse au projet de directives et d'annexes de l'ICNIRP de 2018 sur la limitation de l'exposition aux champs électriques, magnétiques et électromagnétiques variables dans le temps (100 kHz à 300 GHz).* 8 octobre 2018. Consulté le 2 janvier 2019.
www.5gexposed.com/wp-content/uploads/2018/10/FINAL-Martin-L-Pall-Response-to-2018-Draft-Guidelines-8.10.18.pdf

[17] Accord de coopération entre l'Organisation internationale de police criminelle Interpol et l'Union internationale des télécommunications, Conférence plénipotentiaire (PP-18) Dubaï, 29 octobre - 16 novembre 2018. Consulté le 2 janvier 2019.
https://www.itu.int/dms_pub/itu-s/md/18/pp/c/S18-PP-C-0047!!MSW-E.docx
“2. Lors de la mise en œuvre de l'accord, chaque partie agit dans les limites de ses compétences respectives. Plus précisément, la mise en œuvre de l'Accord par l'UIT *n'excède pas son mandat concernant l'instauration d'un climat de confiance et de sécurité dans l'utilisation des TIC,* conformément à la Résolution 130 de la Conférence plénipotentiaires (Rév. Busan, 2014) et à son rôle en matière de protection en ligne des enfants. Conformément à la résolution 179 de la Conférence de plénipotentiaires (Rév. Busan, 2014), la

mise en œuvre de l'Accord par INTERPOL *n'excédera pas son mandat, défini à l'article 2 de sa Constitution, qui comprend des activités relatives à la cybercriminalité* et à l'exploitation des enfants en ligne ». (emphase ajoutée)

[18] Hallmann C.A., M. Sorg et E. Jongejans. «Plus de 75% de la biomasse totale d'insectes volants dans les zones protégées a diminué en 27 ans (anglais seulement)». PLOS One 12, no. 10 (2017): e0185809. Consulté le 1er janvier 2019. http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0185809&type=printable.

[19] Laville, Sandra. " Des millions d'arbres menacés dans le cadre du programme d'abattage ferroviaire sur réseau secret. (anglais seulement). " *The Guardian*, 29 avril 2018. Consulté le 1er janvier 2019. https://www.theguardian.com/business/2018/ apr/29/millions-of-trees-at-risk-in-secretive-network-rail-felling-programme

[20] Berger, Sosthène. "L'arc-en-ciel Invisible : Une Histoire De L'électricité Et De La Vie par Arthur Firstenberg - Résumé En Français - 1." Mieux Prévenir. 10 juin 2018. Consulté le 19 janvier 2019. https://mieuxprevenir2.blogspot.com/2018/06/larc-en-ciel-invisible-une-histoire-de.html.

[21] May, Todd. "L'extinction humaine serait-elle une tragédie? (anglais seulement)." *The New York Times*, December 17, 2018. Accessed January 1, 2019. https://www.nytimes.com/2018/12/17/opinion/human-extinction-climate-change.html.

[22] Davis, Nicola. ""La baisse du taux de fécondité total doit être saluée, estime un spécialiste de la population: les chiffres montrant une baisse du taux de natalité sont un motif de fête, pas une alarme". *The Guardian*, 26 décembre 2018. Consulté le 3 janvier 2019. www.theguardian.com/world/2018/dec/26/falling-total-fertility-rate-should-be-welcomed-population-expert-says.

[23] "Planète Terre; Rayonnement 5G mondial en orbite?" Lettre de Claus Scheingraber, Roland Wolff et d'autres à Elon Musk. 18 juin 2018. Brunnthal, Allemagne. "… Nous sommes sûrs que votre projet de satellite est déjà à un stade avancé. Mais même si beaucoup d'argent a été investi, il faut considérer que très bientôt il ne sera plus possible d'ignorer le fait du potentiel préjudiciable pour la santé des communications mobiles - et en particulier de la communication mobile 5G. C'est pourquoi nous recommandons vivement de ne pas mettre en œuvre le projet de satellite.
(Lettre en allemand) (Lettre en anglais)

5G and the IOT: Scientific Overview of Human Health Risks

https://ehtrust.org/key-issues/cell-phoneswireless/5g-networks-iot-scientific-overview-human-health-risks/

5G is the term used to describe the next-generation of mobile networks beyond the 4G LTE mobile networks commonly used today. 5G is intended to be the technology that allows the Internet of Things (IOT) to exist and tie all internet connected devices together.

Currently there is no standard for 5G networks in place and it will be a combination of a variety of frequencies and modulations. Industry is developing exactly what 5G will be as the standard has not been set yet. It is assumed that 5G networks will not become commercially available until 2020 but several cities are rolling out 5G as test areas *now.* Verizon and Sprint have announced "test cities" for 5G which include Sacramento, Washington DC, Atlanta, Dallas, Miami and New York.

A first glance at US government websites such as the CDC and EPA could lead you to believe that this radiation is safe. Yet over 240 scientists and doctors from 41 nations who have published research in the field have appealed to the United Nations calling for urgent action to reduce these ever growing wireless exposures and they wrote the FCC for a moratorium on the roll-out of 5G citing the serious risks that to human health and the environment.

Published peer reviewed science already indicates that the current wireless technologies of 2G, 3G and 4G – in use today with our cell phones, computers and wearable tech – creates radiofrequency exposures which poses a serious health risk to humans, animals and the environment. Scientists are cautioning that before rolling out 5G, research on human health effects urgently needs to be done first to ensure the public and environment are protected.

However, instead of prudent public health measures to ensure the public's safety, governments such as the United States are quickly rolling out 5G networks in neighborhoods and are enacting various state and federal regulations to "streamline" and fasttrack the rollout. These regulations will end the ability of communities to halt and be a part of the decision making process in this massive 5G infrastructure buildout.

Wireless company documents clearly state that 5G will increase the levels of RF radiation in the vicinity of the antennas. Many countries such as China, India, Poland, Russia, Italy and Switzerland have far more protective and stricter radiation limits which will not allow the deployment of 5G as the increased 5G radiation would exceed their limits. These countries are creating roadblocks to the 5G rollout and industry has launched large scale efforts to loosen limits.

Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields is a comprehensive research review of RF effects in human and animal research. The review concludes that scientific evidence is now adequate to conclude radiofrequency radiation is carcinogenic to humans (Miller 2018). Several previously published studies also concluded that RF can "cause" cancer, for example, Hardell 2017, Atzman 2016 and Peleg 2018.

The US National Toxicology Program (NTP) Study on Cell Phone Radiation found "clear evidence" of cancer, heart damage and DNA damage in a $30-million study designed to test the basis for federal safety limits (NIEHS). The heart and brain cancers found in the NTP rats are the same cell type as tumors that researchers have found to be increased in humans who have used use cell phones for over 10 years. Thus, researchers say this animal evidence confirms the human evidence (Hardell 2019.)

The Ramazzini Institute (RI) Study on Base Station RF was another large scale rat study that also found increases in the same heart cancers as the NTP study found—yet the Ramazzini rats were exposed to much lower levels of RF than the NTP rats. In fact, all the RI Ramazzini radiation exposures were below FCC limits, as the study was specifically designed to test the safety of RF limits for cell tower/base stations (Falconi 2018.)

Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans" is a replication study that used very, very low RF exposures (lower than the Ramazzini and NTP study) and combined the RF with a known carcinogen. Researchers found elevated lymphoma and significantly higher numbers of tumors in the lungs and livers in the animals exposed to both RF and the carcinogen, leading researchers to state that previous research (Tillman 2010) was confirmed and that "our results show that electromagnetic fields obviously enhance the growth of tumors" (Lerchl 2015).

5G Wireless Expansion: Public Health and Environmental Implications is a 5G research review that documents the range of reported adverse effects of RF and millimeter waves—effects range from cancer to bacteria growth changes to DNA damage. The study concludes that "a moratorium on the deployment of 5G is warranted" and "the addition of this added high frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome … from both physical and mental health perspectives" (Russell 2018).

"The Human Skin as a Sub-THz Receiver – Does 5G Pose a Danger to It or Not?" and "*The Modeling of the Absorbance of Sub-THz Radiation by Human Skin"* are two papers by physicists presenting research that found higher 5G frequencies are intensely absorbed into human sweat ducts (in skin), at much higher absorption levels than other parts of our skin's tissues (Betzalel 2017, Betzalel 2018). The researchers conclude, "we are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored."

"Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz" published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power between 3% to 370% when the insects were exposed to the frequencies. Researchers concluded, "This could lead to changes in insect behaviour, physiology, and morphology over time…."

Two recent papers that have investigated frequencies to be used in 5G have called out the need to reevaluate current guidelines due to the unique way higher frequencies interact with human tissue. These studies are clear documentation of the reality that 5G technology is being rolled out before adequate research on human exposures. "Systematic Derivation of Safety

Limits for Time-Varying 5G Radiofrequency Exposure Based on Analytical Models and Thermal Dose concludes that the "results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines." "Human Exposure to RF Fields in 5G Downlink concludes "our results show that 5G downlink RF fields generate significantly higher power density (PD) and specific absorption rate (SAR) than a current cellular system. This paper also shows that SAR should also be taken into account for determining human RF exposure in the mmW downlink."

"A review of the ecological effects of RF-EMF" reviewed 113 studies finding RF-EMF had a significant effect on birds, insects, other vertebrates, other organisms and plants in 70% of the studies (Cucurachi 2013). Development and reproduction in birds and insects were the most strongly affected. As an example of the several studies on wildlife impacts, a study focusing on RF from antennas found increased sperm abnormalities in mice exposed to RF from GSM antennas (Otitoloju 2010). Studies on bees have found behavioral effects (Kumar 2011, Favre 2011), disrupted navigation Goldsworthy 2009, Sainudeen 2011, Kimmel et al. 2007) decreasing egg laying rate (Sharma and Kumar, 2010) and reduced colony strength (Sharma and Kumar, 2010, Harst et al. 2006). Research has also found a high level of damage to trees from antenna radiation. For example, a field monitoring study spanning 9 years involving over 100 trees (Waldmann-Selsam 2016) found trees sustained more damage on the side of the tree facing the antenna.

"Towards 5G communication systems: Are there health implications?" is a research review that details how research has found that millimeter waves can alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes." The researchers conclude, "available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle" (Di Ciaula 2018).

Research on People Near Cell Towers Links Exposure to Adverse Effects

"*The Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station"* is a research study that compared people living close (within 80 meters) and far (more than 300 meters away) from cellular antennas and found that the people living closer had several significant changes in their blood predictive of cancer development (Zothansiama 2017). Researchers controlled for various demographics, including the use of microwaves and wireless in the homes.

"Mortality by neoplasia and cellular telephone base stations" is a 10 year study by the Belo Horizonte Brazil Health Department and several universities in Brazil that found an elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell installations (Dode 2011). Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the city's antennas be removed. Many antennas were dismantled.

A 2019 study of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory and attention (Meo 2019). Examples of other effects linked to cell towers in research studies include neuropsychiatric problems,

elevated diabetes, headaches, sleep problems and genetic damage. Such research continues to accumulate after the 2010 landmark review study on 56 studies that reported biological effects found at very low intensities, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular and metabolic changes, and increases in cancer risk (Lai and Levitt 2010).

Cellular Antennas Create Measurable Increases in Radiation in the Area

A 2018 article published in The Lancet Planetary Health points to unprecedented increasing RF exposures (Bandara and Carpenter 2018). Another key finding from Zothansiama 2017 was that homes closer to antennas had measurably higher radiation levels—adding to the documentation that antennas increase RF levels. An Australian study also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters (Bhatt 2016).

A 2018 multi-country study that measured RF in several countries found that cell phone tower radiation is the dominant contributor to RF exposure in most outdoor areas exposure in urban areas was higher and that exposure has drastically increased. As an example, the measurements the researchers tool in Los Angeles, USA were 70 times higher than the US EPA estimate 40 years ago.

THOUSANDS OF MINI CELL TOWERS TO BE BUILT IN FRONT OF HOMES

5G will require the buildout of literally hundreds of thousands of new wireless antennas in neighborhoods, cities and towns. A cellular small cell or other transmitter will be placed every two to ten homes according to estimates. The purpose of this massive infrastructure build out of small cells, distributed antennae systems and microcells is to increase range and capacity in populated urban areas and *prepare for the future 5G rollout*. 5G frequencies will utilize higher frequencies that do not travel as far as the lower frequencies.

US state and federal governments are moving forth regulations which would make the right of way in front of homes as available sites for 5G transmitters – without consent of the property owners. In response, communities are protesting en mass as they do not want these transmitters built in front of their homes and communities want to be able to regulate the placement on right of ways. Some municipalities are taking the case to the courts with litigation.

5G WILL USE HIGHER ELECTROMAGNETIC FREQUENCIES

5G will utilize multiple frequencies from those currently in use for cell phones and wireless to higher millimeter frequencies.

Today's cellular and Wi-Fi networks rely on microwaves – a type of electromagnetic radiation utilizing frequencies up to 6 gigahertz (GHz) in order to wirelessly transmit voice or data. However, 5G applications will require unlocking of new spectrum bands in higher frequency ranges above 6 GHz to 100 GHz and beyond, utilizing submillimeter and millimeter waves – to allow ultra-high rates of data to be transmitted in the same amount of time as compared with previous deployments of microwave radiation.

Click here to read about the difference between 1G, 2G, 3G and 4G
What is the difference between 1G, 2G, 3G and 4G and 5G ?

- 1G = analog
- 2G = digital, voice
    - Examples include GSM, D-AMPS, PDC
    - Data, but only as analog modem (using the whole channel) at 9.6Kbps
    - 2.5G added dedicated digital data (GPRS)
    - 2.75G faster data (EDGE)
    - Data rates from 9.6Kbps (GSM) to 33Kbps (GPRS) 200Kbps or higher(2.75G)

- 3G = digital, supported data, but still circuit switched
    - UMTS / WCDMA, EvDO
    - Includes data but still onto circuit switched architecture
    - 3.5G faster data, added true always-on / packet data (HSPA)
    - Data rates of 2Mbps to tens of Mbps

- 4G = wireless broadband
    - OFDMA, flat architecture, true packet switched
    - Pure data: voice as VoIP (VoLTE)
    - LTE & WiMAX
    - Data rates of tens of Mbps to hundreds of Mbps

Read more at https://www.lifewire.com/mobile-networking-explained-817468

MILLIMETER AND SUBMILLIMETER WAVES ARE BIOLOGICALLY ACTIVE

Current investigations of wireless frequencies in the millimeter and submillimeter range confirm that these waves interact directly with human skin, specifically the sweat glands. Dr. Ben-Ishai of the Department of Physics, Hebrew University, Israel recently detailed how human sweat ducts act like an array of helical antennas when exposed to these wavelengths.

MECHANISM OF ACTION IS PROVEN

Research already indicates serious adverse effects from the wireless modalities in use today. Research studies from the Dielectric Spectroscopy Laboratory of the Department of Applied Physics, Hebrew University of Jerusalem, headed by Dr. Yuri Feldman, indicate that 5Gs millimeter and submillimeter waves will uniquely interact with human skin and lead to preferential layer absorption. The number of sweat ducts within human skin varies from two million to four million. Replicated peer research of these biological effects in laboratory research has been conducted internationally and scientists consider this mechanism of action well proven (See documentation further down on this webpage).

5G FREQUENCIES ARE USED IN WEAPONS

For years, the U.S., Russian and Chinese defense agencies have been developing weapons that rely on the capability of this electromagnetic frequency range to induce unpleasant burning sensations on the skin as a form of crowd control. Millimeter waves are utilized by the U.S. Army in crowd dispersal guns called Active Denial Systems. Dr. Paul Ben-Ishai pointed to research that was commissioned by the U.S. Army to find out why people ran away when the beam touched them. “If you are unlucky enough to be standing there when it hits you, you

will feel like your body is on fire." The U.S. Department of Defense explains how "The sensation dissipates when the target moves out of the beam. The sensation is intense enough to cause a nearly instantaneous reflex action of the target to flee the beam."

HUMAN SKIN WILL BE CLASSIFIED AS AN EXTREMITY ALLOWING HIGHER EXPOSURES

Our skin is our largest organ. Dariusz Leszczynski, PhD, Chief Editor of Radiation and Health has stated that the *International Commission on Non-Ionizing Radiation Protection usually referred to as I*CNIRP – is developing recommendations for public exposure limits of these higher frequencies is planning to classify all the skin in the human body as belonging to the limbs rather than to the head or torso. Leszczynski cautioned that, "If you classify skin as limbs – no matter where the skin is – you are permitted to expose it more than otherwise."

We assume that in terms of US exposure limits this means that the skin will be classified as "an extremity". Extremities are allowed to be exposed to much higher radiation levels than the brain, torso, legs and arms. In the USA extremities -in regards to wireless radiation- are specifically wrists and hands, ankles and feet and the ear.

5G DEPLOYMENT WITHOUT HEALTH EFFECT EVALUATION

5G is being developed and implemented without adequate evaluation of the effect of this technology on human health after long term exposure to these frequencies. Peer reviewed research studies have found adverse effects from the electromagnetic frequencies currently in use and that will be in use for this new technology.

"There is an urgent need to evaluate 5G health effects now before millions are exposed. We need to know if 5G increases the risk of skin diseases such as melanoma or other skin cancers," stated Ron Melnick, the National Institutes of Health scientist, now retired, who led the design of the National Toxicology Program study on cell phone radiofrequency radiation.

In Dr. Cindy Russell's A 5G Wireless Future: Will it give us a smart nation or contribute to an unhealthy one (Text PDF), published in the the Santa Clara Medical Association, Russell states that "3G, 4G, 5G or a combination of zapping frequencies giving us immersive connection and entertainment but at a potentially steep price." Russell details the scientific documentation on 5G's frequencies which include arrhythmias, heart rate variability, bacterial

affects, antibiotic resistance, immune system affects, chromatin affects, teratogenic effects, altered gene expression and cataracts.

Dr. Cindy Russell lists specific recommendations shared by Environmental Health Trust and scientists worldwide.

Scientific Research on 5G, Small Cells and Health

https://ehtrust.org/scientific-research-on-5g-and-health/

Published Scientific Research on 5G, Small Cells and Health

Published peer reviewed science already indicates that the current wireless technologies of 2G, 3G and 4G – in use today with our cell phones, computers and wearable tech – creates (create) radiofrequency exposures which poses (pose) a serious health risk to humans, animals and the environment. Scientists are cautioning that before rolling out 5G, research on human health effects urgently needs to be done first to ensure the public and environment are protected.

Researchers with the renowned Ramazzini Institute (RI) in Italy performed a large-scale lifetime study of lab animals exposed to environmental levels (comparable to allowable limits from cell towers) of RFR radiation and found the rats developed increased cancers- schwannoma of the heart in male rats. This study confirms the $25 million US National Toxicology Program study which used much higher levels of cell phone radiofrequency (RF) radiation, but also reported finding the same unusual cancers as the Ramazzini- schwannoma of the heart in male rats.

5G will utilize not only the frequencies currently in use, but also higher millimeter wave and sub-millimeter wave frequencies. Small cells being installed in cities are usually 4G technology with a wide variety of frequencies. Thus, when we consider the health impacts of 5G and small cells we are looking at research on current technologies and frequencies in use in addition to research on sub-millimeter and millimeter waves. The 5G standard is new there are no studies that have looked at long term human exposure to 5G. However the current body of research finding effects from current wireless technology provides enough data for scientists to call for a moratorium.

This page lists important research on 5G, millimeter waves, cellular antennas, the environment and human health.

Russell CL. 5G wireless telecommunications expansion: Public health and environmental implications. Environmental Research. Available online 11 April 2018. in press.

- "On the horizon, a new generation of even shorter high frequency 5G wavelengths is being proposed to power the Internet of Things (IoT)."
- "It is argued that the addition of this added high frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives."
- "Like other common toxic exposures, the effects of radiofrequency electromagnetic radiation (RF EMR) will be problematic if not impossible to sort out epidemiologically as there no longer remains an unexposed control group. This is especially important considering these effects are likely magnified by synergistic toxic exposures and other common health risk behaviors. Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radiofrequencies, it will be years or decades

before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated."

- "Current radiofrequency radiation wavelengths we are exposed to appear to act as a toxin to biological systems. A moratorium on the deployment of 5G is warranted, along with development of independent health and environmental advisory boards that include independent scientists who research biological effects and exposure levels of radiofrequency radiation. Sound regulatory policy regarding current and future telecommunications initiative will require more careful assessment of risks to human health, environmental health, public safety, privacy, security and social consequences. Public health regulations need to be updated to match appropriate independent science with the adoption of biologically based exposure standards prior to further deployment of 4G or 5G technology."

Betzalel N, Ben Ishai P, Feldman Y., <u>The human skin as a sub-THz receiver – Does 5G pose a danger to it or not?</u> Environ Res. 2018 May;163:208-216. doi: 10.1016/j.envres.2018.01.032. Epub 2018 Feb 22.

- Experimentally we showed that the reflectance of the human skin in the sub-THz region depends on the intensity of perspiration, i.e. sweat duct's conductivity, and correlates with levels of human stress (physical, mental and emotional). Later on, we detected circular dichroism in the reflectance from the skin, a signature of the axial mode of a helical antenna. The full ramifications of what these findings represent in the human condition are still unclear. We also revealed correlation of electrocardiography (ECG) parameters to the sub-THz reflection coefficient of human skin. In a recent work, we developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it. The presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band.
- In this paper, we summarize the physical evidence for this phenomenon and consider its implication for the future exploitation of the electromagnetic spectrum by wireless communication. Starting from July 2016 the US Federal Communications Commission (FCC) has adopted new rules for wireless broadband operations above 24 GHz (5 G). This trend of exploitation is predicted to expand to higher frequencies in the sub-THz region. One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned.
- We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.

Thielens et al., "<u>Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz</u>" Scientific Reports volume 8, Article number: 3924 (2018)

- Excerpts from abstract: "Insects are continually exposed to Radio-Frequency (RF) electromagnetic fields at different frequencies. This paper is the first to report the absorbed RF electromagnetic power in four different types of insects as a function of frequency from 2 GHz to 120 GHz. A set of insect models was obtained using novel Micro-CT (computer tomography) imaging. These models were used for the first time in finite-difference time-domain electromagnetic simulations. All insects showed a dependence of the absorbed power on the frequency. All insects showed a general increase in absorbed RF power at and above 6 GHz, in comparison to the absorbed RF

power below 6 GHz. Our simulations showed that a shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370%."

- "This could lead to changes in insect behaviour, physiology, and morphology over time due to an increase in body temperatures, from dielectric heating. The studied insects that are smaller than 1 cm show a peak in absorption at frequencies (above 6GHz), which are currently not often used for telecommunication, but are planned to be used in the next generation of wireless telecommunication systems."

Miller AB, Morgan LL, Udasin I, Davis DL. Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). Available online Sep 6, 2018. https://doi.org/10.1016/j.envres.2018.06.043

• Increased risk of brain, vestibular nerve and salivary gland tumors are associated with mobile phone use.
• Nine studies (2011–2017) report increased risk of brain cancer from mobile phone use.
• Four case-control studies (3 in 2013, 1 in 2014) report increased risk of vestibular nerve tumors.
• Concern for other cancers: breast (male & female), testis, leukemia, and thyroid.
• Based on the evidence reviewed it is our opinion that IARC's current categorization of RFR as a possible human carcinogen (Group 2B) should be upgraded to Carcinogenic to Humans (Group 1).

Betzalel, Y. Feldman, and P. Ben Ishai, "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin," IEEE Trans. THz Sci. Tech. (Paris) 7(5), 521–528 (2017).

- In 2008, we demonstrated that the coiled portion of the sweat duct in upper skin layer could be regarded as a helical antenna in the sub-THz band. The full ramifications of what these findings represent in the human condition are still very unclear, **but it is obvious that the absorption of electromagnetic energy is governed by the topology for the skin and its organelles, especially the sweat duct.**

Di Ciaula, Towards 5G communication systems: Are there health implications?, Int J Hyg Environ Health. 2018 Feb 2.

- "Preliminary observations showed that MMW increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, affect neuro-muscular dynamics."
- "Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular. However, available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle, to define exposed subjects as potentially vulnerable and to revise existing limits.

Nasim I, Kim S. Human Exposure to RF Fields in 5G Downlink. Submitted on 10 Nov 2017 to IEEE International Communications Conference.

- "Prior research on human exposure to radio frequency (RF) fields in a cellular communications system has been focused on uplink only due to the closer physical

contact of a transmitter to a human body. However, this paper claims the necessity of thorough investigation on human exposure to downlink RF fields, as cellular systems deployed in mmW bands will entail (i) deployment of more transmitters due to smaller cell size and (ii) higher concentration of RF energy using a highly directional antenna.

- In this paper, we present human RF exposure levels in downlink of a Fifth Generation Wireless Systems (5G). Our results show that 5G downlink RF fields generate significantly higher power density (PD) and specific absorption rate (SAR) than a current cellular system. This paper also shows that SAR should also be taken into account for determining human RF exposure in the mmW downlink."

Soubere Mahamoud Y, Aite M, Martin C, Zhadobov M, Sauleau R, Le Dréan Y, et al. (2016) Additive Effects of Millimeter Waves and 2-Deoxyglucose Co-Exposure on the Human Keratinocyte Transcriptome. PLoS ONE 11(8): e0160810.

- Millimeter Waves (MMW) will be used in the next-generation of high-speed wireless technologies, especially in future Ultra-Broadband small cells in 5G cellular networks. Therefore, their biocompatibilities must be evaluated prior to their massive deployment. Using a microarray-based approach, we analyzed modifications to the whole genome of a human keratinocyte model that was exposed at 60.4 GHz-MMW at an incident power density (IPD) of 20 mW/cm^2 for 3 hours in athermic conditions. No keratinocyte transcriptome modifications were observed. We tested the effects of MMWs on cell metabolism by co-treating MMW-exposed cells with a glycolysis inhibitor, 2-deoxyglucose (2dG, 20 mM for 3 hours), and whole genome expression was evaluated along with the ATP content. We found that the 2dG treatment decreased the cellular ATP content and induced a high modification in the transcriptome (632 coding genes). The affected genes were associated with transcriptional repression, cellular communication and endoplasmic reticulum homeostasis. The MMW/2dG co-treatment did not alter the keratinocyte ATP content, but it did slightly alter the transcriptome, which reflected the capacity of MMW to interfere with the bioenergetic stress response. The RT-PCR-based validation confirmed 6 MMW-sensitive genes (*SOCS3*, *SPRY2*, *TRIB1*, *FAM46A*, *CSRNP1* and *PPP1R15A*) during the 2dG treatment. These 6 genes encoded transcription factors or inhibitors of cytokine pathways, which raised questions regarding the potential impact of long-term or chronic MMW exposure on metabolically stressed cells.

Mandl P, Pezzei P, Leitgeb E. Selected Health and Law Issues Regarding Mobile Communications with Respect to 5G. Presented at 2018 International Conference on Broadband Communications for Next Generation Networks and Multimedia Applications (CoBCom). Graz, Austria. July 11-13, 2018.

- Abstract: Over the next years the demand of wireless communication will increase tremendously. More and more mobile end devices require a high data rate connection e.g. to a smart home (Internet of Things, IoT) or to the internet. The radiation power pattern of base stations and mobile end devices will completely change for the 5G Next Generation Mobile Network technology which will use frequency bands up to 100 GHz. Therefore the electromagnetic exposure especially to human body will increase in the future, because most of the wireless connections are realized in RF technology. In this contribution two different measurement setups are presented. The first shows the electromagnetic radiation regarding a base station powered by a mobile

phone provider over a timespan of a number of days. The second figures out the electromagnetic radiation of a handheld mobile end device to a human head in an area with very poor reception values. The results of those measurements where compared with legal and health limits. All measured and calculated results regarding the base stations were within the legal exposure limits. The calculated legal exposure limits of mobile devices were exceeded twice in areas within very poor reception values. Regarding the expected higher bandwidth and corresponding higher electromagnetic exposure to human bodies in future there have to be periodic measurements to comply with radiation limits.

- Excerpts: "Regarding the above mentioned circumstances it will be necessary to measure the radiation exposure of base stations in the future on a regular basis in order to ensure the legal limits and to reduce possible health hazards. It also will be necessary to develop new measurement strategies and/or technologies regarding the large frequency spectrum 5G will use up to 100 GHz. …When measuring directly on a mobile phone (simulating the use of an end device directly on the human head), it was found that the calculated SAR of 3.834 *W/kg* exceeds the legal limit of 2 W/ *kg*. This shows clearly that the legal limit values can be exceeded significantly in areas with very poor reception values …Increasing the distance between a mobile end device and the head, e.g. by using a hands-free set or a headset can significantly reduce the human exposure to electromagnetic radiation when such a device is used in badly supplied areas and transmits with maximum power."

Neufeld E, Kuster N. Systematic Derivation of Safety Limits for Time-Varying 5G Radiofrequency Exposure Based on Analytical Models and Thermal Dose. Health Phys. 2018 Sep 21.

Extreme broadband wireless devices operating above 10 GHz may transmit data in bursts of a few milliseconds to seconds. Even though the time- and area-averaged power density values remain within the acceptable safety limits for continuous exposure, **these bursts may lead to short temperature spikes in the skin of exposed people.**

- In this paper, a novel analytical approach to pulsed heating is developed and applied to assess the peak-to-average temperature ratio as a function of the pulse fraction α (relative to the averaging time [INCREMENT]T; it corresponds to the inverse of the peak-to-average ratio).
- To stay consistent with the current safety guidelines, safety factors of 10 for occupational exposure and 50 for the general public were applied.
- The results demonstrate that the maximum averaging time, based on the assumption of a thermal time constant of 100 s, is 240 s if the maximum local temperature increase for continuous-wave exposure is limited to 1 K and $\alpha \geq 0.1$. For a very low peak-to-average ratio of 100 ($\alpha \geq 0.01$), it decreases to only 30 s.
- **The results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures,** highlighting the importance of revisiting existing exposure guidelines.

TRIPATHI et al., Frequency of the resonance of the human sweat duct in a normal mode of operation, BIOMEDICAL OPTICS EXPRESS 130, Vol. 9, No. 3 | 1 March 2018

- This result indicates that careful consideration should be given while designing electronic and photonic devices operating in the sub-terahertz frequency region in order to avoid various effects on human health due to these waves.

Declassified by CIA in 2015: Russian Review on Millimeter Waves Biological Effect of Millimeter Waves by Zalyubovskaya

- "Morphological, functional and biochemical studies conducted in humans and animals revealed that millimeterwave caused changes in the body manifested in structural alterations in the skin and internal organs, qualitative and quantitative changes of the blood and bone marrow composition and changes of the conditioned reflex activity, tissue respiration, activity of enzymes participating in the process of tissue respiration and nucleic metabolism. The degree of unfavorable effect of millimeterwave depended on the duration of the radiation and individual characteristics of the organism."

Pakhomov et. al., Current state and implications of research on biological effects of millimeter waves: a review of the literature. Bioelectromagnetics. 1998;19(7):393-413.

- "This paper analyzes general trends in the area and briefly reviews the most significant publications, proceeding from cell-free systems, dosimetry, and spectroscopy issues through cultured cells and isolated organs to animals and humans.
- The studies reviewed demonstrate effects of low-intensity MMW (10 mW/cm2 and less) on cell growth and proliferation, activity of enzymes, state of cell genetic apparatus, function of excitable membranes, peripheral receptors, and other biological systems. In animals and humans, local MMW exposure stimulated tissue repair and regeneration, alleviated stress reactions, and facilitated recovery in a wide range of diseases (MMW therapy). Many reported MMW effects could not be readily explained by temperature changes during irradiation."
- Full paper in draft form is online as **CURRENT STATE AND IMPLICATIONS OF RESEARCH ON BIOLOGICAL EFFECTS OF MILLIMETER WAVES: A REVIEW OF LITERATURE** **CURRENT STATE AND IMPLICATIONS OF RESEARCH ON BIOLOGICAL EFFECTS OF MILLIMETER WAVES: A REVIEW OF LITERATURE** Andrei G. Pakhomov, Yahya Akyel, Olga N. Pakhomova, Bruce E. Stuck, and Michael R. Murphy McKesson BioServices (A.G.P., Y.A., O.N.P.), U. S. Army Medical Research Detachment of the Walter Reed Army Institute of Research (B.E.S.), and Directed Energy Bioeffects Division, Human Effectiveness Directorate, Air Force Research Laboratory (M.R.M.), Brooks Air Force Base, San Antonio, TX
- "It is important to note that, even with the variety of bioeffects reported, no studies have provided evidence that a low-intensity MMW radiation represents a health hazard for human beings. Actually, none of the reviewed studies with low-intensity MMW even pursued the evaluation of health risks, though in view of numerous bioeffects and growing usage of MMW technologies this research objective appears very reasonable. Such MMW effects as alterations of cell growth rate and UV light sensitivity, biochemical and antibiotic resistivity changes in pathogenic bacteria, as well as many others are of potential significance for safety standards. MMW therapy in many cases employs field intensities comparable to or lower than allowed by current safety standards; still, even local and short-term exposures were reported to produce marked effects. It should also be realized that biological effects of a prolonged or chronic MMW exposure of the whole body or a large body area have

never been investigated. Safety limits for these types of exposure are based solely on predictions of energy deposition and MMW heating, but in view of recent studies this approach is not necessarily adequate."

Wu T, Rappaport TS, Collins CM, "The Human Body and Millimeter-Wave Wireless Communication Systems: Interactions and Implications," (2015). Accepted in 2015 IEEE International Conference on Communications (ICC), NYU WIRELESS. 2015

- This paper gives examples of today's regulatory requirements, and provides an example for a 60 GHz transceiver. Also, the propagation characteristics of millimeter-waves in the presence of the human body are studied, and four models representing different body parts are considered to evaluate thermal effects of millimeter-wave radiation on the body. Simulation results show that about 34% to 42% of the incident power is reflected at the skin surface at 60 GHz. This paper shows that power density is not suitable to determine exposure compliance when millimeter wave devices are used very close to the body. A temperature-based technique for the evaluation of safety compliance is proposed in this paper.

Wu T et al., Safe for Generations to Come. IEEE Microw Mag. 16(2): 65–84. 2015

"A literature survey representing the most recent available results related to the biological effects of mmWave exposure, from the well-understood and well-accepted effects of thermal heating to recent reports of nonthermal effects and the attempt to motivate further discussion and research for appropriate emission standards."

- "We highlighted the findings of mmWave radiation studies on the eyes and skin since, in communication applications, these tissues would receive the most radiation, with other tissues receiving, by comparison, a negligible amount. Ocular injury can be induced by short-term high-intensity exposure (e.g., 2,000 mW/cm2, 1.5–5 s) far beyond the anticipated future communication device levels, but the eyes do not appear to suffer damage from longer low-intensity exposure (e.g., 10 mW/cm2, 8 h), which might be experienced from mmWave communication technologies in the far field.
- More work may be required to determine the possible effects from exposure above 10 mW/cm2 that might be experienced in the near field from specific communication devices with adaptive antennas as well as to ensure that mechanisms are in place to ensure that no hazardous levels of energy are transmitted into the eyes. We also showed that using typical power levels, there would be no unsafe temperature increase caused by exposure of skin to mmWave communication technologies in the far field.
- As with the eyes, however, more work is required to determine temperature increases from higher exposure levels that might be experienced in the near field from specific communication devices with high-gain antennas and to develop and demonstrate reliable mechanisms to ensure that no hazardous levels of energy are transmitted to the skin."

Ramundo-Orlando A., Effects of millimeter waves radiation on cell membrane – A brief review. (2010) Journal of Infrared, Millimeter, and Terahertz Waves. 2010; 31(12):1400–1411.

- The millimeter waves (MMW) region of the electromagnetic spectrum, extending from 30 to 300 GHz in terms of frequency (corresponding to wavelengths from 10 mm

to 1 mm), is officially used in non-invasive complementary medicine in many Eastern European countries against a variety of diseases such gastro duodenal ulcers, cardiovascular disorders, traumatism and tumor. On the other hand, besides technological applications in traffic and military systems, in the near future MMW will also find applications in high resolution and high-speed wireless communication technology. This has led to restoring interest in research on MMW induced biological effects. In this review emphasis has been given to the MMW-induced effects on cell membranes that are considered the major target for the interaction between MMW and biological systems.

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RESEARCH ON MILLIMETER WAVES

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American Academy of Pediatrics Website

"Electromagnetic Fields: A Hazard to Your Health?" on Cell Tower Radiation

"In recent years, concern has increased about exposure to radio frequency electromagnetic radiation emitted from cell phones and phone station antennae. An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing:

- Headaches
- Memory problems
- Dizziness
- Depression
- Sleep problems

Short-term exposure to these fields in experimental studies have not always shown negative effects, but this does not rule out cumulative damage from these fields, so larger studies over longer periods are needed to help understand who is at risk. In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment."

–American Academy of Pediatrics

Compilation of Research Studies on Cell Tower Radiation and Health

Zothansiama, et al. "Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations." Electromagnetic Biology and Medicine 36.3 (2017): 295-305.

- This study evaluated effects in the human blood of individuals living near mobile phone base stations (within 80 meters) compared with healthy controls (over 300 meters). The study found higher radiofrequency radiation exposures and statistically significant differences in the blood of people living closer to the cellular antennas. The group living closer to the antennas had for example, statistically significant higher frequency of micronuclei and a rise in lipid peroxidation in their blood. These changes are considered biomarkers predictive of cancer.

Neurobehavioral effects among inhabitants around mobile phone base stations Abdel-Rassoul et al, Neurotoxicology, 2007

- This study found that living nearby mobile phone base stations (cell antennas) increased the risk for neuropsychiatric problems such as headaches, memory problems, dizziness, tremors,depression, sleep problems and some changes in the performance of neurobehavioral functions.

Biological Effects from Exposure to Electromagnetic Radiation Emitted by Cell Tower Base Stations and Other Antenna Arrays, Levitt & Lai, Environmental Reviews, 2010

- This review of 100 studies found approximately 80% showed biological effects near towers. "Both anecdotal reports and some epidemiology studies have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations."

Mortality by neoplasia and cellular telephone base stations. Dode et al. (Brazil), Science of the Total Environment, Volume 409, Issue 19, 1 September 2011, Pages 3649–3665

- This 10 year study on cell phone antennas by the Municipal Health Department in Belo Horizonte and several universities in Brazil found a clearly elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell phone transmission towers. Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the cities antennas be removed. Many antennas were dismantled.

Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations Khurana, Hardell et al., International Journal of Occupational Environmental Health, Vol 16(3):263-267, 2010

- A review of 10 epidemiological studies that assessed for negative health effects of mobile phone base stations (4 studies were from Germany, and 1 each from Austria, Egypt, France, Israel, Poland, Spain) found that seven showed altered neurobehavioral effects near cell tower and three showed increased cancer incidence. The review also found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. Lower cognitive performance was found in individuals living ≤ 10 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations.

Health effects of living near mobile phone base transceiver station (BTS) antennae: a report from Isfahan, Iran. Shahbazi-Gahrouei et al, Electromagnetic Biology Medicine, 2013.

- This cross-sectional study found the symptoms of nausea, headache, dizziness, irritability, discomfort, nervousness, depression, sleep disturbance, memory loss and lowering of libido were statistically increased in people living closer than 300 m from cell antennas as compared to those living farther away. The study concludes that "antennas should not be sited closer than 300 m to people to minimize exposure."

Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. Yakymenko (2011) Exp Oncology, 33(2):62-70.

- Even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby.

Association of Exposure to Radio-Frequency Electromagnetic Field Radiation (RF-EMFR) Generated by Mobile Phone Base Stations (MPBS)with Glycated Hemoglobin (HbA1c) and Risk of Type 2 Diabetes Mellitus , Sultan Ayoub Meo et al, International Journal of Environmental Research and Public Health, 2015

- Elementary school students who were exposed to high RF-EMFR generated by MPBS had a significantly higher risk of type 2 diabetes mellitus relative to their counterparts who were exposed to lower RF-EMFR.

How does long term exposure to base stations and mobile phones affect human hormone profiles? Eskander EF et al, (2011), Clin Biochem

- RFR exposures significantly impacted ACTH, cortisol, thyroid hormones, prolactin for females, and testosterone levels for males.

Investigation on the health of people living near mobile telephone relay stations: Incidence according to distance and sex Santini et al, 2002 , Pathol Bio

- People living near mobile phone masts reported more symptoms of headache, sleep disturbance, discomfort, irritability, depression, memory loss and concentration problems the closer they lived to the installation. Study authors recommend that the minimal distance of people from cellular phone base stations should not be < 300 m.

Navarro EA, Segura J, Portoles M, Gomez-Perretta C, The Microwave Syndrome: A preliminary Study. 2003 (Spain) Electromagnetic Biology and Medicine, Volume 22, Issue 2, (2003): 161 – 169

- Statistically significant positive exposure-response associations between RFR intensity and fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Two Important Animal Studies on Radiofrequency Radiation

These studies indicate that government limits are non protective. Government limits are based on the assumption that radiofrequency radiation is only harmful at thermal levels. However, the cancers developed in animals in these studies at radiation levels that were non thermal.

Belpoggi et al. 2018, "Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency

field representative of a 1.8 GHz base station environmental emission" Environmental Research Journal

- Researchers with the renowned Ramazzini Institute (RI) in Italy performed a large-scale lifetime study of lab animals exposed to environmental levels (comparable to allowable limits from cell towers) of RFR radiation and found the rats developed increased cancers- schwannoma of the heart in male rats. This study confirms the $25 million US National Toxicology Program study which used much higher levels of cell phone radiofrequency (RF) radiation, but also reported finding the same unusual cancers as the Ramazzini- schwannoma of the heart in male rats. In addition, the RI study of cell tower radiation also found increases in malignant brain (glial) tumors in female rats and precancerous conditions including Schwann cells hyperplasia in both male and female rats.
- "Our findings of cancerous tumors in rats exposed to environmental levels of RF are consistent with and reinforce the results of the US NTP studies on cell phone radiation, as both reported increases in the same types of tumors of the brain and heart in Sprague-Dawley rats. Together, these studies provide sufficient evidence to call for the International Agency for Research on Cancer (IARC) to re-evaluate and re-classify their conclusions regarding the carcinogenic potential of RFR in humans," said Fiorella Belpoggi PhD, study author and RI Director of Research.
- The Ramazzini study exposed 2448 Sprague-Dawley rats from prenatal life until their natural death to "environmental" cell tower radiation for 19 hours per day (1.8 GHz GSM radiofrequency radiation (RFR) of 5, 25 and 50 V/m). RI exposures mimicked base station emissions like those from cell tower antennas, and exposure levels were far less than those used in the NTP studies of cell phone radiation.
- Watch Press Conference

Wyde, Michael, et al. "National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposure).Statement on conclusions of the peer review meeting by NIEHS, released after external peer review meeting and the DNA damage presentation.

- This 25 million dollar study is the most complex study completed by the NTP and the world's largest rodent study on radiofrequency radiation exposure to date which found long term exposure at non thermal levels associated with brain cancer and schwannomas of the heart in male rats. In addition damage to heart was found in all exposure levels. The full report is expected to be released in Fall 2018.

More Important Studies on Cell Tower Radiation

Cindy L. Russell, 5 G wireless telecommunications expansion: Public health and environmental implications, Environmental Research, 2018, ISSN 0013-9351

- Radiofrequency radiation (RF) is increasingly being recognized as a new form of environmental pollution. This article reviews relevant electromagnetic frequencies, exposure standards and current scientific literature on the health implications of 2G, 3G, 4G and 5G.
- Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radiofrequencies, it will be years or decades before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated.

Noa Betzalel, Paul Ben Ishai, Yuri Feldman, The human skin as a sub-THz receiver – Does 5G pose a danger to it or not?, Environmental Research, Volume 163, 2018, Pages 208-216, ISSN 0013-9351,

- Researchers have developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it. They found that the presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band that will be used in 5G. "One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored."

Mobile phone infrastructure regulation in Europe: Scientific challenges and human rights protection Claudia Roda, Susan Perry, Environmental Science & Policy, Volume 37, March 2014, Pages 204-214.

- This article was published in Environmental Science & Policy by human rights experts. It argues that cell tower placement is a human rights issue for children.
- "We argue that (1) because protection of children is a high threshold norm in Human Right law and (2) the binding language of the Convention on the Rights of the Child obliges States Parties to provide a higher standard of protection for children than adults, any widespread or systematic form of environmental pollution that poses a long-term threat to a child's rights to life, development or health may constitute an international human rights violation.
- In particular we have explained how the dearth of legislation to regulate the installation of base stations (cell towers) in close proximity to children's facilities and schools clearly constitutes a human rights concern according to the language of the Convention on the Rights of the Child, a treaty that has been ratified by all European States.

SAFETY ZONE DETERMINATION FOR WIRELESS CELLULAR TOWER Nyakyi et al, Tanzania (2013)

- This research looked at the radiation that cell towers emit and states a safety zone is needed around the towers to ensure safe sleeping areas. The authors state that

"respective authorities should ensure that people reside far from the tower by 120m or more depending on the power transmitted to avoid severe health effect."

A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. Ghandi et al, 2014 (India):

- This cross-sectional case control study on genetic damage in individuals living near cell towers found genetic damage parameters of DNA were significantly elevated. The authors state," The genetic damage evident in the participants of this study needs to be addressed against future disease-risk, which in addition to neurodegenerative disorders, may lead to cancer."

Human disease resulting from exposure to electromagnetic fields, Carpenter, D. O. Reviews on Environmental Health, Volume 28, Issue 4, Pages 159172.

- This review summarizes the evidence stating that excessive exposure to magnetic fields from power lines and other sources of electric current increases the risk of development of some cancers and neurodegenerative diseases, and that excessive exposure to RF radiation increases risk of cancer, male infertility, and neurobehavioral abnormalities.

Signifikanter Rückgang klinischer Symptome nach Senderabbau – eine Interventionsstudie. (English-Significant Decrease of Clinical Symptoms after Mobile Phone Base Station Removal – An Intervention Study) Tetsuharu Shinjyo and Akemi Shinjyo, 2014 Umwelt-Medizin-Gesellschaft, 27(4), S. 294-301.

- Japanese study Showed Statistically Significant Adverse Health Effects from electromagnetic radiation from mobile phone base stations. Residents of a condominium building that had cell tower antennas on the rooftop were examined before and after cell tower antennas were removed. In 1998, 800MHz cell antennas were installed, then later in 2008 a second set of antennas (2GHz) were installed. Medical exams and interviews were conducted before and after the antennas were removed in 2009 on 107 residents of the building who had no prior knowledge about possible. These results lead researchers to question the construction of mobile phone base stations on top of buildings such as condominiums or houses.

Effect of GSTM1 and GSTT1 Polymorphisms on Genetic Damage in Humans Populations Exposed to Radiation From Mobile Towers. Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R., Arch Environ Contam Toxicol. 2015 Aug 5. [Epub ahead of print]

- In our study, 116 persons exposed to radiation from mobile towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes by multiplex polymerase chain reaction method. DNA damage in peripheral blood lymphocytes was determined using alkaline comet assay in terms of tail moment (TM) value and micronucleus assay in buccal cells (BMN). Our results indicated that TM value and BMN frequency were higher in an exposed population compared with a control group and the difference is significant. In our study, we found that different health symptoms, such as depression, memory status, insomnia, and hair loss, were significantly associated with exposure to EMR. Damaging effects of nonionizing radiation result from the generation of reactive oxygen species (ROS) and subsequent radical formation and from direct damage to cellular macromolecules including DNA.

Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations, Hutter HP et al, (May 2006), Occup Environ Med. 2006 May;63(5):307-13

- Found a significant relationship between some cognitive symptoms and measured power density in 365 subjects; highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels.

Oberfeld, A.E. Navarro, M. Portoles, C. Maestu, C. Gomez-Perretta, The microwave syndrome: further aspects of a Spanish study,

- A health survey was carried out in La Ñora, Murcia, Spain, in the vicinity of two GSM 900/1800 MHz cellular phone base stations. The adjusted (sex, age, distance) logistic regression model showed statistically significant positive exposure-response associations between the E-field and the following variables: fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty in concentration, loss of memory, visual disorder, dizziness and cardiovascular problems.

Bortkiewicz et al, 2004 (Poland), Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review,Med Pr.2004;55(4):345-51.

- Residents close to mobile phone masts reported: more incidences of circulatory problems, sleep disturbances, irritability, depression, blurred vision and concentration difficulties the nearer they lived to the mast.
- The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station.

Wolf R and Wolf D, Increased Incidence of Cancer Near a Cell-phone Transmitter Station, International Journal of Cancer Prevention, (Israel) VOLUME 1, NUMBER 2, APRIL 2004

- A significant higher rate of cancer (300% increase) among all residents living within 300m radius of a mobile phone mast for between three and seven years was detected.
- 900% cancer increase among women alone
- In the area of exposure (area A) eight cases of different kinds of cancer were diagnosed in a period of only one year. This rate of cancers was compared both with the rate of 31 cases per 10,000 per year in the general population and the 2/1222 rate recorded in the nearby clinic (area B). The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Changes of Neurochemically Important Transmitters under the influence of modulated RF fields – A Long Term Study under Real Life Conditions(Germany), Bucher and Eger, 2011

- German study showing elevated levels of stress hormones (adrenaline, noradrenaline), and lowered dopamine and PEA levels in urine in area residents during 1st 6 months of cell tower installation. Even after 1.5 years, the levels did not return to normal.

The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer (Umwelt·Medizin·Gesellschaft 17,4 2004) Eger et al, 2004 (Germany)

- 200% increase in the incidence of malignant tumors was found after five years' exposure in people living within 400m radius of a mobile phone mast. The proportion of newly developing cancer cases is significantly higher among patients who live within 400 meters of a cell phone transmitter. Early age of cancer diagnosis.

Microwave electromagnetic fields act by activating voltage-gated calcium channels: why the current international safety standards do not predict biological hazard. Martin L. Pall. Recent Res. Devel. Mol. Cell Biol. 7(2014).

- "It can be seen from the above that 10 different well-documented microwave EMF effects can be easily explained as being a consequence of EMF VGCC activation: oxidative stress, elevated single and double strand breaks in DNA, therapeutic responses to such EMFs, breakdown of the blood-brain barrier, cancer, melatonin loss, sleep dysfunction, male infertility and female infertility."

Pall ML. 2015. Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J. Chem. Neuroanat. 2015 Aug 20.

- Non-thermal microwave/lower frequency electromagnetic fields (EMFs) act via voltage-gated calcium channel (VGCC) activation.
- Two U.S. government reports from the 1970s to 1980s provide evidence for many neuropsychiatric effects of non-thermal microwave EMFs, based on occupational exposure studies. 18 more recent epidemiological studies, provide substantial evidence that microwave EMFs from cell/mobile phone base stations, excessive cell/mobile phone usage and from wireless smart meters can each produce similar patterns of neuropsychiatric effects, with several of these studies showing clear dose–response relationships.
- Lesser evidence from 6 additional studies suggests that short wave, radio station, occupational and digital TV antenna exposures may produce similar neuropsychiatric effects. Among the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism and EEG changes. In summary, then, the mechanism of action of microwave EMFs, the role of the VGCCs in the brain, the impact of non-thermal EMFs on the brain, extensive epidemiological studies performed over the past 50 years, and five criteria testing for causality, all collectively show that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects.

This webpage only has a sampling of research on this issue. There is research going back decades on this issue. More can be found here.

Power Density: Radio frequency Non-Ionizing Radiation

'… the possibility of harm from exposures [to low levels of radio frequency radiation] insufficient to cause important heating of tissues cannot yet be ruled out with confidence. Furthermore, the anxieties that some people feel when this uncertainty is ignored can in themselves affect their well-being.'

Sir William Stewart (Chairman)
Mobile Phones and Health:
A report from the Independent Expert Group on Mobile Phones,
(*The Stewart Report*, 2000)

Power Density: Definition

Above 30 MHz, the usual unit of measurement is power density, though electric and magnetic fields can also be measured. It is usually expressed in milli- or microwatts per square centimetre (mW/cm2 or µW/cm2), and is defined as the amount of power per unit area in a radiated microwave field or other type of electromagnetic field.

Introduction

Research from abroad, partially replicated (and in some instances expanded on) by scientists in English speaking countries, indicates many potential benefits in health, wellbeing and work productivity can be obtained from developing a more comprehensive understanding of potential EMF bio-effects. They also indicate ways in which present communications systems, and the electromagnetic nature of the microenvironments individuals occupy, can be improved to benefit all. It is suggested that the potential cost benefits of adopting improved EMF-hygiene protocols and developing new generations of technology that can actually improve biological functioning and human performance is immense, makes tremendous commercial sense and present enormous commercial opportunities.

As can be seen in the following table, both beneficial and detrimental biological effects are indicated at exposure levels far lower than those required for 'thermal effects', the traditional marker used to set many guidelines on presently 'acceptable' power density levels.

The Precautionary Principle/Approach?

'… [the] *actions taken under the precautionary principle should be commensurate with anticipated risks of health detriment*.'

Section 6.14
The Stewart Report, 2000

The need for additional impartial scientific research appears warranted to address such concerns for everyone's benefit and that of the planet...

Power Density –
International Regulations and Possible Biological Effects

Power Density	Reported Biological Effects / Comments	References
0.000000000000001 μW/cm^2	**Cosmic background** at 1800 MHz approx. average	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0000000001μW/cm^2	**Natural background level for all RF frequencies**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0000000001 μW/cm^2	**Threshold of human sensitivity**	N.N. Kositsky, A.I. Nizhelska and G.V. Ponezha (2001), Influence of high-frequency electromagnetic radiation at non-thermal intensities on the human body (a review of work by Russian and Ukrainian researchers) *Translation by Patricia Ormsby, No Place To Hide,* 3(1) Supplement. www.emfacts.com/ussr_review.pdf
0.0000000001 – 0.00000001 μW/cm^2	**Normalising effect on cell growth** of isolated cells damaged by ionising radiation exposed for 7 minutes	L.S. Bundyuk, A.P. Kuz'menko, N.N Ryabchenko and G.S. Litvinov (1994), Corrective action of millimeter waves on systems of various levels of hierarchy. *Physics of the Alive,* 2(1):12-25, cited by Kositsky et al 2001.
0.0000000002 μW/cm^2	**Mobile phone handsets can work down to about this level**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.000000001 μW/cm^2	Altered EEG in humans – a relaxation frequency of protein-bound water thought to occur between 100 - 1,000 MHz. Absorption and quantum effects may be the mechanistic basis for EEG changes noted in most subjects from 0.000000001 μW/cm^2 CW RF energy of 130-960 MHz.	W. Bise (1978), Low power radio-frequency and microwave effects on human electroencephalogram and behavior. *Physiological Chemistry and Physics,* 10(5):387-398. www.ncbi.nlm.nih.gov (abstract)
0.0000000027 μW/cm^2	Growth stimulation in Vicius fabus	Brauer (1950), Experimental studies on the effect of meter waves of various field intensities on the growth of plants by division. *Chromosoma* 3:483-509.
0.00000001 μW/cm^2	**Effects on immune system of mice** exposed for 5 minutes per day for 5 days to 54-76 GHz at this level	L.S. Bundyuk, A.P. Kuz'menko, N.N Ryabchenko and G.S. Litvinov (1994), Corrective action of millimeter waves on systems of various levels of hierarchy. *Physics of the Alive,* 2(1):12-25, cited by Kositsky et al 2001.
0.00000002 μW/cm^2	Stimulation of ovulation in chickens	P.A. Kondra, W.K. Smith, G.C. Hodgson, D.B. Bragg, J. Gavora, M.A.K. Hamid and R.J. Boulanger (1970), Growth and reproduction of chickens subjected to microwave radiation. *Canadian Journal of Animal Science* 50:639-644, cited by A. Firstenberg 2001.
<0.000001 μW/cm^2	**Altered EEG in humans** – temporary changes in brain waves and behaviour.	W. Bise (1978), Low power radio-frequency and microwave effects on human electroencephalogram and behavior. *Physiological Chemistry and Physics,* 10(5):387-398. www.ncbi.nlm.nih.gov (abstract)
0.000001 μW/cm^2	**Burgerforum BRD proposal, sleeping areas (1999)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.000005 μW/cm^2	Effect on cell growth rate in yeast *S. cerevisae*	W. Grundler and F. Kaiser (1992), Experimental evidence for coherent excitations correlated with cell growth. *Nanobiology* 1:163-176
0.00001 μW/cm^2	**Conditioned 'avoidance' reflex in rats**	N.N. Kositsky, A.I. Nizhelska and G.V. Ponezha (2001), Influence of high-frequency electromagnetic radiation at non-thermal intensities on the human body (a review of work by Russian and Ukrainian researchers) *Translation by Patricia Ormsby, No Place To Hide,* 3(1) Supplement. www.emfacts.com/ussr_review.pdf
0.000027 μW/cm^2	**Premature aging of pine needles**	Selga, T. & Selga, M. (1996), Response of *Pinus sylvestris L*. needles to electromagnetic fields. Cytological and ultrastructural aspects. *The Science of the Total Environment* 180:65-73, Elsevier Science BV.
0.0001 μW/cm^2	**Burgerforum BRD proposal, waking areas (1999)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.0001 μW/cm^2	**Salzburg GSM/3G inside houses (2002)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp

Power Density	Reported Biological Effects / Comments	References
0.001 μW/cm^2	100 Yards from a Cellular Phone	A. Firstenberg (2001), Radio Wave Packet, www.goodhealthinfo.net/radiation/radio_wave_packet.pdf.
0.001 μW/cm^2	**Exposure Limit in New South Wales, Australia as at 2001**	A. Firstenberg (2001)
0.001 μW/cm^2	**Salzburg GSM/3G outside houses (2002)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.002 μW/cm^2	**Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb pain, joint pain, digestive problems, fewer schoolchildren promoted** – controlled study near a shortwave transmitter	Altpeter *et al*. (1995, 1997), Study on health effects of the shortwave transmitter station of Schwarzenburg, Berne, Switzerland, Study No. 55, Swiss Federal Office of Energy), cited by A. Firstenberg 2001.
0.0027 μW/cm^2	Growth inhibition in Vicius fabus	I. Brauer (1950), Experimental studies on the effect of meter waves of various field intensities on the growth of plants by division. *Chromosoma* 3:483-509, cited by A. Firstenberg 2001.
0.0027 to 0.065 μW/cm^2	**Smaller tree growth rings**	Balodis, V., *et al* (1996), Does the Skrunda Radio Location Station diminish the radial growth of pine trees? *The Science of the Total Environment* 180:57-64.
0.0048 μW/cm^2	Median level, 15 US cities 1977 (mainly VHF & TV)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.007 μW/cm^2	50 Feet from a Cordless Phone	A. Firstenberg (2001).
0.01 μW/cm^2	**Human sensation**	Kolbun and Sit'ko (1987), Sensory indications by the human body of EHF-range electromagnetic radiation. *Mechanisms of Biological Action of Electromagnetic Radiation: Proceedings of the Pushchino Symposium,* 27-31 Oct. 1987, cited by A. Firstenberg 2001.
0.01 μW/cm^2	**EU-Parl, GD Wissenschaft, STOA GSM (2001), Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.016 μW/cm^2	1 Mile from a Cellular Tower	A. Firstenberg (2001)
0.04 – 0.2 μW/cm^2	SAR-value of 80-400 μW/kg, 0.002 V/m at 947.5 MHz	O. Johansson (1995), 'Elöverkänslighet samt överkänslighet mot mobiltelefoner: Resultat från en dubbel-blind provokationsstudie av metodstudiekaraktär' (=Electrohypersensitivity and sensitivity to mobile telephones: Results from a double-blind provocation study of pilot character', in Swedish), Enheten för Experimentell Dermatologi, Karolinska Institutet, Stockholm, Rapport nr. 2, 1995, ISSN 1400-6111
0.06 μW/cm^2	**Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, structural changes in liver, spleen, testes, and brain** – in white rats and rabbits	Dumanskij & Shandala (1974), The biologic action and hygienic significance of electromagnetic fields of super-high and ultrahigh frequencies in densely populated areas. *Biologic Effects and Health Hazards of Microwave Radiation, Proceedings of an International Symposium,*Warsaw, 15-18 Oct. 1973, P. Czerski et al., eds., cited by A. Firstenberg 2001.
0.05 μW/cm^2	10 Feet from a Wireless Computer	A. Firstenberg (2001).
0.06 μW/cm^2	Slowing of the heart, change in EEG in rabbits	Serkyuk, reported in McRee 1980, cited by A. Firstenberg 2001.
0.1 μW/cm^2	**Italy (single frequency), Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.1 μW/cm^2	**Salzburg 1998 (sum GSM), Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
0.1 μW/cm^2 (0.001 W/Kg SAR)	**EEG brain waves altered under exposure to cell phone signal**	L. Von Klitzing (1995), 'Low-Frequency pulsed electromagnetic fields influence EEG of man.' Physica Medica, Vol. 11, No. 2, pps 77-80, April-June 1995, cited by C. Sage 2004.

Power Density	Reported Biological Effects / Comments	References
0.1 μW/cm^2	Increased in melatonin in cows on 1st night of re-exposure after 3-30 MHz transmitter inoperational for 3 days – difference in salivary melatonin concentration statistically significant, indicating a 2-7-fold increase of melatonin concentration.	K.D.C. stark , T. Krebs, E. Altpeter, B. Manz, C. Griot and T. Abelin (1997), Absence of chronic effect of exposure to short-wave radio broadcast signal on salivary melatonin concentrations in dairy cattle. *Journal of Pineal Research* 22(4):171-176.
0.1 to 1.8 μW/cm^2	Decreased life span, impaired reproduction, structural and developmental abnormalities in duckweed plants	Magone, I. (1996), The effect of electromagnetic radiation from the Skrunda Radio Location Station on *Spirodela polyrhiza* (L.) Schleiden cultures. *The Science of the Total Environment* 180:75-80.
0.13 μW/cm^2	**Decreased cell growth** (human epithelial amnion cells)	Kwee & Raskmark (1997), Radiofrequency electromagnetic fields and cell proliferation. In *Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine*, June 8-12, 1997, Bologna, Italy, F. Bersani, ed.
0.16 μW/cm^2	**Attention, memory and motor function of school children significantly affected in comparison to control groups.** Reaction times slower and neuromuscular apparatus endurance also reduced.	A.A. Kolodynski and V.V. Kolodynska (1996), Motor and psychological functions of school children living in the area of the Skrunda radio location station in Latvia. The Science of the Total Environment, 180 (1):87-93.
0.168 μW/cm^2	**Progressive decrease in number of newborns and irreversible infertility in mice** after 5 generations exposure to radiation from 'antenna park'.	I.N. Magras and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics, 18(6), pp. 455-461.
0.2 – 8 μW/cm^2	**Two-fold increase in childhood leukaemia from AM-FM exposure from TV towers compared to areas with levels of 0.02 μW/cm^2**	B. Hocking, I.R. Gordon and H.L. Grain (1996), Cancer incidence and mortality and proximity to TV towers. *Medical Journal of Australia* 165(11-12):599-600, cited by Sage 2004.
0.3 μW/cm^2	**Impaired motor function, reaction time, memory and attention of schoolchildren, and altered sex ratio of children (fewer boys)**	A.A. Kolodynski and V.V. Kolodynska (1996), Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia. *The Science of the Total Environment* 180:87-93.
0.6 μW/cm^2	**Change in calcium ion efflux from brain tissue**	S. K. Dutta et al, (1986). Microwave radiation-induced calcium ion flux from human neuroblastoma cells: dependence on depth of amplitude modulation and exposure time. *Biological Effects of Electropollution,*S. Dutta and R. Millis, eds., pp. 63-69. Philadelphia, PA: Information Ventures, cited by A. Firstenberg 2001.
0.6 μW/cm^2	**Cardiac arrhythmias and sometimes cardiac arrest (frogs)**	Frey, 1986. Evolution and results of biological research with low-intensity nonionizing radiation. *Modern Bioelectricity,* A.A. Marino, ed., pp. 785-837. New York, NY: Dekker.
0 – 4 μW/cm^2	**Altered white blood cell activity in schoolchildren**	H. Chiang et al., 1989. Health effects of environmental electromagnetic fields. *Journal of Bioelectricity* 8(1):127-131, cited by A. Firstenberg 2001
1.0 μW/cm^2	**Headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion (humans—occupational exposure)**	V. B. Simonenko et al., 1998. Influence of electromagnetic radiation in the radiofrequency range on the health condition of an organized collective. *Voenno-meditsinskiy zhurnal* CCCXIX(5):64-68, cited by A. Firstenberg (2001)
1.0 μW/cm^2	Stimulation of white cells in guinea pigs	M.G. Shandala and G.I. Vinogradov, 1978. Immunological effects of microwave action. *Gigiyena i Sanitariya,* no. 10:34-38, JPRS 72956, pp. 16-21, cited by A. Firstenberg (2001)
1 μW/cm^2	**Change in immunological functions** in NMRI mice after exposure to whole body microwave sinusoidal irradiation of 8.15-18 GHz (1 Hz within).	E.E. Fesenko, V.R. Makar, E.G. Novoselova and V.B. Sadovnikov (1999), Microwaves and cellular immunity. I. Effect of whole body microwave irradiation on tumor necrosis factor production in mouse cells. Bioelectrochemistry and Bioenergetics, 49(1):29-35.

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1 μW/cm^2	In vivo irradiation at 8.15-18 GHz (1 Hz within) increased cytotoxic activity of natural killer cells in rat spleen. For mice exposed 24-72 hours, activity of natural killer cells increased 130-150%. This level persisting within 24 hours after end of treatment. In vivo irradiation for 3.5 and 5 hours, and short exposure of splenic cells in vitro did not affect activities of natural killer cells.	E.E. Fesenko, E.G. Novoselova, N.V. Semiletova, T.A. Agafonova and V.B. Sadovnikov (1999), [Stimulation of murine natural killer cells by weak electromagnetic waves in the centimeter range]. Biofizika 44(4), pp.737-741, (Article in Russian), cited by A. Marino, Recent studies (1995-2000) on the biological effects of radiofrequency and cell phone radiation, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html
1 μW/cm^2	**Immune system response affected by a single 5-hour whole-body exposure to 8.15-18 GHz microwave radiation (with 1 Hz impulse frequency)** that stimulated the immune potential of macrophages and T cells. Antioxidant treatment (through diet) was found to further enhance this effect.	E.G. Novoselova, E.E. Fesenko, V.R. Makar and V.B. Sadovnikov (1999), Microwaves and cellular immunity. II. Immunostimulating effects of microwaves and naturally occurring antioxidant nutrients. Bioelectrochemistry and Bioenergetics, 49(1):37-41.
1 μW/cm^2	**Standards in the former USSR for permissible exposure levels to 30-300 MHz for 8-hour workday.**	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. *Gigiena i sanitariya* 5:72-74, cited by Kositsky et al 2001.
1 μW/cm^2	**Wien (sum GSM)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1 μW/cm^2	Typical reading 100 metres from base station (0.2 to 6 V/m)	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1.053 μW/cm^2	**Irreversible infertility in mice after 3 generations** exposure to radiation.	I.N. Magras and T.D. Zenos (1997), RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics, 18(6), pp. 455-461.
1.3 – 5.7 μW/cm^2	**Exposure to AM RF caused two-fold increase in leukaemia in adults**	H. Dolk, G. Shaddick, P. Walls, C. Grundy, B. Thakrar, I. Kleinschmidt and P. Elliott (1997), cited by Sage 2004. Cancer incidence near radio and television transmitters in Great Britain. Am J Epidemiology 145(1) P 1-9 Jan 1997.
2–10 μW/cm^2 Exposure Limit in Bulgaria, Hungary, Russia and Switzerland as at 2001, cited by A. Firstenberg 2001.		
2.0 μW/cm^2 (lower threshold not known)	**'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.**	A.H. Frey (1963), Human response to very-low-frequency electromagnetic energy. *Nav. Res. Rev.* 1968:1-4. A.H. Frey (1971), Biological function as influenced by low power modulated RF energy. *IEEE Transactions on Microwave Theory and Techniques,* MTT-19(2):153-164. A.H. Frey and R. Messenger (1973), Human perception of illumination with pulsed ultrahigh-frequency electromagnetic energy. *Science* 181:356-358, cited by A. Firstenberg 2001.
2.0 μW/cm^2	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	D.R. Justeson (1979), Behavioral and psychological effects of microwave radiation. *Bulletin of the New York Academy of Medicine* 55(11):1058-1078, cited by A. Firstenberg 2001.
2.0 μW/cm^2	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	R.G. Olsen (1980), Evidence for microwave-induced acoustic resonances in biological material. *Bioelectromagnetics* 1:219, cited by A. Firstenberg 2001.
2.0 μW/cm^2	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	C.W. Wieske (1963), 'Human Sensitivity to Electric Fields.' Proceedings of the First National Biomedical Sciences Instrumentation Symposium. (Vol. 1). Ed. Dr. Fred Alt. New York: Plenum Press, 1963, cited by A. Firstenberg 2001.
2.0 μW/cm^2	'Microwave hearing'— buzzing, chirping, clicking, hissing, or high-pitched tones.	J.C. Lin (1978), *Microwave Auditory Effects and Applications.* Springfield, IL: Charles C. Thomas, Publisher, Springfield, IL 1978, 221 pp, cited by A. Firstenberg 2001.
2.4 μW/cm^2	**Belgium (Wallonia)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
2.4 μW/cm^2	**Interference caused to medical devices** at least up to 1000 MHz (from digital mobile phones).	K.J. Clifford, K.H. Joyner, D.B. Stroud, M. Wood, B. Ward and C.H. Fernandez (1996), Mobile telephones interfere with medical electrical equipment. Australas Phys Eng Sci Med 1994 Mar. 17(1). P 23-7, cited by C. Sage 2004

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2.5 µW/cm^2	**Breakdown of blood-brain barrier** (digital cellular phone used to provide the radiation)	Salford *et al*., (1997), Blood brain barrier permeability in rats exposed to electromagnetic fields from a GSM wireless communication transmitter. In: *Proceedings of the Second World Congress for Electricity and Magnetism in Biology and Medicine,* June 8-12, 1997, Bologna, Italy, F. Bersani, ed., cited by A. Firstenberg 2001.
2 – 4 µW/cm^2	**Low power microwaves directly effect the operation of cellular ACh-related ion-channels that have vital roles in behavioural and physiological functions.**	G. D'Inzeo, P. Bernardi, F. Eusebi, F. Grassi, C. Tamburello and B.M. Zani (1988), Microwave effects on acetylcholine-induced channels in cultured chick myotubes. *Bioelectromagnetics* 9(4):363-372.
4 µW/cm^2	**Standards in the former USSR for permissible exposure levels to 3-30 MHz for 8-hour workday.**	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. *Gigiena I sanitariya* 5:72-74, cited by Kositsky et al 2001.
4 – 10 µW/cm^2	**Lower memory function/visual reaction time in children slowed in tests**	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. Journal of Bioelectricity, 8: 127-131, cited by Sage 2004.
5 µW/cm^2	**Standards in the former USSR for permissible exposure levels to 0.3-300 GHz for 8-hour workday.**	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. *Gigiena I sanitariya* 5:72-74, cited by Kositsky et al 2001.
5.0 µW/cm^2	Study investigated immune systems of women exposed to 500 KHz-3 GHz fields from radio/television transmitters in their residential area for ≥2 years. Exposure levels of 4.3 ±1.4 V/m (mean +/- S.D.) measured on the balconies of the women's homes. Control group exposed to <1.8 V/m fields. Higher field exposure found to reduce cytotoxic activity in the women's peripheral blood without a dose-response effect.	P. Boscol, M.B. Di Sciascio, S. D'Ostilio, A. Del Signore, M. Reale, P. Conti, P. Bavazzano, R. Paganelli & M. Di Gioacchino (2001), Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. *Sci Total Environ* 273(1-3):1-10.
5.0 µW/cm^2	**Leukaemia, skin melanoma and bladder cancer near TV and FM transmitter**	H. Dolk, G. Shaddick, P. Walls, C. Grundy, B. Thakrar, I. Kleinschmidt and P. Elliott (1997), cited by Sage 2004. Cancer incidence near radio and television transmitters in Great Britain. Am J Epidemiology 145(1) P 1-9 Jan 1997.
5.0 µW/cm^2	**Biochemical and histological changes in liver, heart, kidney, and brain tissue**	V.S. Belokrinitskiy (1982), 'Hygienic evaluation of biological effects of nonionizing microwaves', *Gigiyena i Sanitariya* 6:32-34, JPRS 81865, pp. 1-5, cited by A. Firstenberg 2001.
5 – 10 µW/cm^2	**Nervous system activity impaired**	Dumanski and Shandala (1974), The Biological Action and Hygenic Significance of Elecromagnetic Fields of Superhigh and Ultrahigh frequencies in Densely Populated Areas,' from Biological Effects and Health Hazards of Microwave Radiation. Proceedings of an International Symposium, Warsaw 15-18 October, 1973, Polish Medical Publishers, Warsaw, 1974, cited by Sage 2004.
7–10 µW/cm^2	**Exposure Limit in People's Republic of China as at 2001**,	Cited by A. Firstenberg 2001.
8 µW/cm^2	**Association between increased incidences of childhood leukaemia and mortality through RF fields from TV transmitters in comparison to areas with lower power densities.** Overall rate ratio of incidence was 1.58 (95% CI, 1.07-2.34). For mortality it was 2.32 (95% CI, 1.35-4.01). For childhood lymphatic leukaemia the rate ratio for incidence was 1.55 (95% CI, 1.00-2.41) and 2.74 (95% CI, 1.42-5.27) for mortality.	B. Hocking, I.R. Gordon, H.L. Grain and G.E. Hatfield (1996), Cancer incidence and mortality and proximity to TV towers. Med J Aust 165(11-12), pp. 601-605, 1996. (Published erratum appears in Med J Aust 166(2):80, 1997), cited by A. Marino, Recent studies (1995-2000) on the biological effects of radiofrequency and cell phone radiation, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html

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9.5 μW/cm^2	**Switzerland, Lichtenstein, Luxembourg**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 μW/cm^2	**Russian Federation, People's Republic of China, Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 μW/cm^2	**Italy (sum of frequencies)**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
10 μW/cm^2	**Maximum permitted exposure levels for base stations inside and outside of living, public and industrial areas for 300-2400 MHz frequencies** (Russian Federation, since 1 June 2003)	Hygienic requirements for siting and exploitation of land mobile telecommunication systems, SanPiN 2.1.8/2.2.4.1190-03 (2003), Ministry of Health of Russian Federation / Russian Ministry of Health Protection, SanPiN (Sanitary and Epidemiological Norms). (Standard for siting and using 27-2400 MHz land mobile phone systems in the Russian Federation).
10 μW/cm^2	**Impaired / reduced short-term memory function and significant differences in visual reaction time** (1170 test subjects).	H. Chiang, G.D. Yao, Q.S. Fang, K.Q. Wang, D.Z. Lu and Y.K. Zhou (1989), Health effects of environmental electromagnetic fields. *J. Bioelectricity* 8(1):127-131.
10.0 μW/cm^2	**Decreased size of litter, increased number of stillborns in mice**	Il'Chevich (reported in McRee 1980), cited by A. Firstenberg 2001.
≤10 μW/cm^2 (max. mean exposure)	**Sperm counts of Danish military personnel operating mobile ground-to-air missile units, which used several RFR emitting radar systems, were significantly lower than controls.**	N.H. Hjollund, J.P. Bonde, J. Skotte (1997), Semen analysis of personnel operating military radar equipment. *Reprod Toxicol* 11(6):897, cited by www.energyfields.org/science/CWTI.RFR_studies_2.02.doc
10.0 μW/cm^2	Redistribution of metals in the blood, bones, brain, heart, liver, lungs, kidney, muscles, spleen and skin	O.I. Shutenko, I.P. Kozyarin and I.I. Shvayko (1981), Effects of superhigh frequency electromagnetic fields on animals of different ages. *Gigiyena i Sanitariya, no.* 10:35-38, JPRS 84221, pp. 85-90, cited by A. Firstenberg 2001.
10 μW/cm^2	**Damaged mitochondria, nucleus of cells in hippocampus of brain**	V.S. Belokrinitskiy (1982), Destructive and reparative processes in hippocampus with long-term exposure to nonionizing microwave radiation. *Bulletin of Experimental Biology and Medicine* 93(3):89-92, cited by A. Firstenberg 2001.
10 μW/cm^2	Altered brain permeability	W.R. Adey (1982).
10 – 25 μW/cm^2	Changes registered in hippocampus of the brain	Belokrinitskiy, 1982, cited by Sage 2004 'Destructive and reparative processes in hippocampus with long-term exposure to nonionizing radiation.' In U.S.S.R. Report, Effects of Nonionizing Microwave Radiation, No. 7, JPRS 81865, pp. 15-20.
10 – 100 μW/cm^2	RFR at low intensities (0.0027- 0.027 W/kg) induced behavioural and endocrine changes in rats. Decreases in blood concentrations of insulin and testosterone reported, though CW microwaves had no influence on insulin secretion. Inhibition of behaviour by microwaves may depend on strength, exposure time and inhibitory effects on nervous system. Activation correlated with decreases in serum concentrations of insulin and testosterone.	M.A. Navakatikian, L.A. Tomashevskaya (1994), Phasic behavioral and endocrine effects of microwaves of nonthermal intensity. In 'Biological Effects of Electric and Magnetic Fields, Volume 1,' D.O. Carpenter (ed) Academic Press, San Diego, CA, pp.333-342, cited by www.energyfields.org/science/CWTI.RFR_studies_2.02.doc

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20 μW/cm^2	**Changes in brain wave patterns caused by microwave or radio frequency radiation**	C.H. Dodge and Z.R. Glaser, 1977. 'Trends in non-ionizing electromagnetic radiation bio-effects research and related occupational health aspects', *Journal of Microwave Power,* 12, 4 (1977)), cited by P. Bentham (1991), VDU Terminal Sickness: Computer health risks and how to protect yourself, Green Print, London, ISBN 1 85425 043 4.
20 μW/cm^2	Pulsed RF radiation (900 MHz with 217 Hz pulse) slightly elevated cortisol serum level (cortisol is a hormone involved in stress reactions). The increase was transient, suggesting adaptation to the stimulus by the subject. No significant effects found for growth hormone, luteinizing hormone or melatonin under field exposure compared to control condition. The EEG sleep-data revealed no significant variations on exposure, although there was a trend for suppressed REM.	K. Mann, P. Wagner, G. Brunn, F.Hassan, C. Hiemke and J. Roschke (1998), Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system. *Neuroendocrinology* 67(2):139-144.
25 μW/cm^2 at 300 MHz-300 GHz.	**Workers' exposure standard in Russia for 8-hour day (occupational standard introduced in 1986) The standard is based on the total amount of energy absorbed and permits exposures for shorter time periods, e.g. 100 μW/cm² for 2 hours**, cited by C.W. Smith & S. Best (1989).	
27 μW/cm^2	**Standards in the former USSR for permissible exposure levels to 0.3-3 MHz for 8-hour Workday**.	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. *Gigiena i sanitariya* 5:72-74, cited by Kositsky et al 2001.
30 μW/cm^2 (0.015 W/Kg SAR)	Elevation of PFC count (antibody producing cells) in immune system	B. Veyret, C. Bouthet, P. Deschaux, R. de Seze, M. Geffard, J. Joussot-Dubien, M. le Diraison, J.-M. Moreau and A. Caristan (1991), Antibody responses of mice exposed to low-power microwaves under combined, pulse and amplitude modulation,' Bioelectromagnetics 12: P 47-56), cited by Sage 2004.
30 μW/cm^2	Increased brain-amine levels	W.R. Adey (1982).
32.5 μW/cm^2	102nd Floor, Empire State Building in New York	R. Tell & N. H. Hankin (1978), 'Measurements of Radio Frequency Field Intensity in Buildings with Close Proximity to Broadcast Systems', ORP/EAD 78-3, U.S. Environmental Protection Agency, Las Vegas.
50 μW/cm^2	**Exposure Limit in Auckland, New Zealand as at 2001**	A. Firstenberg (2001).
50 μW/cm^2	**18% reduction in REM sleep, which is important to learning and memory functions**	Mann *et al*., 1996, cited by Sage 2004. Effects of pulsed high-frequency electromagnetic fields on human sleep. Neuropsychobiology 1996;33:41-7.
50 μW/cm^2	**Decreased sperm counts**	W.R. Adey (1982).
50 μW/cm^2	2.375 GHz exposure for 30 days resulted in decreased T-cell responses with suppressed phagocytosis noted in rats and guinea pigs.	M.G. Shandala, M.I. Rudnex, G.K. Vinogradov, N.G. Belonozhko and N.M. Gonchar (1977), Immunological and haematological effects of microwave radiation at low power densities. In: Proceedings of the International Union Radio Science Symposium on Biological Effects of Electromagnetic Waves, Airlie, V.A., p. 84, cited by Adey, 1982.
50 μW/cm^2	No differences noted in the awake EEG of healthy subjects exposed nearly 3.5 minutes to the 900 MHz radiation pulsed at 217 Hz with a pulse width of 580 microseconds when compared to effects of inactive GSM system.	J. Roschke and K. Mann (1997), No short-term effects of digital mobile radio telephone on the awake human electroencephalogram. Bioelectromagnetics 18(2), pp.172-176.
60 μW/cm^2	**Disturbance of female cycles of test animals, reduced fertility, dystrophic changes in reproductive organs.** Reduced weight and number of offspring; postnatal deaths of rat pups increased by factor of 2.5.	H.G. Nikitina and L.G. Andrienko (1989), Condition of reproductive functions in experimental animals under the influence of electromagnetic radiation of mm waves. *Fundamental and Applied aspects of Use of mm Electromagnetic Radation in Medicine, Proceedings of the 1st All-Union Symposium with International Participation* (10-13 May 1989, Kiev). Kiev: VNK 'Otklik,' pp. 288-289, 1989, cited by Kositsky et al 2001.

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60 μW/cm^2	**Brain wave activation observed in human subjects exposed to 902.4 MHz mobile-phone radiation.** Significant correlation on EEG recordings noted, particularly when the subjects eyes were closed. This was suggested to be a manifestation of cortex activation under mobile-phone EMF exposure.	N.N. Lebedeva, A.V. Sulimov, O.P. Sulimova, T.I. Kotrovskaya and T. Gailus (2000), Cellular phone electromagnetic field effects on bioelectric activity of human brain. *Crit Rev Biomed Eng* 28(1-2):323-337. Cited by www.energyfields.org/science/CWTI.RFR_studies_2.02.doc
65.9 μW/cm^2	50th Floor, Sears Building in Chicago	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985), The Body Electric, Quill, ISBN 0-688-06971-1.
67.4 μW/cm^2	47th Floor, 1100 Milam Building in Houston	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985).
1 - 97 μW/cm^2	Location specific values found inside tall U.S. buildings that housed or were near broadcast antennas.	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS).
98.6 μW/cm^2	38th Floor, One Biscayne Tower in Miami	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS), cited by R.O. Becker & G. Selden (1985).
100 μW/cm² at 300 MHz-300 GHz for max. 2 hours.	**Workers' exposure standard in Russia for 8-hour day (occupational standard introduced in 1986) Standard based on total amount of energy absorbed**, cited by C.W. Smith & S. Best 1989.	
100 μW/cm^2	**Maximum permitted exposure levels for MPEL for mobile stations (including cellular phones) for 300-2400 MHz frequencies** (Russian Federation, since 1 June 2003)	Hygienic requirements for siting and exploitation of land mobile telecommunication systems, SanPiN 2.1.8/2.2.4.1190-03 (2003), Ministry of Health of Russian Federation / Russian Ministry of Health Protection, SanPiN (Sanitary and Epidemiological Norms). (Standard for siting and using 27-2400 MHz land mobile phone systems in the Russian Federation).
<100 μW/cm^2	54-900 MHz exposure of 95% U.S. urban population in 1979. In urban areas median exposure was 0.005 μW/cm^2.	EPA (Environmental Protection Agency) (1978), Population Exposure to VHF and UHF Broadcast Radiation in the United States, R.A. Tell and E.D. Mantiply, EPA Technical Report ORP/EAD 78-5. Cited in "An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy" , Board on Radiation Effects Research (2005), http://books.nap.edu/openbook.php?record_id=11205&page=48
100 μW/cm^2	**Changes registered in immune system function of male mice**	Elekes et al., 1996. Effect on the immune system of mice exposed chronically to 50 Hz amplitude-modulated 2.45 GHz microwaves. Bioelectromagnetics Vol 17, Issue 3, pp.246-8, cited at www.cellphonesar.com/research/rf_radiation
100 μW/cm^2	**26% drop in insulin registered**	Navakatikian & Tomashevskaya, 1994. 'Phasic Behavioral and Endocrine Effects of Microwaves of Nonthermal Intensity,' by Carpenter DO and Ayrapetyan S, editors. Biological Effects of Electric and Magnetic Fields. Volume 1, published by Academic Press, cited at www.cellphonesar.com/research/rf_radiation
111.5 μW/cm^2	**Belgium (ex Wallonia) Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp

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120 µW/cm^2	**Pathological change noted in the blood brain barrier at 915 MHz**	Salford, L.G., Brun, A., Perrson, B.R.R., and Eberhardt, J., 1993. 'Experimental studies of brain tumor development during exposure to continuous and pulsed 915 MHz radio frequency radiation,' in Bioelectrochemistry and Bioenergetics, Vol. 30: pp. 313-318.
180.3 µW/cm^2	Roof, Home Tower in San Diego	R. Tell & N. H. Hankin (1978), cited by R.O. Becker & G. Selden (1985).
200 µW/cm^2 Public exposure (average)	**ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m. ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes. Reference level category 100 – 400 MHz**, cited by A. Philips (2002)	
200 µW/cm^2	**Exposure Limit in Australia as at 2001**, cited by A. Firstenberg 2001.	
200 – 1000 µW/cm^2	**Exposure Limit in Canada, Germany, Japan, New Zealand and US as at 2001**, cited by A. Firstenberg 2001.	
250-500 µW/cm^2	**Decreased reproductive capacity and litter size**, also premature cessation of reproductive function in mice exposed to microwaves for 4 hours a day for 48 weeks – details on carrier frequencies not given.	Z.V. Gordon, A.V. Rosein and M.S. Byskov (1974), 'Main directions and results of research conducted in USSR on the biologic effects of microwaves,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 22-35, cited by W.R. Adey, 1982.
≤230 µW/cm^2	Location specific values measured outside tall buildings in close proximity to broadcast antennas.	R. A. Tell and N. N. Hankin (1978), "Measurements of radiofrequency field intensities in buildings with close proximity to broadcast stations," Environmental Protection Agency Technical Note, ORP/EAD 78-3, Aug. 1978 (NTIS Order No. PB 290 944/AS).
0.2-360 µW/cm^2	**Mortality rate of exposed chickens almost twice that of control colony.**	C. Romero-Sierra and J.A. Tanner (1970), Microwave Radiation and Egg Production in Chickens. Proceedings of IMPI 5th Annual Microwave Symposium, Schevenigen, Holland. October 1970.
10-10,000 µW/cm^2	Deterioration noted in radiation sensitive Mimosa plant.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagnetic fields And Living Systems With Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
400 µW/cm^2	**Standards in the former USSR for permissible exposure levels to 30-300 kHz for 8-hour workday.**	Yu.D. Dumanskiy and V.Ye. Prokhvatilo (1979), Electromagnetic field of industrial frequency as a factor in the environment and its hygienic regulation. *Gigiena i sanitariya* 5:72-74, cited by Kositsky et al 2001.
>500 µW/cm^2	**Autoimmune disease evoked**, along with production of anti-liver and anti-brain antibodies.	M.G. Shandala, M.I. Rudnex, G.K. Vinogradov, N.G. Belonozhko and N.M. Gonchar (1977), Immunological and haematological effects of microwave radiation at low power densities. In: Proceedings of the International Union Radio Science Symposium on Biological Effects of Electromagnetic Waves, Airlie, V.A., p. 84, cited by Adey, 1982.
500 µW/cm^2	**High Blood Pressure due to imbalances of Potassium and Sodium levels in the body**, also significant shifts in carbon dioxide – rats exposed to 2,450 MHz for 7 hours a day for 3 months.	R.H. Lovely, A.W. Guy, R.B. Johnson, and M. Mathews (1978), Alteration of behavioural and biochemical parameters during and consequent to 500 µW/cm^2 chronic 2450 MHz microwave exposure, Proceedings of the International Symposium on Electromagnetic Waves and Biology, Ottawa, p. 34, cited by W.R. Adey (1982).
500 µW/cm^2	Peak level at residential locations near the Radio Location Station at Skrunda in Latvia which had 2 pulsed-radar systems operating at 152 to 162 MHz, at 1250 kW, with pulse duration of 0.8 msec, interpulse interval of 41 msec and pulse repetition rate of 24.5 Hz. The average intensity at these areas was <10 µW/cm^2.	A. Romancuks (1996), Measurement of the intensity of the electromagnetic radiation from the Skrunda Radio Location Station. The Science of the total environment, 180 (1):51-56. Cited in "An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy" , Board on Radiation Effects Research (2005), http://books.nap.edu/openbook.php?record_id=11205&page=135

Power Density	Reported Biological Effects / Comments	References
900 µW/cm^2	**ICNIRP (1998), WHO, Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
1,000 µW/cm^2	**FCC (USA) OET-65, Public Exposure Guidelines at 1800 MHz**	Powerwatch, International Guidance Levels, www.powerwatch.org.uk/gen/intguidance.asp
<1,000 – 4,500 µW/cm^2 (0–45 mW/cm^2)	**Beneficial effects noted** in transient, reversible and dose-dependent alterations in rates of blastic transformation of unstimulated lymphocytes of hamsters after 15 minutes of irradiation of 2.45 GHz CW field for 5 day period.	A.T. Huang, M.E. Engle, J.A. Elder, J.B. Kinn and T.R. Ward (1997), The effect of microwave radiation (2450 MHz) on the morphology and chromosomes of lymphocytes, Radio Science, 12, Supplement 6, pp. 173-177, cited by W.R. Adey, 1982.
<1,000 µW/cm^2	Change in bioelectric activity of human muscles during deep stages of hypnosis after 10-20 second exposure at 57-78 GHz	S.I. Gerashchenko, O.I. Pisanko and Yu.N. (1991) Mus'kin,. Some physiological reactions of organisms under the influence of EHF radiation. *Apparatniy kompleks 'Elektronika-KVCh' I yevo primenenie v meditsine.,* L.G. Gassanova,ed. Moscow, 156 pp. NPO 'Saturn, Kiev, pp. 65-71, cited by Kositsky et al 2001.
600 µW/cm^2 at 900 MHz – FCC Exposure Limit in USA (FCC OET65:1997-01 based on NCRP report No.86)		
1000 µW/cm^2 at 1800 MHz – FCC Exposure Limit in uncontrolled environment in USA (FCC OET65:1997-01 based on NCRP report No.86)		
1,000 µW/cm^2	**ODC activity increased up to 50% in human melanoma cells** (450-500 MHz at 16 Hz).	W.R. Adey et al., Studies on ornithine decarboxylase (ODC), an enzyme essential for cell growth through DNA synthesis, cited by B.B. Levitt (1995), *Electromagnetic Fields: A Consumer's Guide to the Issues and How to Protect Ourselves.*
1000 µW/cm^2 Occupational exposure (average)	**ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m.** ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes.	Alasdair Philips, Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects. 24th July 2002
1000 µW/cm^2	At 2,450 MHz, maximum specific absorption rate (SAR) for energy of 2.0 W/kg occurs in outer 1.0cm of phantom head (dummy head used for testing).	H.N. Kritikos and H.P. Schwan (1972), Hot spots generated in conducting spheres by electromagnetic waves and biological implications. IEEE Transactions on Biomedical Engineering, 19 (1), 53-58. Cited by W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' Physiological Reviews, 61(2), 435-51.
1000 µW/cm^2	At 918 MHz, energy absorption at centre of head is 0.45 W/kg.	W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' Physiological Reviews, 61(2), 435-51.
2000 µW/cm^2	**Australian Standard public exposure level** – Australian Standard AS2772.1. (1990) **Radiofrequency Radiation Part 1: Maximum Exposure Levels -- 100 kHz to 300 GHz.** Sydney: Standards Australia.	
700-2,800 µW/cm^2	**EEG changes resembling those induced by hallucinogenic drugs noted in rabbits exposed to 9.3 GHz radiation for 5 minutes.** Change noted 10 minutes after exposure with decreased total integrated EEG lasting ≤15 minutes.	L. Goldstein and Z. Sisko (1974), A quantitative electroencephalographic study of the acute effects of X-band microwaves in rabbits. In: *Biological effects and health hazards of microwave radiation* (P. Czerski, Ed.), p. 128-133. Warsaw: Polish Medical Publishers. Cited by R.O. Becker and A.A. Marino (1982), *Electromagnetism & Life*, State University of New York Press, pp. 211, ISBN: 0873955609, www.ortho.lsuhsc.edu/Faculty/Marino/EL/ELTOC.html
1,000-5,000 µW/cm2 above 300MHz	The American National Standard Institution's voluntarily required limit for worker and public exposures as at 1989, cited by C.W. Smith and S. Best (1989).	
2,600 µW/cm^2	Maximum exposure in school with base station on roof. Maximum power density of 0.01 µW/cm^2 measured at two schools without nearby base stations.	A. Thansandote, G.B. Gajda and D.W. Lecuyer (1999), Radiofrequency radiation in five Vancouver schools: exposure standards not exceeded. Canadian Medical Association Journal, 161(10), pp. 1311-1312.
5,000 µW/cm^2	Increased bone marrow cellularity in mice exposed to a 2.88 GHz field (SAR 2.3 W/kg) for 80-400 hours – effect not noted at 10,000 µW/cm^2 indicating possible window effect.	H.A. Ragan and R.D. Philips (1978), Hematologic effects of mice exposed to pulsed and CW microwaves. In: Proc. Int. Union Radio Sci., Symp. On Biologic Effects of Electromagnetic Waves, Helsinki, p. 48, cited by W.R. Adey, 1982.

Power Density	Reported Biological Effects / Comments	References
5,500 µW/cm^2	**Exposing developing chick embryos to 428 MHz radiation for >20 days caused lethal and/or teratogenic effects and delayed hatching.**	K. Saito and K. Suzuki (1991), Lethal and teratogenic effects of long-term low-intensity radio frequency radiation at 428 MHz on developing chick embryo. Teratology, 43, pp. 609-614.
6400 µW/cm^2 Public exposure (peak)	**ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m.** ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes, cited by A. Philips 2002.	
2,640 µW/cm^2 at 400 MHz – General Public Exposure Limit in UK (NRPB, 1993) (TETRA operates at 400 MHz)		
3,300 µW/cm^2 at 900 MHz – old UK General Public Exposure Limit to June 2000). Now ICNIRP is used for 900 MHz		
31,000 ±5,000 µW/cm^2 (Peak values)	Exposure of BALB/c mice to 42.2 GHz fields (with peak specific absorption rate (SAR) at skin of 622±100 W/kg) for 30 minutes daily for 3 days found to ameliorate the immunosuppressive effects of cyclophosphamide (CPA) – a regularly used anticancer drug – by augmenting proliferation of splenocytes and altering activation and effector functions of $CD4^+$ T cells.	V. Makar, M. Logani, I. Szabo, and M. Ziskin (2003), Effect of Millimeter Waves on Cyclophosphamide Induced Suppression of T Cell Functions, Bioelectromagnetics 24:356–365.
4,000 µW/cm^2	**Threshold for neuroendocrine effects**	W.R. Adey (1982).
5,000 µW/cm^2	**FCC threshold in controlled environment.**	Luxorion, Electromagnetic radiations and your health, www.astrosurf.com/luxorion/qsl-em-radiation
6400 µW/cm^2 Public exposure (peak)	**ICNIRP (& UK) public guidance levels at 400 MHz (TETRA) and 28 V/m.** based on power levels averaged over 6 minutes.	A. Philips (2002), Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects.
<10,000 µW/cm^2	**EHF EMR capable of changing functional condition of living organisms**	O.I. Pisanko, V.I. Pyasetskiy and Yu.N. Mus'kin (1991), Questions of hygienic standardization of EHF radiation. *Apparatniy kompleks 'Elektronika-KVCh' i yevo primenenie v meditsine.* L.G. Gassanova, ed. Moscow, 156 pp. NPO 'Saturn,' Kiev, pp. 18-24, cited by Kositsky et al., 2001.
10,000 µW/cm^2 at 1800 MHz	**Old UK General Public Exposure Limit to June 2000).** Now ICNIRP is used for 1800 MHz, cited by A. Firstenberg 2001.	
10,000 µW/cm^2	**Exposure level recommended as safe by the NRPB for the frequency range 30 to 30,000 MHz (as at 1991)** was **10 mW/cm^2** or, **1 mW hour/cm^2**, during any 1 hour period. The NRPB did not include considerations relevant to small children.	
10,000 µW/cm^2	**Molecular and genetic effects (thermal)**	W.R. Adey (1982).
10,000 µW/cm^2	Exposure to 2450 MHz radiation for 90 minutes produced activation of the hypothalamic-pituitary-adrenal axis and increased oestradiol in both virgin and pregnant rats, suggesting **microwaves may greatly stress pregnant organisms**.	H. Nakamura, T. Seto, H. Nagase, M. Yoshida, S. Dan and K. Ogino (1997), Effects of exposure to microwaves on cellular immunity and placental steroids in pregnant rats. Occup Environ Med 54(9), pp. 676-80, cited by A. Marino, www.niehs.nih.gov/emfrapid/extrmurabs/marino.html
10,000-30,000 µW/cm^2	Chickens exposed at pulse repetition rate of 8,000 pulses per sec and frequency of 16,000 Mc/s. **Birds all exhibited a startled reaction at radiation onset, sustained extensor activity of wings and legs also noted.** Similar findings obtained with pigeons and seagulls. **Note: ICNIRP levels are 200 µW/cm^2 at 400 MHz rising to 1000 µW/cm^2 at ≥ 2 GHz**	J.A. Tanner (1966), Effect of Microwave Radiation on Birds, Nature, pp. 636.
10,000 µW/cm^2	No detectable ocular damage to the eyes of rabbits and non-human primates after either single 8-hour exposure to 60 GHz CW radiation or five separate 4-hour exposures on consecutive days.	H.A. Kues, S.A. D'Anna, R. Osiander, W.R. Green and J.C. Monahan JC (1999), Absence of ocular effects after either single or repeated exposure to 10 mW/cm^2 from a 60 GHz CW source. Bioelectromagnetics 20(8), pp.463-473.
1000 –10,000 µW/cm^2	**Exposure limit in UK as at 2001.**	A. Firstenberg (2001).

Power Density	Reported Biological Effects / Comments	References
10,000 µW/cm^2	**US Occupational Safety and Health Administration's standard as at 1989**	C.W. Smith & S. Best (1989), Electromagnetic Man: Health & Hazard in the Electrical Environment, J.M. Dent & Sons Ltd., London, ISBN 0-460-86044-5.
13,300 µW/cm^2 (Average Power Density)	**Millimeter wave treatment (MMWT) is widely used in Eastern Europe. Among reported beneficial effects is suppression of melanoma growth.** Tests on mice injected with B16 melanoma cells used 15-minute exposures (at 61.22 GHz). 5 daily exposures found to suppress subcutaneous tumour growth if started 5 days after inoculation; though if course started on day 1 or day 10 following inoculations they were ineffective.	A.A. Radzievsky, O.V. Gordiienko, I. Szabo, S.I. Alekseev, and M.C. Ziskin (2004), Millimeter Wave-Induced Suppression of B16 F10 Melanoma Growth in Mice: Involvement of Endogenous Opioids, Bioelectromagnetics 25:466–473.
20,000-50,000 µW/cm^2	**Exposed chickens respond with escape or avoidance reactions within seconds of radiation onset.**	J. A. Tanner, C. Romero-Sierra and S. J. Davie (1967), Non-thermal Effects of Microwave Radiation on Birds, *Nature* 216, pp. 1139.
25,000 µW/cm^2	**Young chicks became weak** on entering pulsed 16 GHz fields. Some collapsed to cage floor (where field intensity shown was registered) until radiation switched off. Collapse time (5-20 seconds) varied with chicks' orientation in field. Induced panting continued briefly after field removed. Drowsiness also noted.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagneticfields And Living Systems With Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
28,000 µW/cm^2	**Teratogenic and tumour causing effects**	W.R. Adey (1982), 'Tissue Interactions with Nonionizing Electromagnetic Fields,' Physiological Reviews, 61(2), 435-51.
32,000 µW/cm^2 Occupational exposure (peak)	**ICNIRP public guidance levels at 400 MHz (TETRA) and 28 V/m.** ICNIRP (& UK) Standard Guidance is based on power levels averaged over 6 minutes.	Alasdair Philips, Report 2213, Report regarding Microwave Emissions from the T-Mobile (UK) cellular telephone base station at James Stockdale Ltd, Ratten Row, Seamer, Nr Scarborough with respect to any possible adverse health effects. 24th July 2002.
40,000-165,000 µW/cm^2	**Dogs avoid exposure to 2800 MHz radiation at these intensities**	S. Michaelson et al., (1958). The biological effects of microwave irradiation in the dog, Proc. Second Tri-Serv. Conf. on Biological Effects of Microwave Energy, Rome, New York, p.175, cited by A.S. Presman (1970), Electromagnetic fields and life, (Translated from Russian by F.L. Sinclair). Plenum Press, New York, ISBN 0-306-30395-7, 356pp.
45,000 µW/cm^2	**Dorsally stimulated adult birds exhibited behaviour ranging from immobility to initiation of both flight and collapse.** Contributory factors were found to be behaviour prior to exposure, area of bird radiated and bird's location.	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagneticfields And Living Systems With Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.
46,000 µW/cm^2 (average field intensity 0.152m above floor)	Birds exposed to 9.3 GHz radiation pulsed at 416 pps with 2.3 µsec pulse-width. **Collapse of wing and legs noted at start of irradiation. Birds align themselves to outside of field, with their outer side becoming paralysed. Some exhibit hyperactivity. Escape behaviour also noted.**	J.A. Tanner, C. Romero-Sierra and S.J. Davie (1967), *Non-thermal Effects of Microwave Radiation on Birds*, Nature, 216, (5120), pp. 1139.
50,000 µW/cm^2	**Almost total paralysis observed in chickens.** After 10-20 seconds irradiation pigeons and seagulls showed increased signs of distress noted through defecation, vocalisation and initiation to flight.	J.A. Tanner and C. Remero-Sierra (1974), Beneficial and harmful accelerated growth induced by the action of nonionizing radiation, Annals of New York Academy of Sciences 238, pp. 171-175.
60,000 µW/cm^2	Significant differences noted in EEG patterns of birds when exposed to microwave field modulated sinusoidally at 4 Hz in comparison to non-irradiated situations.	F. Villa, C. Romero-Sierra and J.A. Tanner (1972), Changes in EEG Patterns of Birds under Microwave Radiation. NRC, DME Control Systems Laboratory Technical Report, LTR-CS-56, January 1972.

Power Density	Reported Biological Effects / Comments	References
60,000 μW/cm^2	Increased diffusion rate of aqueous solutions of electrolytes through membranes noted under 10 GHz, CW microwave radiation, being most pronounced when electric field vector oriented perpendicular to plane of the membrane.	J. Bigu del Blanco, C. Romero-Sierra, J.A. Tanner and M.L. Bigu (1973), Progress Report on the Investigation of the Effects of Microwave Radiation on the Diffusion Rate of Electrolytes through Membranes II. NRC, DME Control Systems LTR-CS-73.
80,000 μW/cm^2	**Repeated 1 hour exposures (20-24 times) to 2.45 GHz fields caused lens opacities in the eyes of 1 of 11 rabbits tested** – other studies do not find evidence of cumulative effects.	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
100,000 μW/cm^2	**Repeated exposures caused lens opacities in the eyes of 4 of 10 rabbits tested** – other studies do not find evidence of cumulative effects. (Lens opacities of rabbits used as model for human cataract induction)	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
120,000 μW/cm^2	**Approximately two minutes exposure caused sudden wilting reaction in a Mimosa plant that died without reopening.**	J. A. Tanner and C. Remero-Sierra (1974), Beneficial and harmful accelerated growth induced by the action of nonionizing radiation, Annals of New York Academy of Sciences 238, pp. 171-175.
120,000 μW/cm^2	**Repeated exposures caused lens opacities in the eyes of 8 of 10 rabbits tested** – other studies do not find evidence of cumulative effects.	R.L. Carpenter, E.S. Ferri and G.J. Hagan (1974), 'Assessing microwaves as a hazard to the eye – progress and problems,' Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, ed., Polish Medical Publications, Warsaw, p. 178-185, cited by W.R. Adey 1982.
140,000-190,000 μW/cm^2	5-10 minutes exposures at 140,000-190,000 μW/cm^2 caused plants' primary leaves to wilt. **10-30 minute exposures of most plants to 190,000 μW/cm^2 irradiation caused permanent wilting.**	C. Romero-Sierra, J.A. Tanner, J. Bigu del Blanco (1973), Interaction of Electromagnetic fields And Living Systems with Special Reference To Birds, Control Systems Laboratory, Division of Mechanical Engineering / Division de Génie Mécanique, Canada, Report LTR-CS-113, presented to International Symposium on Biological Effects and Health Hazards of MW Radiation, World Health Organization, Warsaw, October 1973, 37 pp.

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Review

A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF)

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ABSTRACT

Objective: This article presents a systematic review of published scientific studies on the potential ecological effects of radiofrequency electromagnetic fields (RF-EMF) in the range of 10 MHz to 3.6 GHz (from amplitude modulation, AM, to lower band microwave, MW, EMF).
Methods: Publications in English were searched in ISI Web of Knowledge and Scholar Google with no restriction on publication date. Five species groups were identified: birds, insects, other vertebrates, other organisms, and plants. Not only clear ecological articles, such as field studies, were taken into consideration, but also biological articles on laboratory studies investigating the effects of RF-EMF with biological endpoints such as fertility, reproduction, behaviour and development, which have a clear ecological significance, were also included.
Results: Information was collected from 113 studies from original peer-reviewed publications or from relevant existing reviews. A limited amount of ecological field studies was identified. The majority of the studies were conducted in a laboratory setting on birds (embryos or eggs), small rodents and plants. In 65% of the studies, ecological effects of RF-EMF (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. No clear dose–effect relationship could be discerned. Studies finding an effect applied higher durations of exposure and focused more on the GSM frequency ranges.
Conclusions: In about two third of the reviewed studies ecological effects of RF-EMF was reported at high as well as at low dosages. The very low dosages are compatible with real field situations, and could be found under environmental conditions. However, a lack of standardisation and a limited number of observations limit the possibility of generalising results from an organism to an ecosystem level. We propose in future studies to conduct more repetitions of observations and explicitly use the available standards for reporting RF-EMF relevant physical parameters in both laboratory and field studies.

Contents

Abbreviations: ELF-EMF, extremely low field electromagnetic field; CW, continuous wave; MW, microwave; PW, pulsed wave; GSM, global system for mobile communications; UHF, ultra-high frequency; VHF, very-high frequency; DECT, digital enhanced cordless telecommunications; UWB, ultra wide band; AM, amplitude modulation; FM, frequency modulation; GTEM, gigahertz transverse electromagnetic cell; UMTS, universal mobile telecommunications system; CDMA, code division multiple access; TDMA, time division multiple access; WCDMA, wideband code division multiple access; Wi-Fi, Wireless Fidelity; WLAN, wireless local area network; WiMAX, worldwide interoperability for microwave access.

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1. Introduction

1.1. Scope

Anthropocene is a term which has been proposed for the current epoch, due to the global environmental effects of increased human population, and the economic and industrial development and to the deep overall domination and contamination of humans over the environment (Crutzen and Stoermer, 2000; Zalasiewicz et al., 2010). Amongst the many changes, a radical modification has also taken place in the exposure of beings to man-made electromagnetic fields. A continuous, chronic, exposure to a wide range of modulated radiofrequency electromagnetic fields (RF-EMF) burdens all species and groups across the globe.

In terms of mechanisms, the WHO confirms that to date the accepted health effects ascribable to RF-EMF are caused by temperature elevation (van Deventer et al., 2011). Though, several studies have identified possible effects of RF-EMF on organisms, no alternative effect mechanisms have been confirmed to date. Most of the literature has focused on human and occupational health, largely based on animal model studies under laboratory conditions and test subjects exposed to lower frequencies of the spectrum (i.e. extremely low field, ELF-EMF). From the available studies, it became clear that, especially under higher dosages, effects of RF-EMF may be observed. As a response, occupational and human health threshold values and guidelines, proposed by international organisations (ICNIRP, 2010), have been increasingly incorporated into national regulations of states (EU, 2011). However, results are still not conclusive and there is still some uncertainty about the low dosages and non-thermal effects applied in some studies which did find an effect, and the overall quality of the setup of research in the field. The ever increasing use of RF-EMF in the cellular phone ranges (e.g. GSM and UMTS) and the newer forms of wireless communication (e.g. WiFi, WLAN and WiMAX), which are rarely present in the available studies, require new investigations which will look at possible short and long-term effects.

Over time several monographs and reviews have been compiled as to the biological effects of RF-EMF on humans, and on animals (see among others: Michaelson and Dodge, 1971; NCRP, 1986; Bryan and Gildersleeve, 1988; Adair, 1990; Verschaeve and Maes, 1998; Juutilainen, 2005; Balmori, 2009; Pourlis, 2009; ICNIRP, 2010). While of great relevance for the understanding of the phenomenon, these studies lack in the consideration of potential effects which may directly affect other organisms or ecosystems, because of the very limited attention which is usually received by the adverse ecological effects of RF-EMF.

1.2. Problem definition

Limited research and reviews have focused on investigating the possible ecological effects of RF-EMF. It can be argued that many human-related biological studies using animal models (e.g. rats and rabbits) may provide also relevant information about potential ecological effects. Many ecological endpoints (e.g. fertility, reproduction and growth) studied at the level of the individual animal, are also crucial from an ecological point of view. Ecology is, one of the sub-disciplines of biology, which studies all living organisms (including human beings), at all organisational levels (i.e. from the smallest molecular system to the largest ecosystem levels). Ecology is the scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance (Begon et al., 2005). Those interactions refer to the abiotic and the biotic environment. By definition ecology focuses on the higher organisational levels of populations, communities and ecosystems. Despite the lack of information of the ecological effects of RF-EMF, following this definition, it is then plausible to link biological studies with ecological endpoints at the individual animal level to ecological interpretations at a higher organisation level.

This field of research is of crucial importance for the understanding of mechanisms of interaction between complex ecosystems and the environment. Animal studies have still been identified as a major research agenda point by the WHO (Van Deventer et al., 2011). The WHO stated that high priority in the field should be given to research on the effects of RF-EMF on development and behaviour, on ageing and reproduction of animal subjects. The result of these studies might be ecologically interpreted, because they include ecologically relevant endpoints.

As far as strictly ecological research has been conducted, it was mostly presented in the form of non-peer-reviewed *grey literature*. A review of Balmori (2009) is the only oriented one at the effects of RF-EMF on wildlife. However, the contribution by Balmori (2009) has some methodological issues. The criteria for the screening of the literature or the rationale for the inclusion or exclusion of relevant articles have, in fact, not been presented. The review is also missing a detailed analysis of the selected papers (e.g. of the duration of

exposure and of the physical parameters) and it includes only studies finding a significant effect of RF-EMF.

1.3. Research focus

Evidence suggests that there is a large lacuna in research regarding the ecological effects of RF-EMF. The aim of this contribution is to conduct a scientifically sound review of potential ecological effects of RF-EMF. Using the definition and guidelines provided in the clinical sector by Higgins and Green (2006), a systematic review on potential ecological effects of RF-EMF was performed.

The study focuses on the range from 10 MHz to 3.6 GHz (i.e. from AM to the lower band MW EMF), using a transparent, comprehensive and objective substantive review approach and analysis of the available scientific literature on the ecological effects of RF-EMF. The literature search was based on a clear and objective research strategy (see Section 2) performed which used two databases: ISI Web of Knowledge and Google Scholar. The experimental, physical and biological parameters, which were provided by the selected papers were classified and analysed to look for trends and possible links between dosages and effects.

Papers evaluating ecological endpoints as part of biological investigations were selected with a focus on higher organisational biological levels: ecosystem, community, and species. As much as possible also biological studies, present in biological reviews or in relevant papers, if relevant from an ecological point of view, were included in this review and analysed.

A complete review of the biological literature was beyond the scope of this paper. However, laboratory studies on animals and plants which investigated biological endpoints can still provide information relevant for the ecological level.

First in Section 2 the methods are described, in Section 3 the general results are presented, and in Section 4 the specific results are given for each of the analysed groups (i.e. birds, insects, other vertebrates, other organisms, and plants). The final sections (Sections 5 and 6) provide a synthesis, with possible links between dose–response relationship, the setup and dosage of the studies, together with general conclusions and recommendations.

2. Review method

2.1. Criteria of literature search

The literature research was conducted, in the second half of 2011, using ISI Web of Knowledge and Google Scholar databases. Publications on ecological effects of RF-EMF on all relevant endpoints on non-human organisms and parts of organisms (e.g. tissues and cells) were taken into consideration Additional scientific articles published after December 2011 were added upon indication and suggestion of experts.

In order to maintain a high scientific standard for this review paper, only publications which were peer reviewed were considered. As criterion for peer review, the presence of the publication in the ISI Web of Knowledge was used. As for papers present only on Google Scholar an expert selection was made based on the ecological relevance and quality of the studies. The criteria used were based on quality criteria defined by relevant methodological reviews (Repacholi and Cardis, 1997; Stam, 2010). Repacholi and Cardis (1997) suggest that reviews should take into consideration only literature published in scientific peer-reviewed journals to guarantee a selection of articles free from methodological deficiencies and with rigorous analysis and conclusions. They also suggest care when dealing with peer-reviewed reports not published in scientific journals as well as conference abstracts, which are usually not peer-reviewed. In this review, only peer-reviewed papers have been selected. In a limited number of cases peer revision could not be guaranteed: the case of a study conducted by Harst et al. (2006) on honey bee (*Apis mellifera*), where no sufficient information could be found on the review procedure of the relative journal, and the studies by Van Ummersen (1961, 1963), Carpenter et al. (1960), and Clarke (1978) which were reported by the (peer-reviewed) review by Bryan and Gildersleeve (1988).

The literature search was limited to the range of frequencies from 10 MHz to 3.6 GHz. Papers on the biological and ecological effects of ELF-EMF in the range of 1 Hz–100 kHz (e.g. power line fields) were not considered. Date of publication was not used as a restriction and all publications falling within the selection criteria above were analysed, including those which did not find significant effects.

The keywords used in the literature research process are reported in the appendix to this review. Two main categories were defined: *RF-EMF specific* keywords (e.g. GSM, DECT and 1800 MHz) and *ecological* keywords (e.g. growth, population and eco*).

2.2. Description of the literature search

2.2.1. Main search strategy

A step-wise search strategy was conducted to find the most relevant articles in the RF-EMF range selected.

As a first step, the literature research was conducted on the ISI Web of Knowledge website, which provided 451,031 hits. Since this number of articles was too large to handle, a selection process was started. The collection was further refined by selecting only articles, reviews and proceeding papers as document types (440,528 hits). Then specific categories were selected: applied physics, cell biology, plant sciences, environmental sciences, biophysics, zoology, ecology, biology and microbiology. The number of hits was so reduced to 98,620.

In order to reduce the number of hits, all the results clearly outside the RF-EMF field of research, or beyond the scope of this review were excluded. This process reduced the number of hits further to 90,408 hits. A further screening was conducted selecting keywords from the RF-EMF specific and from the ecological defined groups, using one or two of RF-EMF keywords singularly or in combination with a single keyword from the ecological group. The obtained results ranged from 10 hits to 600. Titles were then screened one by one to select papers that could be of interest.

An analogous pattern of searches was performed on Google Scholar and only articles that had not yet been found on ISI Web of Knowledge were added. The number of hits for the initial combination of keywords was 3,600,000, and then reduced with an analogous procedure as described in ISI, but with a more attentive look at the content and the source of the selected papers.

After this first step of the searching process, 709 presumably relevant articles were identified. A one-by-one screening of titles and abstract was performed to investigate which papers would meet the defined criteria (e.g. frequency range and biodiversity exposure to RF-EMF). This second screening led to a new selection of 307 papers.

A closer analysis of the content of these 307 selected papers revealed that most of them regarded highly specific and strictly technical *biological* studies (e.g. rat tissues, cell-line studies, neuronal studies and calcium signalling), which were difficult to link directly to ecological effects, and, therefore, discarded. The final selection was reduced to 55 clearly relevant papers.

2.2.2. Related-references search

As a second step, it was decided to proceed by using a selected number of the 57 available articles to create a search based on “related references” to the ones used by their authors. The first articles used were those that clearly met the scope of the review in terms of focus and content: e.g. Balmori (2005), Panagopoulos et al. (2010) and five others. The screening of a total of 4000 hits provided 32 additional relevant hits.

Also a selection of the relevant references was conducted from the four relevant reviews (Bryan and Gildersleeve, 1988; Juutilainen, 2005; Pourlis, 2009; Verschaeve and Maes, 1998) and this resulted in 15 additional articles.

Regular updates were conducted until October 2012 to also include the most recently published relevant literature. After a careful analysis of all gathered information a total of 113 articles was selected and described in detail in the following sections. The total number of experiments carried out in these articles was 152.

3. General overview of results

The biggest share of the articles (c. 90%) involves laboratory studies with biological endpoints with a clear ecological relevance. The remaining part were ecological field studies (Table 1).

Most of the laboratory studies included had growth, development, behaviour and reproduction/fertility as biological endpoints. The endpoints analysed in field studies were behaviour, shift in populations and fertility. In circa 65% of the studies a statistical significant effect of RF-EMF on ecological relevant endpoints has been found (Table 1). There were no clear differences in percentage effects between articles included in reviews or not included in reviews. Development seemed to be less significantly affected in percentage than growth and fertility.

The most represented groups include vertebrates, other than birds (i.e. predominantly rats, mice and rabbits), then birds and plants. Articles which found significant effects of RF-EMF were found more frequently in the case of birds, insects (i.e. mostly honey bees and fruit flies) and plants. The group of other vertebrates (Table 1) was equally distributed among significant and non-significant effects. Effects were significant in all the articles on other organisms.

The type of endpoints studied differed across groups. Fertility was the mostly analysed endpoint for the birds. Growth was affected in all the experiments conducted on plants and other organisms, while it was affected in 25% of the studies on other vertebrates and ca. 40% on the birds. The effects of RF-EMF on behaviour were found in thirteen of the twenty of the studies on other vertebrates and in 85% ca. of the studies on insects.

Table 1
General overview of effects and no-effects studies across articles types, endpoints and species groups.

General findings of articles		
		Count
Included in review (including 80 articles, 4 reviews and 18 articles from these reviews)		113
Finding an effect		74
Not finding an effect		39
Laboratory studies		106
Field studies		8
Endpoints investigated		152
	Effect	No effect
Subdivision of articles among species		
Birds	18	8
Insects (including bees, fruit flies and ants)	15	2
Other vertebrates (mostly animal models)	25	25
Other organisms (nematodes, bacteria, etc.)	4	0
Plants	12	4
End points studied in screened articles		
Birds	20	18
Growth	3	4
Development	4	3
Fertility/reproduction	4	8
Behaviour/stress	3	0
Mutation	4	0
Mortality	0	1
Population decline	2	2
Insects	22	3
Growth	–	–
Development	4	0
Fertility/reproduction	9	1
Behaviour/stress	6	1
Mutation	–	–
Mortality	0	1
Population decline	1	0
Other vertebrates	35	27
Growth	4	1
Development	9	5
Fertility/reproduction	7	11
Behaviour/stress	13	7
Mutation	1	1
Mortality	1	2
Population decline	–	–
Other organisms	4	0
Growth	2	0
Development	–	–
Fertility/reproduction	–	–
Behaviour/stress	2	0
Mutation	–	–
Mortality	–	–
Population decline	–	–
Plants	22	2
Growth	12	0
Development	3	0
Fertility/reproduction	1	0
Behaviour/stress	3	1
Mutation	3	1
Mortality	–	–
Population decline	–	–

4. Ecological effects of RF-EMF

4.1. Birds

Birds have been widely used to analyse the environmental significance of exposure to nonionizing radiation. The ability of birds to detect magnetic stimuli has been documented by several studies (see Keeton, 1971; Thalau et al., 2005; Wiltschko and Wiltschko, 1996; Wiltschko et al., 2001). A total of 26 articles was selected from the screened literature with 38 relevant endpoints. With the exception of five field studies, all studies were conducted in a laboratory setting.

Of the 26 studies, 70% have been significantly related to the effect of RF-EMF (Table 1). In most cases the effects studied were growth and fertility and were conducted, until the early nineties, under a continuous microwave system of exposure (i.e. 2450 MHz). The physical parameters usually reported regarded the measured level of power flux density and specific absorption rate (SAR). These parameters were either measured using probes or specific detectors or were based on the information of the manufacturers of the exposure devices.

Chicken (*Gallus domesticus*) and Japanese quail (*Coturnix coturnix* subsp. *japonica*) represented the most studied experimental system in laboratory studies on birds. Approximately 60% of the laboratory studies considered a system at the embryo or egg stages of development.

4.1.1. Laboratory studies

4.1.1.1. Embryo and egg. In the eighties and early nineties researchers focused on the effects of MW EMF. There was a high level of interest especially in the ranges that would be relevant, at that time, for the possible implementation of new source of renewable power based on the collection of solar energy in space by means of solar power satellites (SPS add to abbreviation list) and its transmission to earth via MW EMF (Glaser, 1968; Wasserman et al., 1984). The three more recent studies (Table 2) investigated the typical cellular phones range of frequencies.

All the measured physical parameters varied greatly across studies. The estimated SARs ranged between 0.001 W/kg and 140 W/kg (Kleinhaus et al., 1995; Van Ummersen, 1961), while the duration of the exposure was as little as 9 s (McRee and Hamrick, 1977) with peak values of 45 days (Grigoryev, 2003). The variation which was found for the power density ranged from 4.4×10^{-6} mW/cm^2 as in Reijt et al. (2007) to 400 mW/cm^2 measured in Van Ummersen (1961).

Table 2
Summary of articles reporting ecological effects of RF-EMF on birds.

Reference	Country	Species	Scientific name	Life stage[a]	Type of study[b]	Number of subjects[c]	Duration of exposure	Frequency [MHz]	Wave/ modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Carpenter et al. (1960)	USA	Chicken	*Gallus gallus* subsp. *domesticus*	Emb	Lab	n/a[i]	1–15 min	2450	MWCW	200 280 400	70 98 140	Teratogenic effects on the embryo Idem Idem	+
Van Ummersen (1961, 1963)	USA	Chicken	*As above*	Emb	Lab	n/a	1–15 min	2450	MW CW	200 280 400	70 98 140	Inhibition of growth Idem Idem	+
Hills et al. (1974)	Canada	Chicken	*As above*	Emb	Lab	n/a	20–300 s; first 2 days of incubation	2450	MW CW	0.2 246 1020	n/a	Reduced chicken hatchability	+ (33%)
Giarola and Krueger (1974)	USA	Chicken	*As above*	Juv	Lab	n/a	28 days Idem	880 260	UHF CW VHF CW	0.5 0.5	n/a n/a	Reduced growth rate Reduced growth rate	+ +
Hamrick and McRee (1975)	USA	Japanese quail	*Coturnix coturnix* subsp. *japonica*	Emb	Lab	n/a	24 h	2450	MW CW	30	14	Reduced hatchability, altered/ organ development	−
McRee et al. (1975)	USA	Japanese quail	*As above*	Emb	Lab	57 (4)	4 h for first 5 days of incubation	2450	MW CW	30	14	Altered development	−
Krueger et al. (1975)	USA	Chicken	*As above*	Ad	Lab	5 (5)	12 weeks	260	VHF	0–1	n/a	Unaltered fertility, reproduction and hatchability	−
							Idem	915	UHF	1.25	n/a	Unaltered fertility, reproduction and hatchability	–
							Idem	2450	MW CW	1	n/a	Unaltered fertility, reproduction and hatchability	–
Davidson et al. (1976)	Canada	Chicken	*As above*	Juv	Lab	n/a	4.5–6 s	2450	MW	1.043	n/a n/a	Unaffected egg production Unaltered growth, reproduction, mortality	– –
McRee and Hamrick (1977)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW CW	5	4.03	Unaltered development	–
Clarke (1978)	USA	Chicken	*As above*	Emb	Lab	n/a	34th–60th hr of incubation	2450	MW PW (mod. 60 Hz and 12 Hz)	100	n/a	Behavioural changes in hierarchy positioning as adults	+
Fisher et al. (1979)	Canada	Chicken	*As above*	Emb	Lab	n/a	4–5 days	2450	MW CW	3.5	n/a	Early embryonic development	+
Cabe and McRee (1980)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW CW	5	4.03	Altered response to behavioural tests as adults	+
Inouye et al. (1982)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW	5	4.03	Developmental retardation of Embryos No differences after week 8	+ (7%) −

McRee et al. (1983)	USA	Japanese quail	*As above*	Emb	Lab	270 (120)	First 12 days of incubation	2450	MW CW	5	4.03	Reduction in reproductive capacity	+ (8%)
Wasserman et al. (1984)	USA	Sparrow; junco	*Zonotrichia albicollis*; *Junco hyemalis*	Var	Field	12 flocks (2 flocks)	20 min; 200 min	2450	MW	25	0.85–0.92	Variation in level of aggression of birds after exposure	+ (11%)
							20 min	2450		100	Idem		
							7–10 min	2450		155	Idem		
Byman et al. (1985)	USA	Japanese quail	*As above*	Egg	Lab	30 (90)	60 min during 17 days incubation	2450	MW CW	20–50	0.5	Unaltered growth or abnormal development	−
Gildersleeve et al. (1987)	USA	Japanese quail	*As above*	Emb	Lab	468 (468)	12 days during incubation	2450	MW CW	5	4.03	Unaltered fertility, reproduction and hatchability	−
Kleinhaus et al. (1995)	Israel	Migratory birds	n/a	n/a	Sim	n/a	n/a	4–26	Broadcast station	n/a	0.001–0.004	Unaltered development and population levels	−
Bastide et al.(2001)	France	Chicken	*As above*	Emb	Lab	300 (300)	Incubation period	900	GSM	n/a	n/a	Increased mortality. Inhibition of normal development	+ (53%)
Grigoryev (2003)	Russia	Chicken	*As above*	Emb	Lab	n/a	21 days	900	GSM	n/a	n/a	Increased mortality	+
Balmori (2005)	Spain	White stork	*Ciconia ciconia*	Pop	Field	60 nests	2 months	900–1800	GSM base station	0.001477 (mean within 200 m); 7.45093×10^{-5} (mean farther than 300 m)	n/a	Severe decline in productivity	+ (46%)
Balmori and Hallberg (2007)	Spain	Sparrow	*Passer domesticus*	Var	Field	40 visits (1200 data points)	3 years and 8 months	1 MHz–3000	GSM to MW	0.00325 (max); 4.24403×10^{-5} (mean)	n/a	Decline in bird population and dose–effect relationship found between electric field strength and population decline at specific locations	+ (75%)
Everaert and Bauwens (2007)	Belgium	Sparrow	*As above*	Var	Field	150 locations	4 months during the breeding period	925–960	GSM base station	4.34589×10^{-6}	n/a	Significant relationship between number of house sparrows and levels of power density	+ (70%)
							Idem	1805–1880	GSM base station	9.07759×10^{-6}	n/a	Idem	
Reijt et al. (2007)	Poland	Great tit; blue tit	*Parus major*; *Cyanistes caeruleus*	Ad	Field	72 (42)	45 days	1200–3000	Radar	20–50	n/a	Unaltered fertility and growth	−
												Possible shift in species distribution	+ (50%)
Batellier et al. (2008)	France	Chicken	*As above*	Egg	Lab	(240)	Incubation period	900	GSM	0.00306–0.04197	n/a	Reduced hatchability. Increased Embryo mortality	+ (42%) +

[a] Life stage refers to the age of the tested subject at the moment of the experiment. Emb = embryo, Ad = adult and Egg = egg.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects.
[d] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, PW = pulsed wave GSM = Global System for Mobile Communications, UHF = Ultra-High Frequency, and VHF = Very high frequency.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values (PD = $EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

The endpoints included growth, hatchability, development based on evidence of abnormal weight of hatchlings, incidences of abnormalities and mortality. Nine of the 15 experiments showed significant differences between RF-EMF and controlled/sham-exposed eggs.

It is a common opinion among experts (Baranski and Czerski, 1976; Bryan and Gildersleeve, 1988) that the results obtained in most of the studies until the 1980s (i.e. until Inouye et al., 1982 in this selection) relate to increases in the temperature of the egg due to the consequences of hyperthermia a few degrees above normal incubation temperature. An abnormal increase in temperature gradient of 3.5 °C had already been observed in the early study by Van Ummersen (1961, 1963), reported in the review conducted by Bryan and Gildersleeve (1988). In a later study, Byman et al. (1985) found no effect on the growth and normal development of born chicks of birds nesting in proximity to antennas. Temperature rise was controlled and the measured power density was 25 mW/cm^2. Analogous results were obtained by Gildersleeve et al. (1987) who kept the internal temperature of irradiated and sham-exposed eggs to a mean of 37.5 °C without detecting any deficiency in the reproductive performance of males and females allowed to hatch.

Among the three more recent studies, Bastide et al. (2001) and Grigoryev (2003) found a significant increase in mortality due to RF-EMF on chicken (*G. gallus* subsp. *domesticus*) embryos exposed to RF-EMF emitted by a GSM device during the duration of the incubation period.

Also Batellier et al. (2008) studied the effect of exposure to GSM and UMTS frequencies on chicken eggs over the entire period of incubation. Four replicates with a total 240 eggs each were used in the experiment to assess mortality rates. Results showed an increased mortality of 42.2% for embryos under a regime of controlled temperature, humidity and external EMF. However, it was not possible to establish a proportional relationship between the intensity of the electric field and embryo mortality.

4.1.1.2. Juvenile and adult. Five studies focused on the impact of RF-EMF at a later phase of development of chickens: four studies on juvenile and only one on adult subjects (Table 2). The endpoints studied were growth, fertility, rate of egg production, hatchability and mortality.

The only study which found a significant difference between exposed and control/sham groups is the study by Giarola and Krueger (1974) on juvenile chickens. The authors examined, exposure to very-high frequency (VHF) and ultra-high frequency (UHF), together with investigation of MW EMF. Exposure determined reduced growth of chicks and consumption. In a follow-up study Krueger et al. (1975), did not find effects either on fertility or hatchability with a continuous exposure period of 12 weeks at a power density (calculated) of 1 mW/cm^2. Experts from the U.S. Department of Energy (1978) attributed the difference in results to the cage used in the first study which may have determined a higher dose of energy absorbed by the target subjects.

4.1.2. Field studies

There were five field studies on the impact of RF-EMF exposure at various frequencies and physical conditions on populations of birds living in areas in the vicinity of cellular phone masts or base-stations. Anomalies and deviations from normality in the behaviour of exposed subjects and in the level of productivity were found in all these studies.

The values of power density provided by studies ranged from 4.4×10^{-6} mW/cm^2 in the study on sparrows by Everaert and Bauwens (2007) to the highest measured value of 155 mW/cm^2 in Wasserman et al. (1984). In this last case, exposure caused a steady temperature raise which determined a continuous gaping for the total duration of exposure of the exposed population of sparrows (*Zonotrichia albicollis*) and juncos (*Junco hyemalis*). Values for the SARs were provided only by the study of Wasserman et al. (1984) and ranged from 0.85 to 0.92 W/kg. The endpoints studied were density, reproduction, behaviour and community composition. In all the studies and experiments conducted, effects of the RF-EMF were found from a variation of 10% to a maximum of 70% compared to control.

Balmori (2005) monitored the variation of a population of white storks (*Ciconia ciconia*) in the vicinity of a GSM base station (i.e. 900–1800 MHz with 217 Hz modulation) in search of possible effects from the exposure. Total productivity within 200 m was on average 46% less than that found at a distance greater than 300 m from the emitting station. An analogous significant difference was found in the breeding success: in 40% more of the cases no new-born chicks were found in the nest.

In another study, Reijt et al. (2007) studied the influence of long term exposure to RF-EMF from radar (200–1300 MHz) on a population of great tits (*Parus major*) and blue tits (*Cyanistes caeruleus*) living around a military radar station. Possible other sources of co-variance (e.g. from human interactions with the location of birds and other pollutants) were not considered in the study. Unlike in the case of Balmori (2005), the exposure seemed not to have affected the number of nesting tits, but the distribution of the different species. The authors state that the results contradict with the study of Balmori (2005), probably because of the exposure of targets to radar MW (i.e. 1200–3000 MHz), instead of mobile phone exposure (i.e. 900–1800 MHz with 217 Hz modulation).

Additionally, Reijt et al. (2007) found that exposed nests were occupied, compared to control, by the less dominant species of tits (blue tit), which would suggest that birds can perceive high frequency RF-EMF as a stressful factor and, thus, would try to avoid nesting in those areas. An average of 50% of the great tits moved from a more exposed section of the study area to a less exposed one: in the interaction with the great tit, the blue tit is usually less dominant according to behavioural studies by Tanner (1966) and Tanner and Romero-Sierra (1974). Therefore, the great tit would move to areas where the power density is lower, and therefore the blue tit would have to nest elsewhere.

Fig. 1 presents a plot of the effect with the relative measured power density, from studies with a significant effect (see Table 2 for details on the studies). It is not possible to define a clear dose–effect relationship, but also at low values of power density strong effects of RF-EMF are found.

4.1.3. Summary

Most studies on birds were laboratory investigations. The target subjects were in the majority of laboratory studies chicken and Japanese quail. Older laboratory studies exposed targets to high level of MW EMF which probably determined an uncontrolled raise in temperature which affected the exposed systems. Amongst the more recent laboratory studies, evidence of an effect of RF-EMF on mortality and development of embryos was in all cases found at both high and low dosages. In all the five field studies found a significant effect of RF-EMF on breeding density, reproduction or species composition. Field observations give a closer representation of real-life exposure, thus RF-EMF, especially in the 900 MHz GSM band could be a certain factor influencing the ecology of birds.

4.2. Insects

Insects are a useful target system for the investigation of RF-EMF because of the limited size, the short life cycle and the possibility of easily detecting developmental defects (Schwartz et al., 1985). It has been demonstrated that insects can sense magnetic fields as a means for navigation and orientation (Abraçado et al., 2005; Kirschvink et al., 2001; Liedvogel and Mouritsen, 2010; Wajnberg et al., 2010; Winklhofer, 2010). Magneto-reception has been associated with the use of ferromagnetic iron oxide particles embedded in tissue or through pairs of molecules with unpaired electrons (known as radical pairs) that are associated with a light sensitive photoreceptor (Ritz et al., 2002; Knight, 2009; Vácha et al. 2009). The exposure to RF-EMF might disrupt

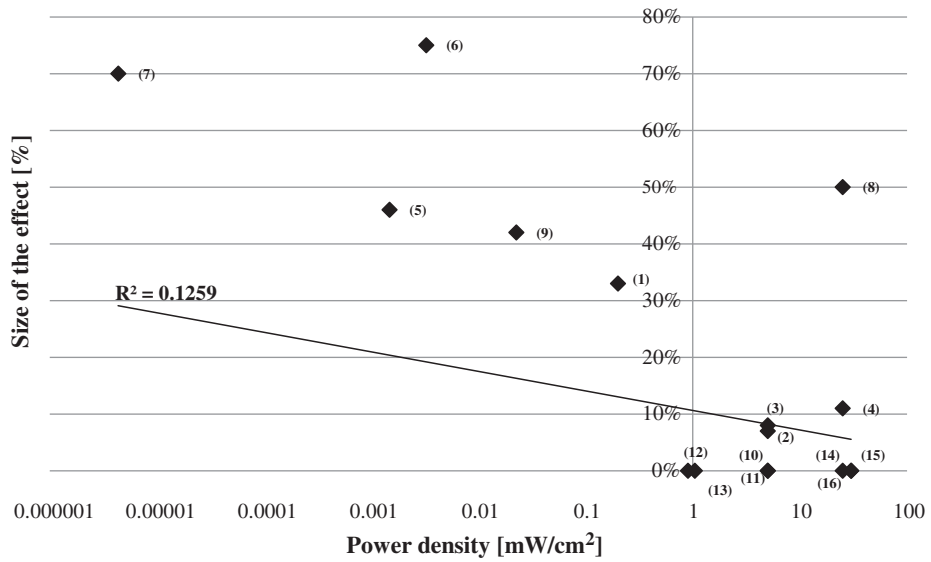

Fig. 1. Size of the ecological effects of RF-EMF on birds related to the power density of exposure. Articles reported in graph: (1) — Hills et al. (1974); (2) — Inouye et al. (1982); (3) — McRee et al. (1975); (4) — Wasserman et al. (1984); (5) — Balmori (2005); (6) — Balmori and Hallberg (2007); (7) — Everaert and Bauwens (2007); (8) — Reijt et al. (2007); (9) — Batellier et al. (2008); (11) — McRee et al. (1975); (12) — Krueger et al. (1975); (13) — Davidson et al. (1976); (14) — McRee and Hamrick (1977); (15) — Byman et al. (1985); and (16) — Gildersleeve et al. (1987). See Table 2 for a complete description of studies. Data is reported for studies from which information could be extracted. The equation of the regression line is $y = -0.0078x + 0.2908$.

this magneto-reception mechanism, which could in turn affect the survival of insects. The most commonly studied species are the honey bee (*A. mellifera*) and the fruit fly (*Drosophila melanogaster*).

4.2.1. Honey bees (A. mellifera)

Over the past few years, a phenomenon known as Colony Collapse Disorder (CCD) has increased the attention of experts on the survival of colonies of honey bees (Balmori, 2009; Schacker, 2008). The reduction in population of bees worldwide could have serious ecological, economic and, thus, political implications given their role as pollinators. It has been estimated that 15% of wild plant species in Europe (Kwak et al., 1998) and 35% of the global crops produced (Klein et al., 2007) are visited by honey bees. Bees are interesting for this reason from an economic perspective: their economic role has been estimated to be around 153 billion euros in the year 2005 (Gallai et al., 2009). RF-EMF has been classified as one of the possible causes of honey bee colonies collapse (Ratnieks and Carreck, 2010). Even though the interest of media and the public in the effects of exposure of honey bees to mobile communication RF-EMF has drastically increased, there seem to be no thorough body of research into their effects in the scientific literature. As a result, the screening conducted in this contribution identified only eight studies which matched the defined criteria (Table 3), for a total of 12 experiments. Six of the studies focused on the frequency ranges specific to mobile communication and in all cases found a significant relationship between the exposure to the field and the effects studied. Only two of the studies found were not produced in the last decade (Westerdahl and Gary, 1981a,b). These studies were the only ones which did not find any significant effect on flight, orientation of behaviour of bees exposed to CW microwaves (i.e. 2450 MHz) at power densities from 3 to 50 mW/cm^2.

Among the studies that did find an effect, Sharma and Kumar (2010), Kumar et al. (2011) and Sahib (2011) found a critical reduction of all studied parameters of the exposed colonies of bees as a response to RF-EMF. In all cases, an acute decrease in the breeding performance or even a collapse of the entire colony resulted as a consequence of exposure to RF-EMF. However, the studies provide limited statistical information on the scale of the effect found and did not take into account other confounding parameters (e.g. the placement of the emitting device inside the hive).

The work by Harst et al. (2006) and Kimmel et al. (2007) from a German research group seems to support the previously described findings, but do not provide any statistical measure of the effects found and did not report any system of control or sham-exposure.

Clearer conclusions can be drawn from the study by Favre (2011), which seems to be the most complete and qualitatively interesting contribution. Using sound-analysis techniques, the author investigated the changes that were triggered in the behaviour of a population of honey bees of the carnica group (*Apis mellifera* subsp. *carnica*). The sounds produced by the bees from five healthy and unexposed hives were used as a negative control and compared with recordings made when the same hives were exposed to a mobile phone handset in a calling position. Another inactive mobile phone was placed, at an earlier stage, to investigate the possible disturbing influence of the sheer presence of the tool in the hives. The analysis of the recorded sounds revealed that the bees produced sounds at higher frequency and amplitude after about 25 to 40 min after the communication had started and became quiet when the handset was switched off.

No particular difference in behaviour and sounds was found for exposure to the inactive handsets. The analysis of the sound data revealed that the bees were, in fact, producing the so-called “worker piping”, which usually serves as a signal for swarm exodus as a response to danger or stress, thus RF-EMF directly affected the community of bees under exposure.

4.2.2. Fruit flies (D. melanogaster)

The screening of the literature identified five studies on the fruit fly (*D. melanogaster*) for a total of nine experiments (see Table 3). All the available studies found a significant effect. The RF-EMF applied focused on the GSM 900 MHz and GSM 1800 MHz (named also DCS—Digital Cellular System) systems.

RF-EMF power density was measured in the range of 0.0002 to 0.0407 mW/cm^2, several order of magnitudes lower than those measured in the previously analysed laboratory studies on birds and bees. All the values can be considered typical for digital mobile telephony handsets and in most cases fall within the current exposure criteria (ICNIRP, 1998). Unlike the previous cases, in most studies it was possible to collect information about the magnetic flux density, which ranged from to the time-averaged 0.003 μT of Panagopoulos et al. (2004) measured for a DCS frequency to 0.09 μT in the study by Panagopoulos et al.

Table 3
Summary of articles on ecological effects of RF-EMF on insects.

Reference	Country	Life stage[a]	Type of study[b]	Number of subjects (or distances if specified)[c]	Duration	Frequency [MHz]	Wave/modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Honeybee (Apis mellifera)											
Westerdahl and Gary (1981a)	USA	Adult foragers	Lab	50(50) bees	30 min for 10 days	2450	MW CW	3–50	0.075–1.25	No impact of radiation on flight, orientation and homing abilities at any power density	−
Westerdahl and Gary (1981b)	USA	Adult	Lab	50(50) bees	30 min for 10 days	2450	MW CW	3–50	0.075–1.25	No differences in longevity between exposed and sham exposed at any power density	−
Harst et al. (2006)	Germany	Various	Field	25 bees selected from 4 colonies	n/a[i]	1900	DECT base station (mod. 100 Hz)	n/a	n/a	Reduced weight of bees. Colony collapse and abnormalities in behaviour	+ (21%)
Kimmel et al. (2007)	Germany	Various	Field	5 at full exposure, 3 at 50% exposure(8)	4 days, 2 months, 45 min per day	1800	DECT (mod. 100 Hz)	n/a	n/a	Change foraging flight	+ (14%)
Sharma and Kumar (2010)	India	Various	Field	2(2) colonies	Continuous for 15 min. 2×day, 2×week, from Feb. to Apr. (11–15 h)	900	GSM	0.0086	n/a	Decline in colony strength and in the egg laying rate. Decline in the number of returning bees and total number of foragers. Decline in the storing ability of honey	+ (62%) (22%) (16%)
Favre (2011)	Switzerland	Various	Field	5 hives	12 experiments of 40 min	900	GSM	n/a	0.271–0.98	Effect on behaviour: worker piping signal was observed 25 to 40 min after the onset of the mobile phone	+
Kumar et al. (2011)	India	Adult worker	Field	10(20) bees	40 min	900	GSM	n/a	n/a	Decreased lipid level in the organism of exposed bees.	+
Sahib (2011)	India	Various	Field	3(3) colonies	10 days, 10 min per day	900	GSM	n/a	n/a	Decreased returning ability bees in exposed hives; reduced strength; reduced egg laying rate of queen	+ (58%)
Fruit fly (Drosophila melanogaster)											
Weisbrot et al., 2003	USA	n/a	Lab	n/a	2 times for 60 min with an interval of 4 h, for 10 days	1900	GSM PW	n/a	1.4 (human head)	Irradiation increased the number of off-springs, enhancing reproductive success	+ (36% mean; 50% max)
Panagopoulos et al. (2004)	Greece	n/a	Lab	n/a	6 min/day for 5 days	900	GSM device (in talk mode)	0.041	n/a	Decreased reproductive capacity	+ (50%)
Panagopoulos et al., 2007	Greece	n/a	Lab	2 distances (1 control)	6 min/day for 6 days	900	GSM PW phone antenna	0.407 (±0.061)	n/a	Decrease of reproductive capacity, seemingly dependent on field intensity more than on frequency	+ (41.4% mean; 255.2% max)
						1800	DCS PW phone antenna	0.283 (±0.043)	n/a	Idem	
	Greece	n/a	Lab			900			0.89		

Panagopoulos et al., 2010				12 distances (1 control)	6 min/day for 6 days		GSM CW phone antenna	0.378 (±0.059; max value at 0 cm from antenna)		Reproductive capacity decreased at all distances studied at increasing pwoximity to the antenna. A window effect was revealed at distances of 20–30 cm.	+ (11% mean; 40.6% max)
								0.0004 (±0.0001; min value at 100 cm from antenna)	Idem	Idem	Idem
						1800	DCS CW phone antenna	0.252 (±0.05; max value at 0 cm from antenna)	Idem	Idem	Idem
								0.0002 (±0.0001; min value at 100 cm from antenna)	Idem	Idem	
Panagopoulos and Margaritis, 2010	Greece	n/a	Lab	n/a	1–21 min for 5 days	900	GSM PW phone antenna	0.01 (time averaged; ±0.002 at a distance of 30 cm)	0.795	Almost linear decrease in reproductive capacity at increasing durations of exposure.	+ (49.3% mean; 67.4% max)
					1–21 min for 5 days	1800	DCS PW phone antenna	0.011 (time averaged; ±0.003 at a distance of 30 cm)	0.795	Idem	Idem
Panagopoulos, 2012	Greece	n/a	Lab	n/a	6 min for 5 times	900	GSM CW phone antenna	0.063	0.795	Decreased ovarian size after two exposures.	+ (21% mean; 29.5% max)
Other insects: tobacco hornworm (Manduca sexta), American cockroach (Periplaneta americana), and ant (Myrmica sabuleti)											
Schwartz et al. (1985)	Canada	Adults exposed at larval stage	Lab	n/a	From larva to pre-pupal stage	2695 (500 pulse per second)	Anechoic chamber, horn antenna PW	4	23	Decreased food consumption and larval body weight after 20 days. Deformed adults. Higher mortality. Lower number of laid eggs.	+ (50%) (2%) (20%) (23%)
Vacha et al. (2009)	Czech Republic	n/a	Lab	11(11 non exposed)	3 h	1.2–7	RF generator	n/a	n/a	Rise in the locomotor activity and disruptive effect at 1.2 MHz.	+ (14%)
Cammaerts et al. (2012)	France	Various life stages	Lab	6 large naive colonies	Three exposure periods: 4.5 days; 6 days; 1.5 days	900	GSM from vector signal generator	7.95×10^{-5}	n/a	Diminished acquired association between food and a olfactory and visual cues.	+ (40%) (42.5%)

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors. In the case of studies regarding the fruit fly the distances applied are reported.
[d] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, and DECT = Digital Enhanced Cordless Telecommunications.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values (PD = $EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

Table 4
Summary of articles on ecological effects of RF-EMF on other vertebrates (than birds).

Reference	Country	Species (*scientific name*)	Life stage[a]	Number of subjects[b]	Duration of exposure	Frequency [MHz]	Wave/ modulation[c]	Power density [mW/cm^2][d]	SAR [W/kg][e]	Effect[f]	Effect size[g]
Chernovetz et al. (1975)	USA	Rat (*Rattus norvegicus*)	n/a[h]	n/a	11–14 days, 10 min	2450	MW CW	20	38	No effect on development	−
Berman et al. (1978)	USA	Mouse (*Mus musculus*)	Emb	n/a	1–17 days, 100 min/day	2450	MW CW	3.4–28	2–22	Reduced foetal weight and hampered development	+
Berman et al. (1980)	USA	Rat (*as above*)	n/a	n/a	80 h, 4 weeks	2450	MW CW	n/a	5.6	Transient reduction in fertility	−
Jensh et al. (1982)	USA	Rat (*as above*)	Ad	12 (59; 4)	6 h/day (pregnancy period)	2450	MW CW	20	5.2	No changes in development	−
									3.6	Idem	
Kowalczuk et al. (1983)	Great Britain	Mouse (*as above*)	Ad	50 (50)	30 min	2450	MW PW	n/a	44	Significant effect on reproduction: decreased sperm count, increased abnormal sperm	+ (35%) (330%)
Lary et al. (1983)	USA	Rat (*as above*)	Ad	n/a	6–11 days, 24 h/day	100	FM	25	0.4	Unaltered development	−
Nawrot et al. (1985)	USA	Rat (*as above*)	Emb	n/a	6–15 days, 8 h/day	2450	MW CW	30	40	Altered development	+
Lebovitz et al. (1987a)	USA	Rat (*as above*)	n/a	n/a	6 h/day, 9 days	1300	PW (600 Hz pulse)	n/a	7.7	No effect on reproduction/fertility: sperm production, sperm morphology	−
Lebovitz et al. (1987b)	USA	Rat (*as above*)	n/a	n/a	8 h	1300	CW	n/a	9	No effect on reproduction/fertility: testicular function	−
D'Andrea et al. (1989)	USA	Rhesus monkey (*Macaca mulatta*)	Juv	5 (same test group, sham-exposed)	1 session of 60 min per day per 1 week	1300	MW PW	0.92 mean (peak of 0.1318)	0.09 mean in the head (15 peak in the head)	No change in behaviour as compared to sham-exposed sessions	−
Berman et al. (1992)	USA	Rat (*as above*)	Juv/Ad	119 (0; 129)	22 h/day, 18 days (from 1st through 19th day of gestation)	970	n/a	n/a	0.07	Unaltered development	−
									2.4	Unaltered development	−
									4.8	Foetal development alterations	+ (7%)
Lai et al. (1994)	USA	Rat (*as above*)	Juv	n/a	n/a	2450	PW	n/a	0.6	Decreased performance in behavioural tasks in T-maze. Deficit in memory function	+ (50%)
Sherry et al. (1995)	USA	Rhesus monkey (*as above*)	Ad	6 (no control or sham-exposed group)	2 min (7200 pulses)	100–1500	MW UWB	1.65782×10^{7}	0.5 (whole body average)	Unaltered behavioural test performance	−
Klug et al. (1997)	Germany	Mouse (*as above*)	Emb	53 (65)	36 h	150	AM	0.95491–95.4907	n/a	Unaltered growth	−
									0.2	Idem	
									1	Idem	
									5	Idem	
						900	GSM	1.33714	0.2	Idem	
									1	Idem	
									5	Idem	
Jensh (1997)	USA	Rat (*as above*)	Juv/Ad	n/a	6 h/day, 5 days	915	GSM CW	10	n/a	Unaltered growth	−
					6 h/day, 5 days	2450	MW CW	20	n/a	Idem	
Magras and Xenos (1997)	Greece	Mouse (*as above*)	Juv	36	5 pregnancies	88.5–950	FM; UHF TV; GSM	1.053×10^{-3}	1.936×10^{-3}	Progressive decrease in the number of newborns per dam leading to irreversible infertility Improved prenatal development parameters	+ (76%) + (27%)
								168×10^{-6}	Idem	Idem	
Khillare and Behari (1998)	India	Rat (*as above*)	Ad	18 (18)	2 h/day, 35 days	200	AM (mod. 16 Hz)	1.47	1.65–2	Decreased fertility observed in exposed tests. Unaltered development	+ (42%) −
Bornhausen and Scheingraber (2000)	Germany	Rat (*as above*)	Ad	12(12)	20 days (pregnancy period)	900	GSM (mod. 217 Hz)	0.1	0.75	Unaltered growth	−
Sienkiewicz et al. (2000)	UK/USA	Mouse (*as above*)	Ad	n/a	45 min 10 days	900	PW (mod. 217 Hz)	0.54	0.05	Unaltered learning in the performance of tasks	−
									5.7		
Yamaguchi et al. (2003)	Japan	Rat (*as above*)	Ad	168	1 h/day for 4 days; 45 min daily for 4 days; 1 h/day for 5 days and 2 days of rest for 4 weeks	1439	PW TDMA	n/a	1.7	Unaltered learning abilities in the performance of tasks	−

Cassel et al. (2004)	France	Rat (*as above*)	Ad	n/a	45 min	2450	PW	n/a	0.6	Unaltered learning in the performance of tasks	−
Cobb et al. (2004)	USA	Rat (*as above*)	n/a	n/a	45 min, 10 days	2450	MW PW	n/a	0.6	Unaltered brain development and performance of spatial tasks	−
Cosquer et al. (2005)	France	Rat (*as above*)	Juv	48	45 min	2450	PW	n/a	0.6	Unaltered performance in spatial tasks	−
Dasdag et al. (2008)	Turkey	Rat (*as above*)	Ad	14 (10 control; 7 sham-exposed)	2 h/day, 7 days/week, 10 months	900	PW	0.02384–0.17561	0.07–0.57	Unaltered fertility	−
Kumlin et al. (2007)	Finland	Rat (*as above*)	Juv	18(6)	2 h/day, 5 days/week, 5 weeks	900	PW	n/a	0.3 (mean value)	Improvement in learning abilities of rats	+ (20%)
Ribeiro et al. (2007)	Brasil	Rat (*as above*)	Juv	16 (8)	1 h/day, 11 days	1850	PW	1.4	n/a	Unaltered fertility	−
Yan et al. (2007)	USA	Rat (*as above*)	Ad	16	2 times/day for 3-h periods for 18 weeks	1900	CDMA	n/a	1.8	Higher incidence of sperm cell death	+ (37%)
Mathur (2008)	India	Rat (*as above*)	Juv	n/a	2 h/day, 45 days	73.5	AM (mod. 16 Hz)	1.33	0.4	Abnormal behavioural response to noxious stimuli	+ (38%)
Nittby et al. (2008)	Sweden	Rat (*as above*)	Ad	28 (16; 8 sham-exposed)	2 h/week, 55 weeks	900	Lower power level GSM	3.3×10^{-4}	0.62×10^{-3}	Behavioural abnormalities: altered performance of rats during episodic-like memory test	+ (75%)
								n/a	0.37×10^{-3}	Idem	
							GSM	33×10^{-4}	62×10^{-3}	Idem	
									37×10^{-3}	Idem	
Daniels et al. (2009)	South Africa	Rat (*as above*)	Juv	12 (12)	3 h/day, 12 days (2 days after birth)	840	RF signal generator	2.1247×10^{-10} (d = 0.93 m)	n/a	Decreased behaviour. Decreased locomotive activity. Unaltered performance of memory tasks	+ (60%)−
Gathiram et al. (2009)	South Africa	Rat (*as above*)	Ad	32 (32)	8 h/day, 10 days	100–3000	Unique field system	n/a	n/a	Unaltered fertility of exposed male and female individuals	−
Lee et al. (2009)	Korea	Mouse (*as above*)	Ad	17 (14)	90 min/day (15 min break) 17 days (gestation period)	848.5	CDMA	1.4174–8.2501	0.69–4.04	Unaltered development	−
								n/a	2 (Power = 30 W)	Unaltered development	−
				20 (20)	90 min/day (15 min break) 17 days (gestation period)	1950	WCDMA	1.0923–7.0043	1.11–7.13		
Mailankot et al. (2009)	India	Rat (*as above*)	Juv	n/a	1 h/day, 28 days	900–1800	GSM	n/a	n/a	Detrimental effects on fertility	+ (53%)
Nicholls and Racey (2009)	UK	Bat (*Pipistrellus Pipistrellus*)	n/a	n/a	20 h (bat activity); 16 h (insect count); 3 fields	n/a	PW radar	3.8101×10^{-3}–1.7275×10^{-1} (peak values at distance of 10–30 m)	n/a	Reduced foraging and activity of bats	+ (16% in bat counts; 13% bat passes)
										No effect on the abundance of insects	−
Sommer et al. (2009)	Germany	Mouse (*as above*)	Multi-gen.	128 male 256 female,3 generations	570 days (chronic exposure), 30 min/day break	2000	UMTS	0.135	0.08–0.144	Unaltered fertility and development	−
								0.68	0.4–0.72	Idem	
								2.2	1.3–2.34	Idem	
Fragopoulou et al. (2010)	Greece	Mouse (*as above*)	Juv	12 (12)	4 days, 2 h/day	900	GSM	0.05–0.2	0.41–0.98	Deficits in consolidation and/or retrieval of learned spatial information	+ (30%)
Balmori (2010)	Spain	Frog (*Rana temporaria*)	Juv	70 (70)	2 months from egg phase until prior to metamorphosis	648–2155	Cell-phone base station	8.5942×10^{-4}–3.2493×10^{-3}	n/a	Increased mortality rate. Asynchronous growth of exposed subject; disrupted behaviour	+ (90%)
Salama et al. (2010a)	Japan	Rabbit (*Oryctolagus cuniculus*)	Ad	8 (8; 8 sham-exposed)	8 h/day, 12 weeks	800	PW	6.2910×10^{-5}–2.2616×10^{-3} (mean value over time at minimum to maximum distance from the phone)	0.43 (whole body)	Significant decrease in sperm concentration at week 8. Decrease in motile sperm population at week 10. Overall effect on testicular function and reproduction ability	+ (62%) (25%)

(continued on next page)

Table 4 (*continued*)

Reference	Country	Species (*scientific name*)	Life stage[a]	Number of subjects[b]	Duration of exposure	Frequency [MHz]	Wave/ modulation[c]	Power density [mW/cm^2][d]	SAR [W/kg][e]	Effect[f]	Effect size[g]
Salama et al. (2010b)	Japan	Rabbit (*as above*)	Ad	8 (8; 8 sham-exposed)	8 h/day, 12 weeks	800	PW	6.2910×10^{-5}–2.2616×10^{-3} (mean value over time at minimum to maximum distance from the phone)	0.43 (whole body)	Detrimental effects on sexual behaviour: increased number of mounts, increased number of mounts without ejaculation	+
Imai et al. (2011)	Japan	Rat (*as above*)	Juv	24 (24;24)	5 h/day, 7 days/week, 5 weeks	1950	WCDMA CW	n/a	0.4	No effects on reproduction and development	−
Kesari et al. (2011)	India	Rat (*as above*)	Juv	6 (6 sham-exposed)	2 h/day, 35 days	900	n/a	9.2558×10^{-2} (peak value at 20 m);8.2819×10^{-2}(peak value at 30 m)	0.9 (Power= 2 mW)	Potential significant effect on reproduction (fertilizing potential of spermatozoa)	+ (41%)
Sarookhani et al. (2011)	Iran	Rabbit (*as above*)	n/a	18	2 h/day, 2 weeks	950	GSM	n/a	n/a	Decreased reproductive capacity	+ (90%)
Aldad et al. (2012)	USA	Mouse (*as above*)	Ad	39 pregnant (42 sham-exposed)	0 to 24 h/day from day 1 to day 17 of gestation	800 1900	GSM	n/a	1.6	Behavioural and neurophysiological alterations	+ (7%)
Bouji et al. (2012)	France	Rat (*as above*)	Middle-aged	9 (9 sham-exposed)	15 min	900	GSM PW	n/a	6	Altered behaviour and increased stress	+ (47%)
Hao et al. (2012)	China	Rat (*as above*)	n/a	16 (16)	2 times/day for 3 h/day, for 5 days/week, for 10 weeks	916	Mobile phone antenna	1	n/a	Altered learning. Altered memory. Adaptation to field after long term exposure	+ (18%) (18%)
Jiang et al. (2012)	China	Mouse (*as above*)	n/a	5 (5; 5 exposed to gamma radiation; 5 exposed to combined RF and gamma radiation)	4 h/day for 1 to 14 days	900	Wireless transmitter	120	0.548	No effect on mutation	−
Lee et al. (2012)	Korea	Rat (*as above*)	n/a	5 (5; 5 exposed to gamma radiation; 5 exposed to combined RF and gamma radiation)	45 min/day, 5 days/ week, 12 weeks	848.5	CDMA	n/a	2 (4 combined with WCDMA)	No effect on reproduction	−
				idem	idem	1950	WCDMA	idem	2 (4 combined with CDMA)	idem	−
Ozlem Nisbet et al. (2012)	Turkey	Rat (*as above*)	Juv	11 (11;11)	2 h/day for 90 days	900	GSM	n/a	0.003	Increased testosterone level and sperm motility. Altered morphology	+ (15%) (3%)
				idem	idem	1800	GSM	idem	5.3×10^{-5}	idem	+ (14%) (2%)
Poullettier de Gannes et al. (2012)	France	Rat (*as above*)	Various	20 (20;20)	2 h/day, 6 days/week, 18 days	2450	W-LAN Wi-Fi	n/a	0.08	No abnormalities in reproduction and development	−
Yang et al. (2012)	China	Rat (*as above*)	Ad	12 (12 sham-exposed)	20 min	2450	MW PW	65	6	Stress response elicited in rat hippocampus	+ (30%)

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors.
[c] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, DECT = Digital Enhanced Cordless Telecommunications, PW = pulsed wave, UWB = ultra wide band, AM = amplitude modulation, FM = frequency modulation; UMTS = Universal Mobile Telecommunications System; CDMA = Code division multiple access; TDMA = time division multiple access; and WCDMA = Wideband Code Division Multiple Access.
[d] Values of power density are reported as provided by authors or recalculated by conversion of electric field values (PD = EF^2/3770) and expressed in mW/cm^2.
[e] Values of SAR are reported as provided by authors and expressed in W/kg.
[f] Biological or ecologically relevant endpoints studied.
[g] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[h] n/a indicates that data was not provided by authors.

(2010). SAR levels were, when provided, obtained by elaboration of data provided by the manufacturer (i.e. for the human head) of the system used for exposure and not directly measured.

The ecologically relevant endpoints analysed in the studies were growth and reproduction. All of the analysed studies found a significant effect compared to the control. With the exception of a study by Weisbrot et al. (2003), all studies were conducted by a research group from the University of Athens, Greece. In the study of Weisbrot et al. (2003) the irradiation determined a beneficial effect on the reproductive success of the exposed system. The number of offsprings even increased by up to 50% compared to control. All the other studies found a significant depression of growth and reproduction as a response to exposure. Several studies performed by Panagopoulos and co-authors (see Table 4) found a maximum decrease in the endpoints of at least 40% compared to control. Exposure duration lasted for 6 min/day or increased over time up to a maximum of 21 min over a period of six or five days. The reproduction of experiments performed at several distances from the emitting system (i.e. a telephone device) suggested in all cases a quasi-linear decrease at increasing durations of exposure (Panagopoulos and Margaritis, 2010) and increase in proximity to the source of the emission (Panagopoulos et al., 2010). In this last study a window-effect was found at distances of 20–30 cm from the device, which resulted in the highest decrease of the measured values.

4.2.3. Effect on other insects

The remaining studies in this section focus on the tobacco hornworm (*Manduca sexta*), on the American cockroach (*Periplaneta americana*) and on a species of ant (*Myrmica sabuleti*; Table 3). The study by Schwartz et al. (1985) analysed differences in development, reproduction and mortality in tobacco hornworms exposed during their larval stage to PW RF-EMF at a frequency of 2695 MHz and a power density of 4 MW/cm^2. All the measured parameters were affected and effect size was as high as 50% lower compared to control.

The studies on the American cockroach (Vacha et al. 2009) and the ant (Cammaerts et al., 2012) focused on the effects of RF-EMF on the magneto-reception of the insects. In the study by Vacha et al. (2009), it was found that, during and after the rotation of the natural geomagnetic field, the insects turned around, as a response of the detection of the field. However, their ability to detect the geomagnetic field was disrupted after exposure to a field at 1.2 MHz with a magnetic flux density between 12 and 18 nT.

Cammaerts et al. (2012) investigated the impact of RF-EMF on the acquisition and loss of olfactory and visual cues of six experimental colonies of the ant *Myrmica sabuleti*. The exposure to a GSM-generated signal determined a loss in the acquired association between food and a visual cue (40% worse than control), a decreased retention of acquired knowledge, and a total loss of visual memory.

The representation of the size of the effect compared to the power density (Fig. 2) shows that significant effects are found both at high and low dosages, revealing no clear dose–response relationship. In one of the analysed studies, no effects were found at high levels of power density.

4.2.4. Summary

A limited set of articles regarding the possible impact of RF-EMF on honey bees is available in literature. Most of the analysed studies found an effect on the target colonies. The most affected endpoints seemed to be behaviour and orientation of exposed bees, which lead to disruptive consequences in the colonies. The majority of the studies did not provide statistical analysis and did not use clear control measures to analyse results. One exception is the study conducted by Favre (2011), in which the behaviour of the bees seems to be comparable to that experienced by colonies exposed to extreme danger and stress.

The studies analysing the effects of RF-EMF on fruit flies found in all cases a significant effect. Results of one study show an increased reproductive success after exposure. The remaining studies, which were conducted by the same research institute in Greece, found in all cases a significant depression of growth and reproduction at both 900 and 1800 MHz. Two studies on the American cockroach and a species of ant analysed the effects of exposure to RF-EMF on the magneto-reception and orientation of the insects. The behaviour of target systems was disrupted by the exposure to RF-EMF.

4.3. Other vertebrates

The impossibility of conducting laboratory experiments into the effects of RF-EMF on humans steadily increased the number of scientific studies on laboratory vertebrate models. As suggested by the WHO (2006), studies conducted on immature animals can, for instance, provide a useful indicator of possible cognitive and behavioural effects on children. The vast majority of studies focused on the analysis of intracellular pathways, for instance through changes in calcium permeability across membranes (e.g. Maskey et al., 2010); or on gene expression,

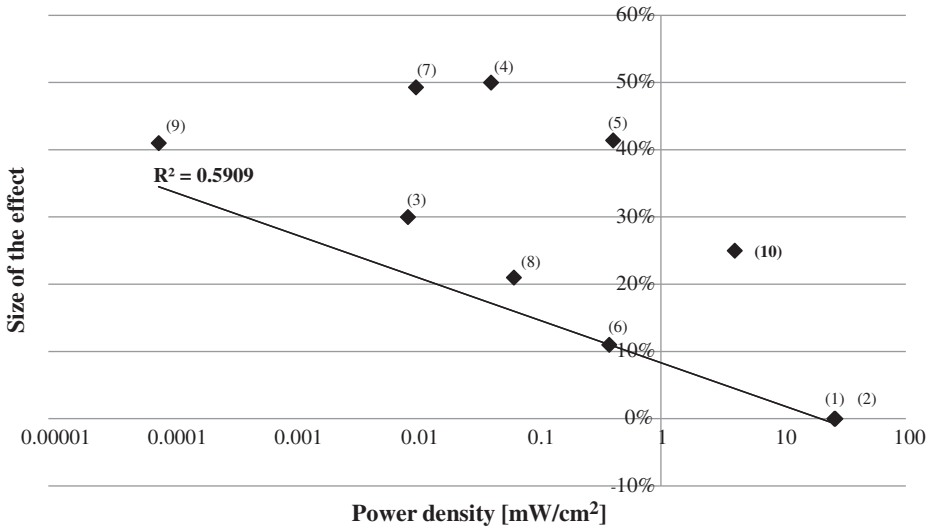

Fig. 2. Size of the effects of RF-EMF on insects compared to the power density of exposure. Articles reported in graph: (1) — Westerdahl and Gary (1981a); (2) Westerdahl and Gary (1981b); (3) — Sharma and Kumar (2010); (4) — Panagopoulos et al. (2004); (5) — Panagopoulos et al. (2007) (6) — Panagopoulos et al., 2010; (7) — Panagopoulos and Margaritis, 2010; (8) — Panagopoulos (2012); (9) — Schwartz et al. (1985); and (10) — Cammaerts et al. (2012). See Table 3 for a complete description of studies.

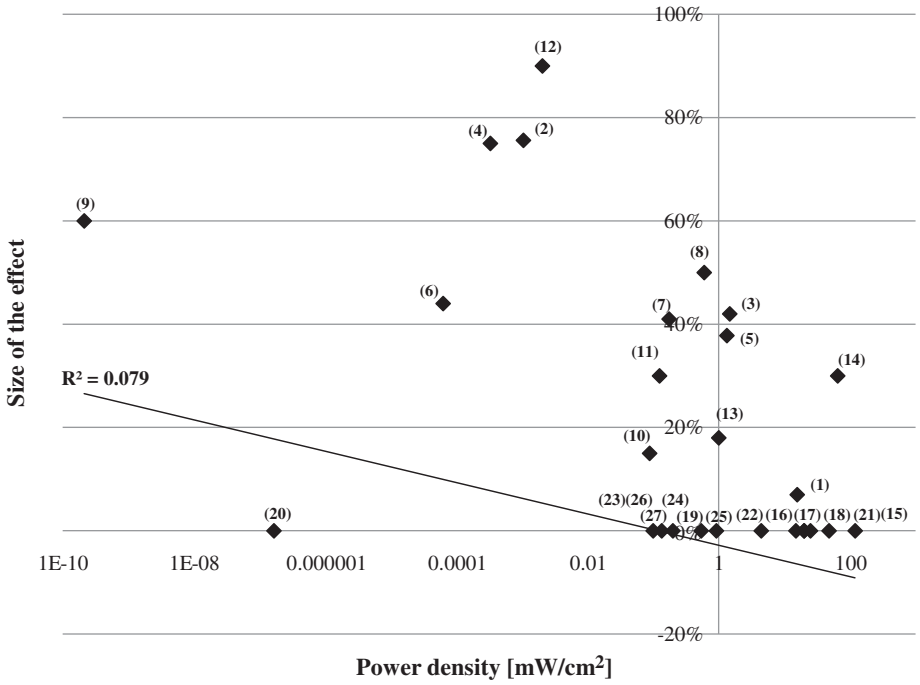

Fig. 3. Size of the effects of RF-EMF compared to the power density of exposed vertebrate animal models. Articles reported in graph: (1) — Berman et al. (1992); (2) — Magras and Xenos (1997); (3) — Khillare and Behari (1998); (4) — Nittby et al. (2008); (5) — Mathur (2008); (6) — Salama et al. (2010a); (7) — Kesari et al. (2011); (8) — Lai et al. (1994); (9) — Daniels et al. (2009); (10) — Nicholls and Racey (2009); (11) — Fragopoulou et al. (2010); (12) — Balmori (2010); (13) — Hao et al. (in press); (14) — Yang et al. (2012); (15) — Jiang et al. (2012); (16) — Chernovetz et al. (1975); (17) — Jensh et al. (1982); (18) — Lary et al. (1983); (19) — D'Andrea et al. (1989); (20) — Sherry et al. (1995); (21) — Klug et al. (1997); (22) — Jensh (1997); (23) — Bornhausen and Scheingraber (2000); (24) — Dasdag et al. (2008); (25) — Lee et al. (2009); (26) — Sommer et al. (2009); and (27) — Sienkiewicz et al. (2000). See Table 4 for a complete description of studies.

namely on the neurons of rats exposed to RF-EMF (e.g. Salford et al., 2003; Zhao et al., 2007); or on possible chromosomal damage in mice cells (e.g. Nikolova et al., 2005).

A total of 50 scientific articles were selected for a total of 62 relevant ecological experiments (Table 4). The endpoints analysed which were of interest were fertility, growth, behaviour and mortality (Table 1).

With the exception of one study on bats (*Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Myotis daubentonii*, and *Myotis nattereri*) breeding nearby a wind turbine and one study on the tadpoles of frogs (*Rana temporaria*), all studies were conducted in a laboratory setting. The animal systems under investigation were rats commonly used in laboratory studies (*Wistar albino rat* and *Sprague Dawley rat*), mice (*Balb/c* and *Balb/c/f*), rabbits (*White New Zealand Rabbit*), rhesus monkeys (*Macaca mulatta*). Of the total of 50 articles, 50% of the studies were conducted on rats. A total of 27 experiments (43%) showed no significant results of an impact of RF-EMF under the physical and experimental settings used. The power density ranged from 0.6×10^{-6} to 20 mW/cm^2, which was the maximum value measured for MW CW exposures (Table 4). The SARs values measured ranged from 0.00194 to 44 W/kg, with a peak value measured at 2450 MHz for MW PW exposure. In the studies in which higher level of exposure to RF-EMF were applied and temperature was not controlled, results may be related to an increase in body temperature as a consequence of exposure.

A large share of the studies on vertebrate animal models focused on changes in behaviour as a result of exposure. This choice may be related to investigating of possible influences of RF-EMF on the behaviour and cognitive performance of humans, who use mobile phone devices in close proximity to their heads. Some commonalities between human and rat response to noxious substances have been explored by other fields of science (Hammond et al., 2004). Lai et al. (1994) suggested that rats suffer from a deficit in spatial working memory function when exposed to RF-EMF (50% decreased performance compared to control). The repetition of the experiment with similar conditions of exposure by Cassel et al. (2004), Cobb et al. (2004), and Cosquer et al. (2005) found no effects on learning abilities of rats in the performance of spatial tasks and no evidence of altered brain development.

Another example in this direction is the work of Daniels et al. (2009), who investigated the effect of RF-EMF in the mobile phone range on the behaviour of the rat with controversial results. Spatial memory was tested using the Morris water maze test (Morris, 1984), and mood disturbances and anxiety-like behaviour were tested in an open field test, for twelve radiated and twelve control subjects. Results showed no significant differences between groups in the Morris test, suggesting no significant difference in the behaviour of exposed and control rats. However, male rats performed significantly worse (60%) in the open field test.

The articles by Lee et al. (2009, 2012) and Imai et al. (2011) are the only studies focusing on the impact of the frequencies network standards found in 3 G mobile communication (Collins and Smith, 2001), working with protocols like wideband code division multiple access (W-CDMA) or CDMA. All experiments, on mice and rats, did not have any observable adverse effect on development, reproduction or mutation of tested subjects. No effects on the development of rats were also observed by the study of Poullettier Poulletier de Gannes et al. (2012), where Wireless Fidelity (Wi-Fi) signal at 2450 MHz was applied on rats, and by the study of Jiang et al. (2012), where mice were exposed to a wireless transmitter at 900 MHz. These studies represent the first attempt to investigate the effects of wireless communication on health.

The field experiment of Balmori (2010) on the behaviour and growth of the tadpoles of frogs (*Rana temporaria*) placed 140 m from a field station provides evidence of the effect of RF-EMF. The exposed group showed low coordination of movements, an asynchronous growth and a high mortality (90%). The control group was exposed to the same environmental conditions, but placed inside a Faraday cage. As a result, the coordination of movements was normal, the development was synchronous, and the mortality rate was 4.2%. The research goal of the field study by Nicholls and Racey (2009) was to test whether PW RF-EMF emitted by a radar could be used as a method of preventing bats from death caused by collisions with wind turbines. The authors analysed 20

Table 5
Summary of articles on ecological effects of RF-EMF on the bacterium *Escherichia coli*, the nematode *Caenorhabditis elegans*, and the land snail *Helix pomatia*.

Reference	Country	Species	Scientific name	Duration of exposure	Frequency [MHz]	Wave/ modulation[a]	Power density [mW/cm^2][b]	Magnetic flux density [μT][c]	SAR [W/kg][d]	Effect[e]	Effect size[f]
Grospietsch et al. (1995)	Germany	Bacterium	*Escherichia coli*	6 h	150	PW (mod. 72 Hz)	6.7905	5.4	n/a[g]	Enhanced growth at higher field frequencies, identical at various modulation frequencies	+
				Idem	150	PW (mod. 217 Hz)	6.7905	5.4	n/a		
					150	PW (mod. 1100 Hz)	6.7905	5.4	n/a		
					150	CW	6.7905	5.4	n/a		
Daniells et al. (1998)	UK	Nematode	*Caenorhabditis elegans* strain PC72	2–16 h continuous	750 300	MW TEM cell	n/a	n/a	n/a	Stress reporter gene induction after 2 and 16 h of exposure	+ (150%)
de Pomerai et al. (2002)	UK	Nematode	*Caenorhabditis elegans*	20 h	1000	MW CW	5.37×10^{-5}	n/a	0.001	Enhanced growth as a consequence of exposure	+ (9.8% mean; 11.2% max)
Nittby et al. (2012)	Sweden	Landa snail	*Helix pomatia*		1900	GSM modulated signal	0.068	n/a	0.048	Beneficial induced analgesia	+ (20%)

[a] Wave/modulation indicates the type of RF-EMF applied/measured in the study. Modulation value reported if provided by authors. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, PW = pulsed wave, and DCS = digital cellular system.
[b] Values of power density are reported as provided by authors or recalculated by conversion of electric field values (PD = EF^2/3770) and expressed in mW/cm^2.
[c] Values of magnetic flux density if provided by authors.
[d] Values of SAR are reported as provided by authors and expressed in W/kg.
[e] Biological or ecologically relevant endpoints studied.
[f] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[g] n/a indicates that data was not provided by authors.

foraging sites. The exposure of bats to a pulsed wave radar system determined a significant reduction in foraging activity of bats.

The plotting of the size of the effect with the relative measured power density (where the value was provided by authors) of positive studies does not show any detectable trend (see Fig. 3). No clear pattern is visible from the analysis of the data and effects were found both at high and low levels of power density.

4.3.1. Summary

Rats and rabbits exposed to RF-EMF in a laboratory setting represented the most studied animal model. Changes in behaviour as a result of exposure were analysed in most studies and presented contradictory results. As for the other endpoints, significant effects were found under various conditions of exposure and under different laboratory setups. A field study showed a significant effect of exposure on the growth and mortality rates of tadpoles of frogs under field conditions. In another RF-EMF reduced the foraging activity of bats.

4.4. Other organisms

This section includes studies on the effect of RF-EMF on the bacterium (*Escherichia coli*), the nematode (*Caenorhabditis elegans*), and the land snail (*Helix pomatia*), which constitute the species not yet included in the previous sections.

The screening of the literature identified four studies for a total of eight experiments (Table 5). In all cases effects were significant. The RF-EMF applied were mainly the GSM 900 MHz and GSM 1800 MHz (DCS—Digital Cellular System) systems, with the exception of the study of Grospietsch et al.(1995) and de Pomerai et al. (2002), which studied respectively a pulsed wave modulated frequency at 150 MHz and a microwave continuous wave frequency at 1000 MHz (Table 5).

RF-EMF power density was measured in the range of 0.0005 to 0.679 mW/cm^2. All the values can be considered typical for digital mobile telephony handsets and in most cases fall within the current exposure criteria (ICNIRP, 1998).

The ecologically relevant endpoints analysed in the studies were growth, reproduction and stress. All of the analysed studies found a significant effect compared to the control. The exposure of the bacteria *E. coli* and the nematode *C. elegans* suggests that RF-EMF tend to enhance growth of the organisms. The study on the land snail (Nittby et al., 2012) found a beneficial non-thermal analgesic effect on a group of 29 land snails placed on a hot plate. The response time to heat of GSM-exposed snails was 20% higher than that of the control. The study by Daniells et al. (1998), which exposed a transgenic nematode (*C. elegans* PC72) to RF-EMF at a frequency of 750 MHz, found a significant drastic effect on the stress levels (i.e. 150% higher than control) of the exposed target system.

4.4.1. Summary

Studies on the effects of RF-EMF on the bacterium (*E. coli*), the nematode (*C. elegans*) and the land snail (*H. pomatia*) reported in all cases a significant effect on behaviour and growth of target subjects and under all laboratory setups applied. The study on the *E. coli* and *C. elegans* beneficially affected growth. The exposure of the land snail to RF-EMF retarded the response to heat determining a beneficial analgesic effect.

4.5. Plants and yeasts

The influence of the earth's natural magnetic field or that of superimposed artificial magnetic fields on plants has been known for many years. Static magnetic fields, in fact, have been proven to have a beneficial impact on the stimulation of growth and germination of plants (Dulbinskaya, 1973; Pittman, 1965; Savostin, 1930), or inhibitive impact depending on the species and their physiological state (Krizaj and Valencic, 1989; Ružič et al., 1998). According to Soltani et al.

Table 6
Summary of articles on the ecological effects of RF-EMF on plants.

Reference	Country	Species	Scientific name	Life stage[a]	Type of study[b]	Number of subjects[c]	Duration of exposure	Frequency [MHz]	Wave/ modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Haider et al. (1994)	Austria	Spiderwort	*Tradescantia*	Plant cuttings with young flower buds	Field	n/a[i]	30 h	10–21	AM CW	0.43	n/a	Clastogenic effect at all distances and electric field levels	+ (157% mean)
								14		1.3	n/a	Idem	
								10		0.43	n/a	Idem	
								14		2.15	n/a	Idem	
								18–21		0.0003 (200 m from broadcasting area)	n/a		
								18–21		1.1207 (mesh cage at 10 m from the slewable curtain antenna)	n/a		
Balodis et al. (1996)	Latvia	Pine	*Pinus sylvestris*	50–90 years old	Field	20 trees per plot, 8 plots	21 years	154–162	Radio transmitter with horizontal polarisation	n/a	n/a	Diminished radial growth near source	+
Magone (1996)	Latvia	Great duckweed	*Spirodela polyrhiza Schleiden*	Plants of different age	Lab	10–30 plants, 5 flasks	5 days	156–162	PW	0.0018 (max value)	n/a	Accelerated reproduction rate. Developmental abnormalities compared (after 30 to 80 days). Shorter life span	+ (150% mean) (58%) (22%)
Schmutz et al. (1996)	Switzerland	Spruce; beech	*Picea abies () Karst.; Fagus silvatica*	Seedling	Field	135 (3 replicates)	3 years, 7 months	900	MW	10(600 W of power); 30;1;3;0.1;0.3	n/a	Unaltered growth and photosynthetic activity. Decreased calcium and sulphur in beech leaves at increasing power densities	−
Selga and Selga (1996)	Latvia	Pine	*Pinus sylvestris*	Needles and cones	Lab	n/a	n/a	154–162	Radio transmitter (*horizontal polarisation)	4.2440×10^{-7}–16.578	n/a	Cytological andultra-structural changes	+
Urech et al. (1996)	Switzerland	Lichens	*Parmelia tiliaceaHypogymnia physodes*	n/a	Lab	n/a	24 h/day, up to 800 days	2450	MW CW	0.2–50	0.9 (mean wet)	Reduced growth rate at 50 mW/cm^2 (thermal effect). No alterations at 5 mW/cm^2 or below.	+ (67%)
												No alterations at 9.5 MHz	−
								2450	MW CW	50	0.9 (mean wet)		−
								9.5	Short-wave broadcast transmitter	14.65	0.0004 (mean wet)		−
Gos et al. (2000)	Switzerland	Yeast	*Saccharomyces cerevisiae*	Cell	Lab	4 (strains)	1 h	900	GSM PW	n/a	0.13	No effect on mutation or stress	−
							36 h				1.3		
Tkalec et al. (2005)	Croatia	Duckweed	*Lemna Minor*	Cultures of young and old leaves	Lab	n/a	2–14 h	400	CW; GTEM cell	0.0265 (for 14 h); 0.14 (2 h and 4 h); 0.446 (2 h); 40.345 (2 h)	n/a	Reduced growth	+ (15% mean after 8 days)
								400	AM CW	0.140	n/a	Reduced growth	(14% mean after 8 days)
								900	CW; GTEM cell	0.0265(for 14 h); 0.1403(2 h and 4 h); 0.4459 (2 h); 40.3448 (2 h)	n/a	Reduced growth	(37% mean after 8 days)
								900	AM CW	0.140	n/a	Reduced growth	(29% mean after 8 days)
								1900	CW; GTEM cell	0.0265	n/a	Decrease in growth	(22% mean after 8 days)
	France	Tomato		3 weeks old	Lab	n/a	10 min	900	GSM	0.0066	n/a		

Roux et al. (2006)			*Lycopersicon esculentum VFN8.*									Evidence of stress-related responses	+ (173% mean)
Tkalec et al. (2007)	Croatia	Duckweed	*Lemna minor*	Cultures	Lab	10–12	2 h	400–900	GTEM cell	0.0265	n/a	Depending on the field frequencies applied and on strength modulation and exposure time, induced oxidative stress	+ (25% mean)
										1.403	n/a	Idem	
										0.4459	n/a	Idem	
										3.8196	n/a	Idem	
							2–4 h			1.403	n/a	Idem	
Roux et al. (2007)	France	Tomato	*Lycopersicon esculentum VFN8*	Cell cultures	Lab	58 plants, 4 replicates	10 min	900	CW	0.0066	n/a	Strong correlation between stress-related parameters and exposure	+ (6% mean treated; % mean shielded)
Sharma et al. (2009)	India	Mung bean	*Vigna radiata*	Seedling	Lab	50 (50)	0.5 h; 1 h; 2 h; 4 h	900	GSM CW	0.00855	n/a	Inhibition of germination. Inhibition of root growth as a consequence of oxidative stress	+ (16% mean)
Ursache et al. (2009)	Romania	Maize	*Zea mays*	Seedling	Lab	25, 5 replicates	1 h; 2 h; 4 h; 12 h	418	CW; TEM cell	0.6	n/a	Increased photosynthesis efficiency.	+ (60% higher chlorophyll content; 35% higher carotene content)
Jinapang et al. (2010, 2009)	Thailand/ USA	Mung bean; water convolvuluses	*Vigna radiata*; *Ipomea aquatica*	Seedling	Lab	240 (15), 3 replicates	1 h; 2 h; 4 h	425	CW; TEM cell	0.015 (power 10 W)	n/a	Improved growth. Optimum respectively at: 100 mW for 1 h and 1 mW of power for 2 h	+ (33% mean mung bean; 28% mean water convol-vuluses)
Vrhovac et al. (2010)	Croatia	Yeast	*Saccharomyces cerevisiae*	Strains (FF18733, FF1481, D7)	Lab	3	15–60 min	905	MW PW; GTEM cell	n/a	0.12	Affected growth of three strains of *Saccharomyces cerevisiae*, due to DNA damage	+ (34% mean)
Chen et al. (2012)	China	Yeast	As above	Cells	Lab		5 min with system on, 10 min with system off for 6 h	1800	GSM PW	n/a	4.7	Altered gene-expression	+

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors.
[d] Wave/Modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, PW = pulsed wave, UWB = ultra wide band, AM = amplitude modulation, FM = frequency modulation, and GTEM = gigahertz transverse electromagnetic cell.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values ($PD = EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

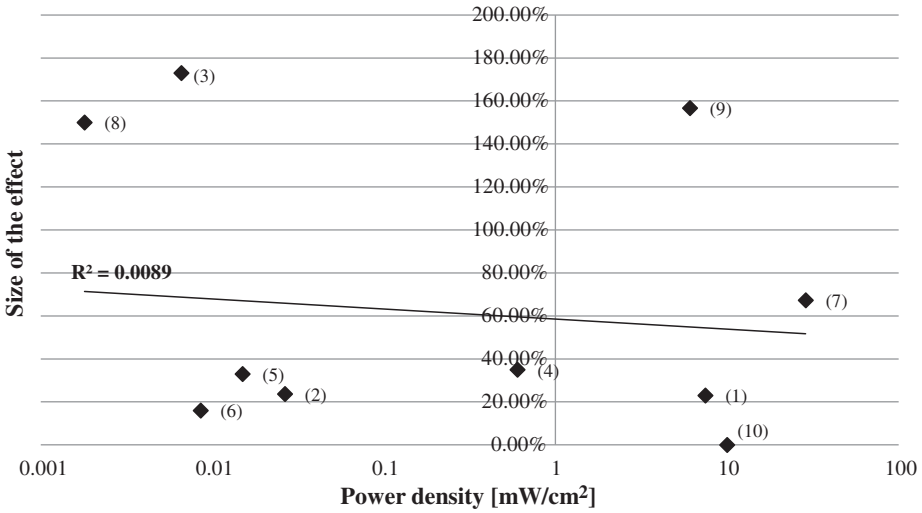

Fig. 4. Size of the effects of RF-EMF compared to the power density of exposed plants. Articles reported in graph: (1) — Tkalec et al. (2005); (2) — Tkalec et al. (2007); (3) — Roux et al. (2007); (4) — Ursache et al. (2009); (5) — Jinapang et al. (2010); (6) — Sharma et al. (2009); (7) — Urech et al. (1996); (8) — Magone (1996); (9) — Haider et al. (1994); and (10) — Schmutz et al. (1996). See Table 6 for a complete description of studies.

(2006), until now no proper physiological explanation has been provided for the described effects, though the biological effects of weak static MF do not only depend on the physical conditions of the exposure (e.g. power density and frequency), but also on the environmental conditions in place.

The analysed literature considered that plants are continuously exposed to RF-EMF as they cannot avoid them, by moving away from the source of emission. As in the case of the studies explored in earlier sections, little is known about a possible mechanism explaining how exposure to RF-EMF may cause biological/ecological effects, and therefore most of the investigations were aimed at the possible mechanisms underlying the effects in plants.

In total, 16 studies and 29 experiments were selected based on the ecological relevance of the endpoints studied (Table 6). Ten experiments investigated the impact of RF-EMF on the inhibition of the regular growth of plants. Four experiments directly investigated the stress levels of plants exposed to RF-EMF as a variation in specific test methods. The remaining studies focused on abnormalities as a consequence of the exposure, and on the effect on the photosynthesis.

The frequency investigated ranged from as low as 10 MHz from an AM CW system (Haider et al., 1994) to 2450 MHz MW CW EMF (Schmutz et al., 1996). Power density ranged from 0.015 mW/cm^2 to 50 mW/cm^2, therefore lower than the values measured in the previous section on the fruit fly (*D. melanogaster*, in Section 4.4) and in line with the applications measured for birds and bees (Sections 4.1 and 4.2). When measured and provided, SAR values were in the range of 0.0–4.7 W/kg (see Table 6).

The experiment by Schmutz et al. (1996) investigated the effects of a long term exposure to 900 MHz MW on the spruce and the beech (*Picea abies* and *Fagus silvatica*). At a measured power density of 10 mW/cm^2, growth parameters and photosynthetic activities of the systems were not affected. No evidence was found on the mutation and the stress levels of yeast (*Saccharomyces cerevisiae*) in the laboratory experiment by Gos et al. (2000) and on mutation in the study by Chen et al. (2012). No information was provided on the levels of power density.

Among the studies with a significant effect on plants, three were published in 1996 by a Latvian group of researchers (Balodis et al., 1996; Magone, 1996; Selga and Selga, 1996). The researchers focused on the area of Skundra, Latvia, where a radio location station had been operating for 20 years. The three studies provide a unique experience of a complete set of experiments and field studies conducted around a radio station in the short as well as in the long term. The area of study also allowed for the investigation of RF-EMF effects at different distances from the station. The effects of other environmental and anthropogenic factors (e.g. pollution levels and population density) were also evaluated without revealing any significant effect on the parameters studied. As a result, the non-thermal RF-EMF under investigation indicated that the effects of short term exposure (i.e. up to five days) are dependent on the stage of growth of great duckweed (*Spirodela polyrhiza*; Magone, 1996) at the time of exposure. The vegetative growth of young plants decreased as a consequence of exposure, while it even accelerated in the case of older plants. The exposed population of adult plants was on average growing 150% more than the control unexposed samples. In the other two studies the pine tree (*Pinus sylvestris*) was under investigation. The effects of RF-EMF emitted by the radio station were analysed using retrospective tree ring data in Balodis et al. (1996): a significant negative correlation between the measured electric field at specific sample locations and the mean relative additional annual increment of pines has been identified. Selga and Selga (1996) found significant cytological and ultra-structural changes in exposed pine needles and cones.

Duckweed (*Lemna minor*) was used as a model plant for the monitoring of effects on growth and other physiological responses also in two studies by Tkalec et al. (2005, 2007), which confirmed that under most of the investigated conditions of field frequencies, modulation, and exposure time growth was significantly reduced (i.e. 29% on average less) compared to control.

A connection between exposure and very rapid molecular stress responses was made in the studies performed by Roux et al. (2006, 2008) focusing on the molecular responses of tomato plants (*Lycopersicon esculentum* Mill VFN8). The study was based on the use of several stress related transcripts (e.g. energy charge and protease inhibitor). Great differences were found in the exposed population compared to the control (up to 300%). The data supports the evidence that plants respond to exposure as they would respond to any other injurious treatment. Even though the RF-EMF used was non-thermal and the total power used was low, results, as the authors commented, are strikingly similar to those found when plants are wounded, cut or burned.

Plotting of the size of the effect and the power density measured in studies (i.e. where provided) did not show any identifiable trend (see Fig. 4): effects were found at high and low dosages and the size of effects varied greatly across studies.

4.5.1. Summary

Significant effects of RF-EMF were found mostly on the inhibition of the growth of exposed plants. Oxidative stress (e.g. for tomato plants or duckweed) and continuous abiotic stress have been presented in some

studies as possible determinants of the mechanism. Of interest is the case of studies performed for an extensive period of time in an area in Latvia around a radar station and involving both field and laboratory investigations. These studies showed possible effects of RF-EMF on the radial growth of pine trees (*P. sylvestris*), and on the growth of duckweed (*L. minor*) or great duckweed (*S. polyrhiza*).

5. Synthesis

5.1. General

The reviewed literature focused on birds, insects, plants and other vertebrates studied as model species. Other important ecological groups such as e.g. bumble bees, were underrepresented. Field studies were limited and mostly focused on the analysis of the response of birds and honey bees to RF-EMF. Irrespective of the studied group, development and reproduction were the most studied ecological endpoints.

The number of studies finding effects was highest for plants (90%) and insects (90%), lower for birds (70%), other vertebrates (56%) and other organisms (50%). In all the available field studies significant effects of RF-EMF were found. In laboratory experiments, birds and vertebrate animal subjects were in most cases tested at higher frequencies than smaller organisms (e.g. fruit flies) and plants. Older experiments on birds were often carried out at relatively high frequency MW (i.e. 2450 MHz and higher) and dosages(power density greater than 100 mW/cm^2), which possibly determined a thermal increase of body temperature. In later experiments temperature was kept under control.

The quality of the reported RF-EMF characteristics was heterogeneous. Some studies only provided the frequencies of the RF-EMF emitting device and one dosage parameter (e.g. power density in mW/cm^2). A limited number of studies supplied the full list of physical parameters needed for an adequate description of the exposure (e.g. modulation, spatial connotation of field, polarisation, field pattern and measuring techniques). The reporting of the measured or extrapolated power density values and relative electric field values were discordant and no precise information was given on measurement or calculation procedures. Also relevant biological parameters were often neglected or not described (i.e. size, tissue dielectric properties, size, geometry, and relation to polarisation; see Michaelson, 1991).

The overall quality of the studies varied across and within groups. In the case of the studies regarding bees (with the exception of the study of Favre, 2011) a limited definition of the characterisation parameters of the exposure, and a low number of control/sham measurements limit the possibility of generalising results and for possible ecological effects.

5.2. Dose–effect relationships

The studies that did find an effect did not always refer to the existence of a dose–effect relationship. Two studies from a Greek research group (Panagopoulos and Margaritis, 2010; Panagopoulos et al., 2010) described a non-linear window-effect of RF-EMF at a specific distance from the emitting source. Despite a high number of studies finding a significant effect, there was no clear relationship between applied dosage and size of effect, at the level of ecological groups. However, the analysis was hampered by the use of different and scarcely comparable physical parameters to characterise dosage and the use of different ways of shielding control groups (e.g. not always a Faraday cage was used). Experimental groups were not always shielded from extraneous sources of RF-EMF and other types of RF-EMF not expressly taken into consideration.

One important conclusion is that even at low dosages, high effect percentages were described in the range of between 10 and 90%. There seem to be no specific physical parameters and experimental conditions that seem to determine an effect. In the field experiment the proximity to the emitting device (i.e. usually a base station) contributes to increase the size of the effect.

5.3. From biological to ecological mechanisms and effects

In studies involving RF-EMF exposure temperature increase is often the only recognised and recognisable agent causing an effect. The WHO (2010) considers temperature as the only clear mechanism active, especially in the studies exposing subjects to higher dosages. Most studies only report an effect of RF-EMF, without paying any attention to possible explanations. Stress is often mentioned as a possible influential element. Studies which use a sham-exposed group investigating also the possible influence of the sheer presence of the emitting device in the test area tend to exclude stress as the sole triggering factor for the effect, suggesting that the effect should be ascribed totally to the physical composition of the EMF and to the exposure conditions.

In the case of plants, a used theory is that the effects of RF-EMF could be described and explained, also at non-thermal exposure dosages, as an ordinary stress factor, like drought or heat. The size of effects mentioned in studies with effects is relatively large in comparison with the control situations, and therefore it may be tentatively concluded from these studies that RF-EMF might have a significant ecological effect.

5.4. Differences between effect and no-effect studies: a possible bias?

The differences in articles between effect and no-effect RF-EMF studies were compared regarding the country of the origin, the exposure duration, the applied RF-EMF frequencies, and the impact factor of the journal of publication (see Table 7).

The comparison of the countries of origin of the main authors and research groups showed in both groups a clear prevalence of studies coming from the USA (Table 7). Among the studies that did find a significant effect the most represented countries were India, Greece, France, Croatia, Germany, and Latvia (see Table 7). A lower variation in countries was found in the case of no-effect studies.

The analysis of the duration of the exposure showed that exposure was on average twice as high in the case of positive studies than in studies with no significant effects. Minimum and maximum values were also higher in the first case (see Table 7).

The distribution of studies according to the RF-EMF frequencies applied confirmed a clear prevalence of the range between GSM and MW lower band in the case of studies finding an effect. Most of the studies which did not find an effect applied RF-EMF frequencies higher than 2000 MHz (see Table 7). The analysis of the impact factors (JRC WEB, Journal Citation Reports, 2012) of the journals where the selected articles were published showed on average a higher score for studies not finding an effect (see Table 7).

In conclusion, possible ecological effects of RF-EMF seem to be found more at higher duration in the GSM bands and in the MW frequency bands (>2000 MHz).

5.5. Minimum requirements for studies on ecological effects of RF-EMF

In Michaelson (1991) and Beers (1989) attention is paid to the experimental set up of RF-EMF experiments, and to the criteria to conduct biological (therefore, also ecological) RF-EMF field and laboratory studies. The criteria are in line with the propositions of WHO (van Deventer et al., 2011) and their proposed research agenda. None of the studies analysed in this review reported the use of these standard procedures of exposure and analysis.

According to Michaelson (1991) and Beers (1989), experimental conditions should be meticulously defined, selecting the most appropriate animal species to investigate the effect of RF-EMF: intrinsic physical and physiological dissimilarities between species could be confounding elements. The experiments/studies should include a total precise duration

Table 7
Analysis of differences in articles between RF-EMF effect and no-effect studies.

Parameter	Effect	No effect
Country (number)[a]		
USA	18	17
India	8	3
Greece	8	2
France	5	8
Croatia, China, Germany, Latvia, Spain and UK	3	
Canada, Japan and Switzerland	2	
Others	10	12
Exposure duration (min)[b]		
Mean	146,960.5	63,241.26
Median	1800	1800
Mode	30	300
Standard deviation	836,108.1	232,212.2
Sample variance	6.99E+11	5.39E+10
Minimum	5	0.0875
Maximum	7,257,600	1238,400
Based on number of articles	79	39
Frequency ranges (MHz) (number)[c]		
0–30	3	2
31–200	7	2
201–900	38	9
901–1200	7	1
1201–1800	4	5
1801–2000	3	4
>2000	19	16
Journal Impact Factor[d]		
Mean	2.079973	2.449725
Median	2.291	2.371
Mode	0.73	2.291
Standard deviation	1.094949	0.897919
Sample variance	1.198914	0.806259
Minimum	0.13	0.246
Maximum	4.411	4.411
Based on number of articles	73	40

[a] Country: location of the university where main author or research group are based. Data tested by Fisher Exact Test (p-value = 0.1595).
[b] Exposure duration (min): duration of exposure of target subject in minutes as reported by author. Data tested by Kruskal–Wallis (p-value = 0.9514).
[c] Frequency ranges (MHz): type of RF-EMF frequency ranges applied in studies. Data tested by Fisher Exact Test (p-value = 0.03531).
[d] Journal Impact Factor: impact factor of journal of publication, if available, of RF-EMF study as reported by Journal of Citation Reports on the Web (JRC WEB). Data tested by Kruskal–Wallis (p-value = 0.3233).

of exposure, the length of periods of exposure, intervals (if any) between exposures and heating amplitude. Relatively to the SAR levels, the experts warn that they are often predicted using models which fail to characterise specific features of the species exposed (bone, tissue and energy deposition). All the factors that can influence biological responses at the same SAR level (e.g. sex, age and number of subjects) need to be reported.

As for the setup of laboratory experiments, standard laboratory stressors should be avoided or at least accounted for (e.g. using sham-exposure). The effects of other intervening factors (e.g. temperature, noise and chemicals) should be considered (or avoided).

Relative to the characteristics of the RF-EMF, some effects might be related to (or influenced by) the local geomagnetic field and, oddly enough, by the variation occurring in RF-EMF because of lunar phases (Beers, 1989). Other factors that affect the absorption of the RF-EMF (e.g. frequency, polarisation, modulation and field pattern) have to be considered and reported, together with other possible confounding elements (e.g. RF-EMF alien to the experiment/study under investigation).

In the number of studies analysed in this review, it appears that too little attention is paid to these important recommendations. The majority of the reviewed research has been done using small rodents. Scaling of results to other species is needed to further investigate and extend results to the ecosystem level. Some exposure setups are capable of reflecting or focusing the EMF, inducing the SAR levels to increase more than experimenters may have realised, which may lead to erroneous conclusions. There is a clear need for proper dosimetry in experimental procedures with a detailed description of the methods. A special point of attention is the control: not only a control situation, but also a sham situation should be included. This procedure might introduce some extra difficulties in field situations but might still be possible (e.g. by experimentally shutting down the communication stations for a period of maintenance).

There is a great need for more ecological experiment/studies on the effects of RF-EMF, taking into account the reported guidelines. From this ecological review it became, in fact, clear that the way in which RF-EMF were applied and measured, was very heterogeneous, limiting the possible comparison of the effects found.

6. Conclusions and recommendations

The screening of literature in the field ranges that were analysed provided a limited number of strictly ecological studies. The distinction between biological studies and ecological studies as intended in this review has been detailed in Section 1 of this contribution. Only endpoints that may provide an *ecologically* relevant picture were selected, in order to quantify significant biological effects, which may provide valuable hints on the ecological implications of results. The effects of RF-EMF on different biological groups were investigated. With reference to the groups under investigations in the selected studies (i.e. birds, honeybees, mammals, plants, *Drosophila* and others) there is ecologically relevant evidence that the RF-EMF caused an effect in about 50% of the animal studies and about 90% of the plant studies. No studies, in fact, were found on the impact of RF-EMF at the ecosystem level. The sole study by Reijt et al. (2007) investigated the alteration in the interaction among two species of Tits. Only eight studies were conducted in the field.

Nevertheless, an ecological interpretation of the biological studies under review was necessary. The information and results on effects gathered in laboratory studies may need to be cautiously handled due to the sheer nature of the laboratory solutions adopted. The conditions applied in the laboratory studies, in fact, do not always reflect real conditions of exposure, and at times it is important to carefully evaluate the plausibility that biological systems exposed to RF-EMF could likely translate into ecologically relevant effects.

As suggested by the expert panel to the European Commission SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) (2009) and Foster and Repacholi (2004), while it seems appropriate to perform experimental studies using pure experimental RF fields, it may be necessary to emulate the complex modulation patterns and intensity variations typical to real RF-EMF exposure. Few of the studies found were performed in the field and engaged in real exposure conditions and only few laboratory studies dealt with real-exposure modulation.

The ICNIRP guidelines (1998, 2010) provide limiting values as basic restrictions and reference levels for the exposure of humans to RF-EMF. These guidelines have been adopted by most European countries which have imposed limits (EU Commission implantation Reports, 2008). To our knowledge, there are currently no guidelines for the exposure of biodiversity to RF-EMF. The available data has so far been inadequate to judge whether the ICNIRP guidelines and other environmental standards should be the same or significantly different from those appropriate to protect human health (EU, 2011).

However, if we consider that the guidelines might protect biodiversity (i.e. with the consideration of differences in size and exposure conditions), in some studies analysed we encountered applications of dosages hardly experienced by animals and plants in case of real outdoor conditions. As a general trend, no clear relationship was determined between maximum effects found in different studies and the dosage of the RF-EMF applied. Also at very low dosages significant ecologically relevant effects were found. These values are compatible with real field situations, and could be found under environmental conditions. From the limited number of field studies decreasing effects could be determined at increasing distances from the emitting source, but residual relevant effects were

still detected as far as 300 m away and with an average measured electric field of 0.53 V/m, thus 7.45×10^{-5} mW/cm^2 (ICNIRIP limit for general human population 0.0004 V/m).

As ICNIRP suggests (2010), when reference levels are exceeded restrictions values are not necessarily exceeded. Further investigations, need to be undertaken. For instance, localised fields in excess of the reference levels can be emitted by certain devices (i.e. wireless or remotely-controlled devices) but there might be a weak coupling of the field with the body of the exposed target subject (e.g. due to the size of the exposed subject). Therefore, while it is not possible to rule out the adverse ecological relevance of effects, ICNIRP (2010) and WHO (2010) suggest to extrapolate only cautious indications on the global impact of RF-EMF on ecosystems.

Considering the relevant remark of Beers (1989) "a long list of reports of positive results yielded by inadequate experiments may appear impressive in a review and yet mean little". No clear relationships, in fact, could be found between dosage and effects because of a wide variety of exposure strengths, durations, conditions, frequencies, time between exposures, assessment methods, measurement systems, replications efforts, and adequate dosimetry. In the older laboratory studies the interpretation of results needs to be filtered by the consideration of a lack of control of temperature. In the other studies the balance of experimental evidence points towards a non-thermal effect of RF-EMF exposure. In field studies additional confusion might be caused by the simultaneous exposure to multiple field strengths and frequencies and other environmental confounding variables. A similar conclusion can be drawn for those laboratory studies that did not adequately control the exposure to other sources of electromagnetic fields, in which the influence of other variables on the result was also usually not handled in the design or in the analysis.

The plotting of the size of the ecologically relevant effects in relationship to the dose conditions applied did not seem to define a trend. Thus, the result of the graphical meta-analysis leads to no definitive conclusions about whether the effects are real, not real, or can be found only under certain conditions. The study of the differences between significant and non-significant studies presented in Section 5 revealed differences in the duration of the exposure of the target subjects, in the selection of the frequency band of exposure and in the impact score of the journals where articles were published.

Potential further sources of bias should be further examined using tools such as *funnel* or *forest* plots (Egger et al., 1997; Peters et al., 2006, 2008). These might reveal asymmetries due to: location biases (e.g. language bias, citation bias and multiple publication bias), heterogeneity (e.g. intensity of intervention and differences in odds ratios), data irregularities (e.g. poor or inadequate analysis), poor choice of effect measure, and chance.

At the current state of our knowledge, it is possible to conclude that there is an urgent need for repetitions of experiments and field studies by other research groups and under other (standard) situations and setup in order to confirm the presence/absence of effects. We, once again, refer to the ICNIRP statement of (2010), suggesting that results can only be accepted 'for health risk assessment if a complete description of the experimental technique and dosimetry are provided, all data are fully analysed and completely objective, results show a high level of statistical significance, are quantifiable and susceptible to independent confirmation, and the same effects can be reproduced by independent laboratories' (Repacholi and Cardis, 1997). If the significant conclusions found by studies are confirmed, they will be important for a mechanistic understanding of the interaction of RF fields with ecosystems.

In the synthesis the requirements to conduct an adequate study of the (ecological) effects of RF-EMF have been described in detail. Advances in dosimetric investigations in terms of precision and resolution were appreciable in some of the more recent studies, while standards seemed to be totally neglected in others. The application of the suggested *best practice* would allow to handle the information on the reported effect or absence of effect with greater precision.

Our review highlights that there is a clear need for the study of the effects of RF-EMF on more species and organisms and, by means of field studies, on populations and interactions between species. Studies at the ecosystem level should start from the consideration of micro-ecosystems and micro-cosmos, which would allow for laboratory results to be more informative and ecologically-relevant, also at a policy level.

The number of experiments assessing new technologies is limited: only 5 matched the ecological criteria set in this review. Experiments evaluating the impact of newer wireless technologies (e.g. WiMAX, WLAN and WiFi), together with studies analysing new generations of mobile phone technologies (e.g. 3G and 4G) would shade some light on the impact of these technologies for ecosystems. To our knowledge solely the study on mice by Lee et al. (2009) investigated the possible impacts of these technologies. In order to minimise the uncertainties as efficiently as possible a number of situations with limited number of studies should be investigated: the long-term monitoring of selected species and/or ecosystems, field studies under a controlled system of exposure, laboratory studies following given recommendations, and studies on important ecological groups, other than those here analysed, would be a solid base on which to focus future studies.

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Appendix A

Keywords for literature screening

Main search strategy

RF-EMF OR SAR OR electromagnetic OR "power density" OR "internal electric field" OR "current density" OR non-ionising OR non-ionising OR RF OR "electric field" OR "magnetic field" OR Wi-Max OR WiMax OR W-LAN OR WiFi OR Wi-Fi OR modulation OR DCS OR GSM OR FM OR UMTS OR AM OR television OR TV or FM or AM or radio OR transmitter OR broadcast OR antenna OR aerial OR "base station" OR phone OR wireless OR DECT OR TETRA OR radar OR phone mast AND reproduction OR fecundity OR mortality OR behaviour OR behaviour OR activity OR density OR growth OR navigation OR orientation OR eco* OR malformation OR insect OR honey bee OR bee OR bat OR fruit fly OR mammal OR plant OR fauna OR biodiversity OR community OR population OR wildlife OR animal OR organism OR tree OR plant OR fish OR invertebrates OR fauna OR flora OR fungi OR birds OR vegetation.

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Review

Comparing DNA damage induced by mobile telephony and other types of man-made electromagnetic fields

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ABSTRACT

The number of studies showing adverse effects on living organisms induced by different types of man-made Electromagnetic Fields (EMFs) has increased tremendously. Hundreds of peer reviewed published studies show a variety of effects, the most important being DNA damage which is linked to cancer, neurodegenerative diseases, reproductive declines etc. Those studies that are far more effective in showing effects employ real-life Mobile Telephony (MT) exposures emitted by commercially available mobile phones. The present review - of results published by my group from 2006 until 2016 - compares DNA fragmentation induced by six different EMFs on the same biological system - the oogenesis of Drosophila melanogaster - under identical conditions and procedures. Such a direct comparison between different EMFs - especially those employed in daily life - on the same biological endpoint, is very useful for drawing conclusions on their bioactivity, and novel. It shows that real MT EMFs are far more damaging than 50 Hz alternating magnetic field (MF) - similar or much stronger to those of power lines - or a pulsed electric field (PEF) found before to increase fertility. The MT EMFs were significantly more bioactive even for much shorter exposure durations than the other EMFs. Moreover, they were more damaging than previously tested cytotoxic agents like certain chemicals, starvation, dehydration. Individual parameters of the real MT EMFs like intensity, frequency, exposure duration, polarization, pulsing, modulation, are discussed in terms of their role in bioactivity. The crucial parameter for the intense bioactivity seems to be the extreme variability of the polarized MT signals, mainly due to the large unpredictable intensity changes.

1. Introduction

1.1. Microwave EMFs, DNA damage and related effects

The number of published peer review studies showing DNA damage and related effects induced by Radio Frequency (RF)/microwave Electromagnetic Fields (EMFs), especially by Mobile Telephony (MT) EMFs, on a variety of organisms/cell types under different experimental conditions is increased considerably in recent years [1–36], in spite of attempts to dispute some of them [37–39].

Specifically, the damage on reproductive cells of different animals found in several of the above studies explains other findings connecting microwave EMF exposure with insect, bird, and mammalian (including human) infertility [40–48], or reduction in bird and insect (especially bees) populations during the past 10–15 years [49–53].

The effects on DNA and reproduction reported by different labs on a variety of animals demonstrate a remarkable similarity. For example, Sharma and Kumar [47] found a large decrease in reproduction (egg laying) of bees after exposure to mobile phone radiation, which was identically observed before in fruit flies [15,16,41,42] and birds [49–51]. The recorded decreased reproduction is strongly corroborated by very similar effects in amphibians [54,55], rats [17,46], and human sperm [44]. This unique similarity of effects in different organisms found by different research groups can be explained by the observed cell death induction in reproductive cells due to DNA damage found for Drosophila ovarian cells [15,16], human sperm cells [22], mice and rat sperm cells [10,17], and chick embryos [36]. It is evident that such a similarity of findings is not a coincidence.

It is important to note that the exposure levels in the majority of the above studies were below the officially accepted exposure limits [56] and only in a few of them [4–6,13] they were slightly exceeding these limits.

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1.2. Microwave EMFs, electro-hypersensitivity, and cancer

During the past 15 years several statistical studies indicate a connection between residential exposure to radiation of MT base station antennas (which emit similar radiation with that of mobile phones), and reported symptoms of unwellness usually referred to as "microwave syndrome", or "electro-hypersensitivity" (EHS). These include headaches, fatigue, sleep disorders, etc. [57–63]. Similar effects that were previously categorized as medically unexplained symptoms (MUS) are recently attributed to chronic stress and inflammation [64]. Recently, in an effort to find objective methods for EHS evaluation, ~80% of EHS self-reporting patients were found to present oxidative stress biomarkers in their peripheral blood [65] which is strongly related to DNA damage.

At the same time, more and more epidemiological studies indicate an increasing connection between mobile phone use and brain tumors in humans, [66–75]. The time length of cancer development after cellular damage may be many years depending on the animal and the type of cancer. It is called latency period and is defined as the time between the initial causative event and the development of clinically recognizable cancer. The latency period for gliomas (type of brain cancer) is more than 20 years in humans [76]. This probably explains why epidemiological studies only recently have started showing a connection between mobile phone use and cancer.

Tumor promotion in experimental animals after long-term RF exposure at levels below the officially accepted limits is also reported [77,78]. In a recent study of the USA National Toxicology Program (NTP) rats were exposed for 2 years, 9 h per day, in a simulated near field of a mobile phone antenna emitting 2nd generation (Global System for Mobile telecommunications - GSM) or 3rd generation (Code Division Multiple Access - CDMA) EMFs. [The CDMA is part of the Universal Mobile Telecommunication System – UMTS]. Exposed rats developed brain cancer (glioma) and heart cancer (malignant schwannoma) for both lower (1.5 W/kg) and higher (3, and 6 W/kg) Specific Absorption Rate (SAR) levels than the current exposure limit (2 W/kg) for the human head [56,79]. An Italian life-span exposure study of rats in a simulated GSM 1800 far field, also found induction of heart schwannomas and brain glial tumors, in agreement with the results of the NTP study [80].

These findings are in agreement with the above reported DNA damage findings, since DNA damage is a main cause of cancer [81,82]. Alternatively, DNA damage may result in cell death, reproductive declines, or neurodegenerative diseases [83,84].

1.3. Combination of frequency bands in telecommunication microwave EMFs

It is important to note that except for the RF/microwave carrier frequency, Extremely Low Frequencies - ELFs (0–3000 Hz) are always present in all telecommunication EMFs in the form of pulsing and modulation. There is significant evidence indicating that the effects of telecommunication EMFs on living organisms are mainly due to the included ELFs [29,30,85–91]. For example, Frei et al [87] found that a 2.8 GHz RF EMF pulsed on 500 Hz was significantly more effective in increasing heart rate in rats than the corresponding continuous wave (CW) (un-pulsed) RF 2.8 GHz EMF with the same average intensity and exposure duration. Huber et al [90] found exposure to 900 MHz RF EMF pulse modulated on GSM MT ELFs, to induce changes in the human electro-encephalogram (EEG), while the corresponding CW signal (same RF frequency un-pulsed) with the same exposure duration did not. Similarly, Franzellitti et al [29] found that a 1.8 GHz RF signal amplitude-modulated by GSM pulsing ELFs induced DNA damage in cultured human trophoblast cells, while the same signal un-modulated (CW), with the same exposure duration, was ineffective. Moreover, ELF EMFs alone are found independently to be bioactive, as are RF EMFs modulated or pulsed by ELFs [92–94]. Bawin and Adey [92] found that the ELF sinusoidal signals used previously to modulate a RF carrier CW EMF [85,86] induced alone (without the RF carrier) alterations in Ca^{2+} concentration in chicken and cat brain cells as did the modulated RF EMF, while the RF carrier alone (un-modulated) was ineffective.

These experimental results are in agreement with the "ion forced-oscillation mechanism" for irregular gating of electro-sensitive ion channels on cell membranes which predicts that pulsing EMFs are more bioactive than CW EMFs of the same other parameters, and that the biological activity of any specific type of EMF is inversely proportional to its frequency and proportional to its intensity [95–97]. The International Agency for Research on Cancer (IARC) has classified both ELF and RF EMFs as possibly carcinogenic to humans [98,99].

1.4. Conflict between experimental studies due to unrealistic exposures

An extremely important observation is the intense opposition between the results of experimental studies that employ real exposures from commercially available devices (mobile phones or other telecommunication devices), and studies employing simulated exposures from generators or "test" phones with similar but invariant parameters such as intensity, frequency etc. While ~50% of the studies employing simulated exposures do not find any effects, studies employing real-life exposures from commercially available devices display an almost 100% consistency in showing adverse effects [34–36,84,100–118]. A wide variety of biological and clinical effects are already found to be induced by real-life exposures on a similarly wide variety of animals/biological samples including human volunteers exposed in vivo (19 studies) [19,34,35,100,104,106–109,114,116], human sperm in vitro (2 studies) [23,100], mice or rats or guinea pigs or rabbits in vivo (24 studies) [100,102,103,105,110,111,115,117], Drosophila (11 studies) [15,16,26,31,41,42,100,101,140,141], bees (4 studies) [47,100,118], ants (1 study) [100], chick embryos (3 studies) [36,45,100], quails (1 study) [100], human cells in vitro (2 studies) [100,112], cow brain tissue in vitro (1 study) [113], mouse cells in vitro (1 study), protozoa (1 study), and even purified proteins in vitro (1 study) [100]. From a total of 71 studies reviewed above that employed real exposures 68 recorded significant adverse effects (95.8%) ranging from loss of orientation, kinetic, behavioural, or EEG changes, heart rate changes, effect on cognitive function and memory impairment, effect on cell growth and proliferation, temperature increases in brain tissue, to decrease in male and female reproductive capacity, reproductive declines, molecular changes, changes in enzymatic activity, biochemical changes in the pregnant women and their embryos, DNA damage and cell death, protein damage, and histopathological changes in the brain [34–36,84,100–118]. From the remaining three studies, two reported no effect and one reported an increase in short-term memory of children which we did not count as an adverse effect although it may be [100,106]. Nineteen of the above 71 studies were published within the last three years [35,36,102–118] after the publication of the observation that real exposures induce stronger effects than simulated ones [100]. (For real exposure studies published up to 2015, see Refs. [34,101], and reviews [84,100]. For real exposure studies published from 2016 up to today references are [35,36,102–118]).

The only difference between real and simulated electromagnetic signals emitted by modern telecommunication devices/antennas (and corresponding exposures) is that real ones are highly and unpredictably variable each moment (especially in their intensity), while simulated ones have fixed parameters, and thus are invariable and totally predictable.

Although experimental studies employing real-life microwave telecommunication exposures are obviously much more effective in showing effects, there also seems to be an overall predominance (~60%) of studies showing effects. In a recent review of in vitro studies investigating a variety of microwave effects in many different cultured cell types regardless of real-life or simulated exposure, from a total of 161 studies, 98 found effects (60.87% of the studies), and 63 did not [119].

1.5. Comparison of bioactivity between MT and other types of man-made EMFs

Comparison studies between different EMFs on the same biological model/endpoint under the same conditions and procedures are rare in the scientific literature, in spite of the fact that they can be very useful in drawing conclusions on the bioactivity of the different physical parameters between EMFs. Such studies are those already discussed above [29,30,85–91] which suggested that the ELF pulsing and modulation is mainly responsible for the biological effects of the modulated (information carrying) RF EMFs and not the RF carrier itself. This observation is of great importance in terms of protection/safety especially in the case of modern types of microwave/RF telecommunication EMFs all of which increasingly employ ELF pulsing (and modulation) in order to increase the density/amount of transmitted information (see 4.3). A recent study by D'Silva et al [36] compared bioactivity between 2nd (GSM) and 3rd (UMTS) generation MT EMFs emitted by real mobile phones on chick embryo development and found that both induced DNA damage and structural changes, with the UMTS being even more bioactive than the GSM.

There are a few studies comparing power frequency (50–60 Hz) EMFs with CW RF EMFs. These RF fields bear no similarity with real modern telecommunication RF EMFs basically due to the absence of ELF pulsing and modulation. Marchionni et al [120] found a 50 Hz alternating Magnetic Field (MF) to be able to stimulate ion channels in rat sensory neurons while a 900 MHz CW EMF was not. Lin et al [121] found that a 50 Hz EMF (60 G, 205 V/m) or a 2 GHz CW RF EMF 20 V/m, could both upregulate gene transcription in yeast.

Two studies were found comparing 50–60 Hz fields with simulated MT EMFs. These studies are closer to reality than the CW RF studies, but not close enough since they did not employ real MT EMFs. Simulated MT EMFs include ELF pulsing at the same average frequencies and intensities as the real ones, but this pulsing is totally invariant and thus predictable, in contrast to the real fields in which ELFs (and RFs) vary unpredictably each moment [84,99,100]. Therefore, simulated MT EMFs are certainly expected to be more bioactive than CW RF EMFs, but not as bioactive as real MT EMFs. A study by Belyaev et al [8] reported that GSM 900 simulated exposure by a "test" phone (with SAR = 0.037 W/kg), or exposure of equal duration (2 h) to 50 Hz alternating MF (with intensity 0.15 G), induced chromatin condensation (a sign of cell death) in human lymphocytes at similar degrees. A more recent study by Duan et al [122] compared a 50 Hz alternating MF (10, 20, or 30 G) with a simulated GSM 1800 MHz EMF (1, 2, or 4 W/kg) with the same exposure duration, and found only the strongest fields of both types (both exceeding ICNIRP limits) to be able to induce DNA damage at more or less comparable degrees, although of different patterns.

The direct comparison of effects on the same biological model under identical conditions and procedures between MT EMFs, and a 50 Hz alternating MF is important, since 50 Hz alternating MFs are those of power lines which are accused for carcinogenicity long before the MT EMFs [123–126], and both types of EMFs are classified as possible carcinogens [98,99].

A specific aim of the present review (apart from reviewing other related studies), is the direct comparison of DNA fragmentation recorded in our previous studies on Drosophila ovarian cells, under identical conditions and experimental procedures, induced by six different man-made EMFs: GSM 900, GSM 1800 [15,16], 50 Hz alternating MF 1, 11, 21 G [94], and 8 kHz (44.4 Hz pulse repetition rate), 400 kV/m, pulsed electric field (PEF) [127]. Moreover, to draw conclusions on which specific physical parameters of the EMFs are most responsible for the recorded bioactivity. In this case the MT EMFs are real ones and thus this comparison is novel.

1.6. Drosophila oogenesis as a detector for EMF-induced DNA fragmentation

Each ovary of an adult female Drosophila consists of 16 to 20 ovarioles. Each ovariole is an individual egg assembly line, with new egg chambers produced in the most anterior cyst called germarium (g). During oogenesis, new egg chambers produced by specific stem cells bud off the germaria and develop through 14 successive developmental stages (S1-S14) moving toward the posterior end to be fertilized and laid through the oviduct. Each egg chamber consists of a cluster of 16 germ cells, surrounded by an epithelial monolayer of somatic follicle cells (FCs) responsible for building the egg shell. In the germarium, the germline cyst originates from a single cell, (cystoblast), which undergoes four mitotic divisions to form the 16-cell cluster. Among the 16 germ cells, one differentiates as the oocyte (OC) - the single cell which after fertilization will give the embryo - and the rest become nurse cells (NCs) which will serve as nutrients for the OC. Therefore, each egg chamber in the ovaries of female Drosophila consists of three different types of cells; a single OC, 15 NCs, and up to ~1200 FCs [128–132].

NCs and FCs, undergo Programmed Cell Death (PCD) during the late oogenesis stages 11–14 after they have completed their role and are no longer needed, exhibiting DNA fragmentation, actin cytoskeleton disorganization, chromatin condensation, and phagocytosis of the cellular remnants by the adjacent follicle and epithelial cells [128–130].

In addition to PCD during late oogenesis, Stress-Induced Cell Death (SICD) may take place during the early- and mid-stages (from germarium up to stage 10) in cases that certain egg chambers do not develop normally due to starvation or other stress factors, [128–130]. Both PCD and SICD occur after DNA fragmentation. The most sensitive developmental stages during oogenesis for SICD, are the germarium referred to as the "germarium checkpoint" or "early oogenesis checkpoint", and stages 7–8 just before the onset of vitellogenesis (stages 8–10), referred to as the "mid-oogenesis checkpoint" [129,130]. Both checkpoints were found to be very sensitive to stress factors such as poor nutrition [129], or exposure to cytotoxic chemicals like etoposide or staurosporine [128]. In all cases, the stress-induced DNA fragmentation at the two checkpoints was observed only in the NCs and FCs, not in the OC. Moreover, apart from the two checkpoints, egg chambers were not observed before our experiments [15] to degenerate during other stages of early- or mid-oogenesis [15,128–132].

In our experiments we studied DNA fragmentation induced by different types of man-made EMFs, not PCD. For this reason, late oogenesis egg chambers (stages 11–14) were excluded, and we only examined egg chambers from germarium up to stage 10.

2. Exposure details and experimental methods

In each experiment with all six different EMFs, newly emerged adult *Drosophila melanogaster* flies from the stock were collected; anesthetized very lightly with diethyl ether and separated males from females. The collected flies were then put in groups of ten males and ten females in standard laboratory glass vials, with standard food forming a smooth plane surface 1 cm thick at the bottom of the vials. The glass vials were closed with cotton plugs. Detailed descriptions were given before [15,16,41,42,94,127].

The exposures to the EMFs started on the first day of each experiment (day of eclosion), 1 h after all flies were fully awaken from the anesthesia, and lasted for a total of 120 h (5 days). The net duration of exposure/sham-exposure to each individual EMF, and the field/radiation intensities ± standard deviation (SD) were as follows: a) Exposure/Sham-Exposure to the GSM 900 or 1800 EMFs for 6 min every 24 h (36 min total) with the handset in "talk" mode and in contact with the vials (RF radiation intensity ~0.378 ± 0.059 mW/cm^2, ELF E-field

~19 ± 2.5 V/m, ELF B-field ~0.9 ± 0.15 mG for GSM 900 and ~30% lower corresponding values for GSM 1800, highest SAR for human head of the handset used in our experiments given by the manufacturer 0.89 W/kg) [15,16]. b) Exposure/Sham-Exposure to the 50 Hz alternating MF (1 or 11 or 21 G) continuously for the 5 days (120 h total) within especially designed and constructed coils [94]. c) Exposure/Sham-Exposure to the 8 kHz (44.4 Hz pulse repetition rate), 400 kV/m PEF for 30 min every 2 h during the 5 days (30 h total) in especially designed and constructed capacitors [127]. [This PEF roughly resembles the atmospheric EMFs (sferics) produced by lightning during thunderstorms. These have a ~10 kHz carrier frequency (instead of 8 kHz) with a ~20 Hz pulse repetition (instead of 44.4 Hz). The shape of the pulses is in both EMFs bipolar damping) [127,133]].

Then, 120 h after the beginning of exposure/sham-exposure, the flies were removed from the glass vials, the females were collected, anesthetized, and dissected. Egg chambers from germarium up to stage 10 were collected from both ovaries, and fixed for the TUNEL (Terminal deoxynucleotide transferase dUTP Nick End Labeling) assay, as described before [15,16,94,127].

The TUNEL assay is a known marker for DNA fragmentation (severe DNA damage including single and double strand breaks). According to this assay, fluorescein dUTP (a fluorescent substance) binds through the action of terminal transferase (an enzyme that catalyzes the specific biochemical reaction), onto fragmented genomic DNA which then becomes labelled by characteristic fluorescence. The label incorporated at the damaged sites of DNA is visualized by fluorescence microscopy [134].

3. Comparing DNA damage from the different EMFs

The comparison of DNA fragmentation in Drosophila ovarian cells (sum ratio of TUNEL-positive to total number of egg chambers) between GSM 900, GSM 1800, 50 Hz MF 1 G (MF1), 11 G (MF2), 21 G (MF3), and PEF 400 kV/m, is presented in Table 1, and Fig. 1.

MT EMFs were found to be significantly more hazardous than the other types of EMFs inducing DNA fragmentation in a much higher degree even though the durations of daily exposure to the other EMFs were significantly longer than the 6 min daily exposure to MT EMFs.

More specifically: GSM 900 or GSM 1800 mobile phone radiation with total exposure duration 36 min induced DNA fragmentation to up to 50.16% of the egg chambers in the ovaries of the exposed females (with the GSM 900 being more bioactive than GSM 1800 basically due to its higher intensity) [15,16] (Table 1, Fig. 1). The corresponding percentages for 1, 11, and 21 G, 50 Hz MF exposure were up to 7.52% with total exposure duration 120 h [94] (Table 1, Fig. 1). Finally, the corresponding percentage for the PEF was 2.74% with total exposure duration 30 h [127], (Table 1, Fig. 1). [The above percentages (as in Table 1) refer to the difference in the percentage of egg chambers with fragmented DNA between exposed and sham-exposed animals. If we referred to % deviation (increase) in DNA damage of the exposed in regards to the sham-exposed, the corresponding percentages would be much greater (669.6% for the GSM EMFs, 114.8% for the MF, and 47.7% for the PEF)].

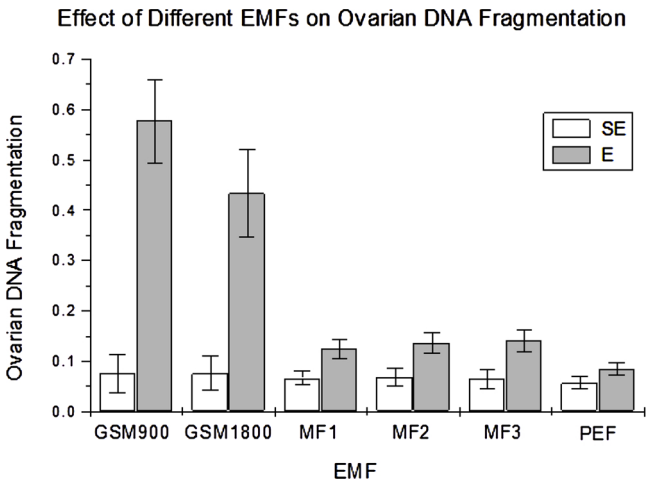

Fig. 1. Ovarian DNA Fragmentation (ratio of TUNEL-positive to total number of egg chambers), induced by six different EMFs [GSM 900, GSM 1800, 1 G MF (MF1), 11 G MF (MF2), 21 G MF (MF3), and 400 kV/m PEF], under identical conditions/procedures. E: exposed groups, SE: sham-exposed groups.

It should be emphasized that while the mobile phone EMFs/radiation exposed the samples at the very same intensity levels as users are daily exposed by mobile phones, the intensities of the other EMFs were significantly higher than the environmentally accounted ones: 1) The strongest MF intensity accounted at the closest proximity to the most powerful power lines is usually significantly less than 1 G or 0.1 m T [94]. In our experiments exposure to 1 G caused 5.72% increase in ovarian DNA fragmentation, while 11 G caused 6.71%, and 21 G caused 7.52% DNA fragmentation [94] (Table 1, Fig. 1). 2) The PEF similar to those of atmospheric discharges (sferics) exposed the animals at 400 kV/m, while sferics are sensed by sensitive individuals at (totally polarized) intensities down to ~0.35 V/m (approximately ~1000 km from a thunderstorm) [127,133].

From the above comparison, it follows that (real) MT EMFs are much more bioactive than the other EMFs, and - most important - much more bioactive than the 50 Hz alternating MF which was (and is still) accused for carcinogenicity, long before the MT EMFs.

Previously examined stressors like cytotoxic chemicals such as etoposide or staurosporine, or poor nutrition were only observed to induce DNA fragmentation, exclusively in the NCs and the FCs, and exclusively at either one of the two checkpoints (germarium and stages 7–8) during early and mid-oogenesis [128–130,132]. Thus, they were not found to induce DNA fragmentation in the OC, neither at developmental stages other than the two checkpoints. Later it was found that the absence of water (dehydration) can induce DNA fragmentation at more developmental stages in addition to the two checkpoints, but again not in the OC [135].

Fig. 2 shows an ovariole of an unexposed female with TUNEL-

Table 1
Effect of Different EMFs on Ovarian DNA Fragmentation.

EMF	Ratio of TUNEL-positive to total number of egg-chambers (**Exposed**) ± SD	Ratio of TUNEL-positive to total number of egg-chambers (**Sham-Exposed**) ± SD	**Difference** in DNA fragmentation between Exposed and Sham-Exposed Groups	*P*-value, between Exposed and Sham-Exposed groups
GSM 900	0.5772 ± 0.083	0.075 ± 0.038	+ 50.16 %	< 0.0002
GSM 1800	0.4339 ± 0.087	0.062 ± 0.034	+ 35.77%	< 0.0005
MF 1	0.1243 ± 0.019	0.0671 ± 0.014	+5.72%	< 0.001
MF 2	0.1367 ± 0.02	0.0696 ± 0.018	+ 6.71%	< 0.001
MF 3	0.1407 ± 0.021	0.0655 ± 0.019	+7.52%	< 0.001
PEF	0.0848 ± 0.012	0.0574 ± 0.012	+2.74%	< 0.05

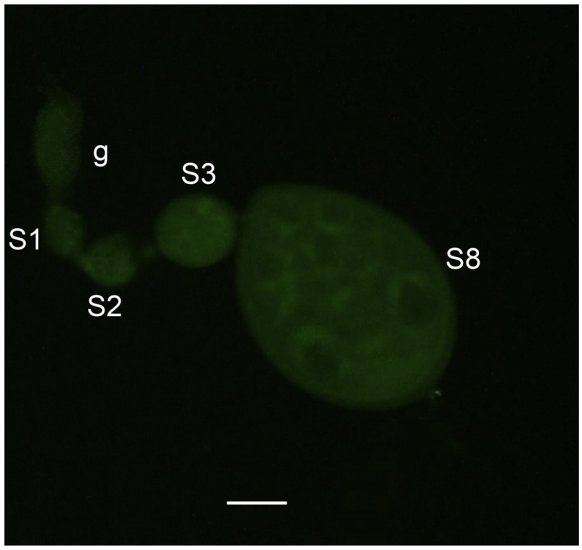

Fig. 2. Normally developed ovariole of an unexposed female Drosophila, containing egg chambers from germarium (g) up to stage 8 (S8), all TUNEL-negative. Bar: 10 μm.

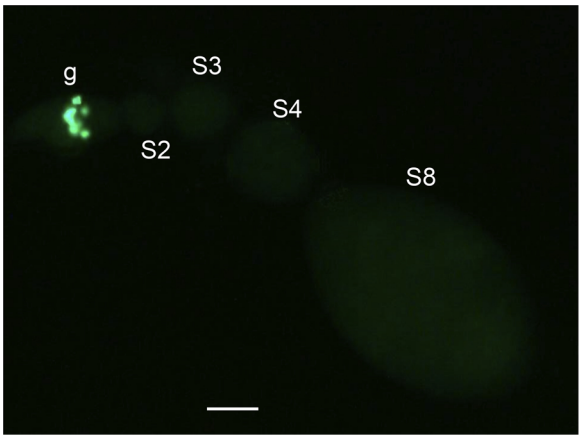

Fig. 3. Ovariole of an exposed to 1 G (0.1 mT) MF female Drosophila, containing egg chambers from germarium (g) up to stage 8 (S8), with fragmented DNA only at the germarium and TUNEL-negative at all other developmental stages. Bar: 10 μm.

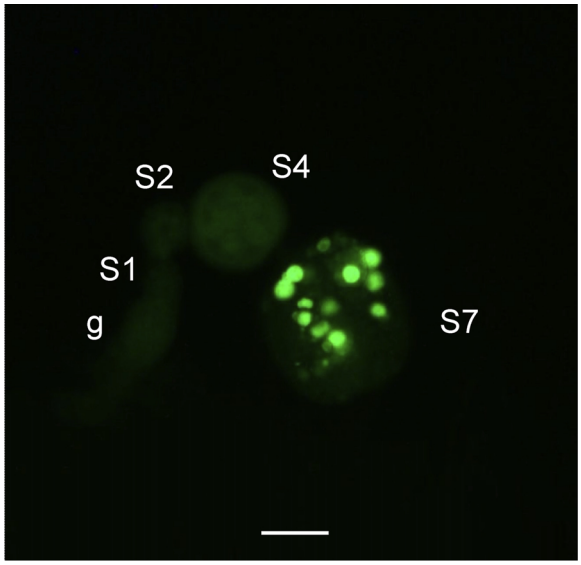

Fig. 4. Ovariole of an exposed to PEF female Drosophila, containing egg chambers from germarium (g) up to stage 7 (S7), with fragmented DNA only at the stage 7 egg chamber and TUNEL-negative at all other developmental stages. Bar: 10 μm.

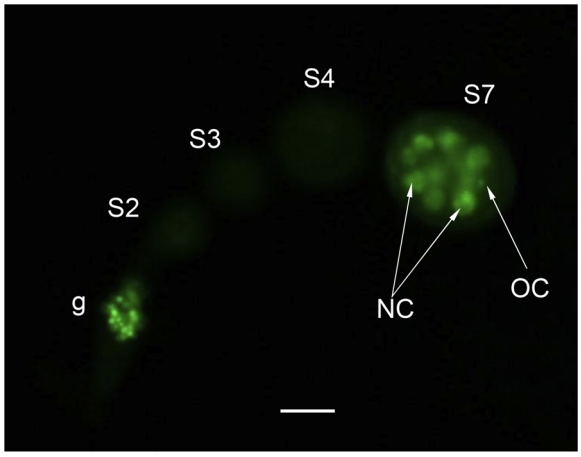

Fig. 5. Ovariole of an exposed to 21 G (2.1 mT) MF female Drosophila, containing egg chambers from germarium (g) up to stage 7 (S7), with fragmented DNA in the nurse cells (NC) at both checkpoints, germarium and stage 7, and TUNEL-negative at all other developmental stages. In the stage 7 egg chamber, the TUNEL-positive signal is evident also in the oocyte (OC). Bar: 10 μm.

negative egg chambers at all stages. Figs. 3–5 show ovarioles of females exposed to MF (Fig. 3,5), or exposed to PEF (Fig. 4). The degree of damage induced by the PEF or the MF is more or less comparable with that from other cytotoxic agents (except for dehydration) examined before [94,127–129] and smaller than the damage caused by dehydration [135]. Only in a few cases, exposure to the strongest MF (21 G or 2.1 m T) caused DNA damage also in the OC (Fig. 5), something that was not observed with any other examined cytotoxic agent [94,128,129,135]. [The nucleus of the OC is distinct as is smaller than the nuclei of the NCs (Fig. 5, 7)].

Mobile phone EMF/radiation exposure during normal “talk” mode was found to induce DNA fragmentation, not only at the two checkpoints, but at all developmental stages during early- and mid-oogenesis (from germarium up to stage 10), and moreover to all three types of egg chamber cells, i.e. NCs, FCs and the OC [15,16].

Figs. 6 and 7 show ovarioles of females exposed to MT EMFs exhibiting a TUNEL-positive signal at all developmental stages during early and mid-oogenesis and in all three types of egg chamber cells (NCs, FCs, OC). Thus, MT EMFs were found to be significantly more bioactive than all other previously examined stress factors (etoposide, staurosporine, starvation, dehydration), although a direct comparison is not possible.

4. Discussion

4.1. What does the comparison of effect of different EMFs on Drosophila ovarian DNA show?

We compared results from previous studies in which we used the Drosophila oogenesis as a sensitive biological system, and the TUNEL assay to record DNA fragmentation in the ovarian cells induced by six different man-made EMFs under identical conditions and procedures. The six different EMFs: were 1) GSM 900 mobile phone radiation, 2) GSM 1800 mobile phone radiation [15,16], 3) 1 G, 50 Hz alternating MF (MF1), 4) 11 G, 50 Hz alternating MF (MF2), 5) 21 G, 50 Hz alternating MF (MF3) [94], and 6) PEF (8 kHz, 44.4 Hz, 400 kV/m) found before to increase fertility [127], similar to EMFs of atmospheric

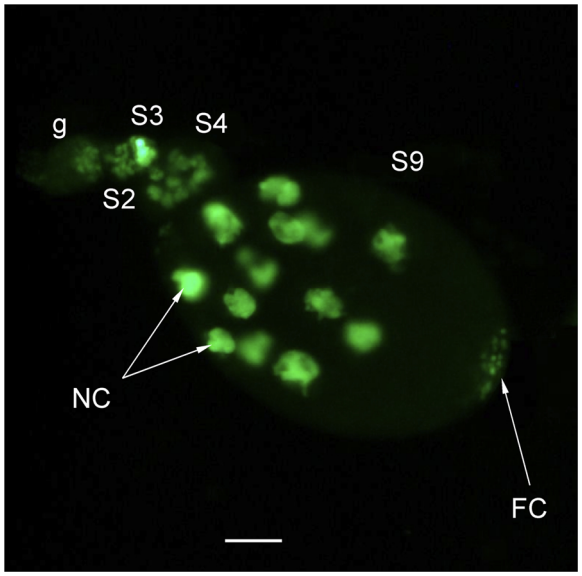

Fig. 6. Ovariole of an exposed to MT EMF (GSM 1800) female Drosophila, containing egg chambers from germarium (g) up to stage 9 (S9), with fragmented DNA in the nurse cells (NC) at all developmental stages from germarium up to stage 9. At the stage 9 egg chamber the TUNEL-positive signal is evident also in the follicle cells (FC). Bar: 10 μm.

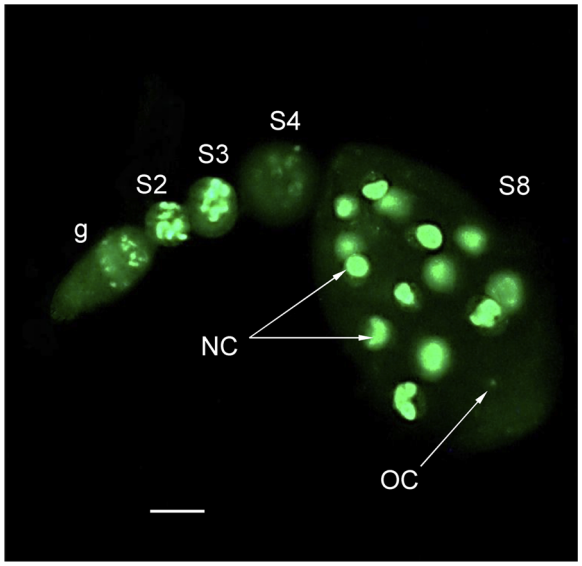

Fig. 7. Ovariole of an exposed to MT EMF (GSM 900) female Drosophila, with fragmented DNA in the nurse cells (NC) at all developmental stages from germarium (g) up to stage 8 (S8). At the stage 8 egg chamber the TUNEL-positive signal is evident also in the oocyte (OC). Bar: 10 μm.

discharges [133].

From the comparison it becomes obvious that the MT EMFs (GSM 900, GSM 1800) are far more damaging than the 50 Hz MFs, or the PEF (Table 1, Fig. 1). Moreover, MT EMF exposure was found to induce DNA fragmentation in Drosophila ovarian cells more than other types of external stress examined before like certain chemicals (etoposide or staurosporine), starvation, or dehydration. The MT EMFs were found to induce DNA fragmentation not only at the two most sensitive developmental stages (checkpoints) but at all developmental stages during early- and mid-oogenesis (from germarium up to stage 10), and in all three kinds of egg chamber cells (i.e. not only in the NC and FC but also in the OC). DNA fragmentation in the OC may result, if not in cell death, in heritable mutations transferred to the next generations. Such a possibility can be far more dangerous than a reduction in the offspring, since it may lead to cancerous or mutated organisms. The 50 Hz alternating MF or the PEF were found to induce DNA fragmentation at more or less comparable degrees with the non-electromagnetic agents.

The observed DNA fragmentation is an indirect effect, since EMFs compared in the present study are non-ionizing, meaning they do not cause direct ionization. The indirect effect on DNA can be induced by irregular release within the cell of oxidative free radicals or hydrolytic enzymes like DNases, which may occur after irregular gating of voltage-gated ion channels on the cell membranes caused by ELF EMFs, such as the ELF pulses and modulation always present in MT EMFs/radiation. Irregular gating of ion channels in cell membranes by EMFs is described by the "ion forced-oscillation mechanism" [95–97], and may lead to disruption of the cell's electrochemical balance and function [136,137]. The validity of this mechanism has been verified by computer numerical test. Other mechanisms suggested before failed to pass the same test [138]. The same mechanism was recently applied successfully to explain health symptoms caused by atmospheric discharges (lightning) reported for decades but never explained before [133].

Despite many other studies that report no effects [93,94,98–100,106,119], the consistency and remarkable similarity of many of the reported effects - including the most detrimental DNA damage - and the rapidly increasing number of the studies reporting effects during the recent years is alarming. All studies from different research groups and on different biological models/endpoints cited in the Introduction of the present study exhibit mutually supportive results and this makes unlikely the possibility that these results could be wrong or due to randomness.

In addition to remarkable gene similarities, the basic cellular processes are identical in insect and mammalian cells. All cells in both insects (including *Drosophila*) and mammals (including humans) have the same type of cell membranes, are full with billions of identical free ions like calcium (Ca^{+2}), potassium (K^{+}), sodium (Na^{+}) etc, initiating and accompanying all cellular events, and have the same intracellular organelles like mitochondria, ribosomes, endoplasmic reticulum, nucleus containing the cell's genomic DNA with the same basic structure, chemical elements and bonds in all organisms, etc. [139]. These similarities at the cellular level between all animals are more fundamental than differences in volume, mass, shape, macroscopic functions, intelligence, etc, since all health effects are initiated at the cellular level. Thus, it is reasonable to assume that a cellular effect caused by EMFs on *Drosophila* (e.g. DNA damage) can be expected to occur also in the human organism. The great advantage in studying the effect on Drosophila is - among others - the much shorter life-cycle due to which, an effect can be observed within a few hours or days, while in mammals it would take much longer.

4.2. Examination of physical parameters responsible for the intense bioactivity of MT EMFs

It is evident that real-life microwave telecommunication EMFs are very bioactive. The question arising is, which specific parameter(s) of this type of EMFs is mainly responsible for this intense bioactivity?

Plea of experimental data in combination with theoretical calculations [16,97,100,140,141] point that the most important physical parameters of EMFs in terms of bioactivity, are: 1) polarization (in combination with coherence), 2) ELF components (pulsing, modulation, etc.), 3) field/radiation intensity, 4) exposure duration, 5) field variability.

Let us now examine the individual parameters of the specific EMFs compared in the present study: 1) All six EMFs were totally (linearly) polarized (and coherent), therefore we must exclude polarization/coherence as the critical parameter. 2) All six of them include ELFs, three of them (GSM 900, GSM 1800, PEF) were pulsed on ELF, and still the PEF did not cause significant DNA fragmentation, therefore we must also exclude ELF and pulsing. 3) Although a direct comparison in

intensity is not possible due to the different frequencies and waveforms among the MT, MF, and PEF EMFs, the MT EMFs were at environmentally accounted intensities, while the other EMFs were at significantly higher intensities than environmentally accounted ones, and still the effect induced by the MT EMFs was much stronger. Therefore, we must also exclude field/radiation intensity. 4) The MT EMFs were the most bioactive despite the shortest exposure duration, therefore we must also exclude exposure duration.

What else was different in the MT EMFs than in the other four EMFs? Obviously the answer is the *variability* of the exposure. The parameters of the (real) MT fields (and especially intensity and waveform) change tremendously and unpredictably each moment during the exposure (even though average intensity values over a few min or more may not change very much), while the parameters of the MFs and the PEF are invariable (apart from the constant alternation or the constant pulsing of the carrier wave which are absolutely predictable).

Now is time to go back to the previous studies in which they also compared the action of GSM and 50 Hz alternating MF exposures. In the Belyaev et al study [8] the effects induced by the two EMFs were of similar degrees. The intensities of both types of EMFs were smaller in that study than in our studies. More specifically, the intensity (SAR) of the GSM EMF was ~10 times smaller, and the intensity of the MF 140 times (21/0.15) smaller than the strongest one in our studies. That means the balance between the two EMFs in our studies favored the (strongest) MF by ~14 times than in [8], and in addition the exposure to the MF was much longer (120 h) in our studies than the exposure to the GSM EMFs (36 min), while in [8] the exposures were of equal durations. And still, in our studies the effect of the GSM EMF was much stronger than the corresponding effect of the 50 Hz MF. What was different? Obviously, the difference was that we employed real-life highly variable GSM EMFs emitted by commercially available mobile phones [15,16], while Belyaev et al [8] employed simulated GSM EMFs with invariable parameters emitted by "test" mobile phones.

Similarly, in the Duan et al study [122] the effects induced by the 50 Hz MF (30 G) and by the simulated GSM EMF (4 W/kg) were of similar degrees. Their intensities in both fields were stronger than in our studies [15,16]. More specifically, the intensity (SAR) of the GSM EMF was ~4.5 times bigger (4/0.89), and the intensity of the MF 1.43 times bigger (30/21) than the strongest one in our studies. That means the balance between the two EMFs in their study favoured the GSM EMF by ~3 times than in our studies, and in addition their exposures were of equal durations, while in our studies the exposure to the GSM EMFs was much shorter than the exposure to the MF. And still, in their study the effect of the GSM field was much smaller than in our studies (of similar degree with that of the MF), since in our studies the effect of the GSM EMF was much stronger than the corresponding effect of the 50 Hz MF. Again, the crucial difference was obviously the real GSM exposure employed in our studies [15,16] being much more bioactive than the simulated invariable exposure by a generator employed in the Duan et al study [122].

4.3. The inherent variability of the real MT EMFs and its role in bioactivity

All types of modern microwave telecommunication EMFs such as MT, domestic cordless phones (DECT), wireless internet (Wi-Fi), combine RF fields (with frequency on the order of ~1 GHz) as the carrier signals, with ELF fields (0–3000 Hz) to modulate the carrier and for increasing the capacity of transmitted information by pulsing the signal. GSM EMFs, emitted by mobile phones and base antennas, except for their RF carrier signal, (900, 1800, 1900 MHz) include a pulse repetition frequency 217 Hz, plus other ELFs such as the multi-frame repetition frequency of 8.34 Hz. UMTS (3rd generation) mobile phones and base station antennas emit an RF carrier signal at 1900–2100 MHz, with two pulsing ELFs, at 100 Hz ("Time Division Duplex"), and 1500 Hz ("Adaptive Power Control"). During any conversation with either GSM or UMTS mobile phones, there are constant unpredictable changes related with the varying information transmitted each moment. Moreover there are continuous sudden unexpected changes in intensity, due to changes in location, number of subscribers using the network each moment, atmospheric conductivity changes, etc. which may exceed 100% of average intensity. Finally, for energy saving reasons, when GSM handsets operate in "listening" mode, the average emitted power is much less (about one tenth) than when they operate in "speaking" mode [32,41,100,142–145]. Thus, real digital microwave telecommunication EMFs change constantly and unpredictably, being impossible to simulate them by EMFs of fixed parameters.

Why exposure variability is so important for bioactivity? Living organisms have been constantly exposed throughout biological evolution to terrestrial static electric and magnetic fields of average intensities ~130 V/m and ~0.5 G respectively. While no adverse health effects are connected with normal exposure to these natural ambient fields, variations in their intensities on the order of ~20% during "magnetic storms" or "geomagnetic pulsations" due to changes in solar activity with an average periodicity of about 11 years are connected with increased rates of animal/human health incidents, including nervous and psychic diseases, hypertensive crises, heart attacks, cerebral accidents, and mortality [146,147].

Voltage-gated ion channels in all cell membranes switch between open and close state whenever a change exceeding ~30% in the membrane voltage takes place [139,148], and all physiological cellular effects are initiated by changes in ionic concentrations mediated by ion channel gating [139]. It is known that ~30 mV changes in the normal ~100 mV transmembrane voltage is able to gate voltage-gated ion channels in cell membranes [95–97,139,148].

Living organisms perceive EMFs as environmental stressors [93,100,146]. It is reasonable to assume that cells/organisms adapt more easily when EMFs are not significantly and unexpectedly varying, in other words when their parameters are kept constant or vary only slightly, or when the variation is predictable (as e.g. with the alternating 50 Hz MFs, or the PEF in the present study, or the simulated MT EMFs employed in many other studies). Since living organisms do not have defense against variations on the order of ~20% of natural EMFs as reported, it is realistic to expect that they do not have defense against EMFs, which vary unpredictably and at ~100% or even more from average intensity (and in addition are totally polarized, coherent, pulsed, modulated, including simultaneously several different frequencies, etc. as are the microwave EMFs employed in all modern telecommunications). Similarly, since cells respond to changes on the order of ~30% of the physiological membrane fields, it is realistic to expect that they will - irregularly - respond to changes in externally applied polarized EMFs of adequate intensity.

What is the difference between the natural EMFs in the terrestrial environment, the physiological EMFs of cell membranes, and the man-made EMFs employed in the studies? Terrestrial and cell membrane fields are static and significantly (almost totally) polarized. They normally do not vary considerably in their intensities, but variations on the order of 20–30% induce cellular/health effects. Man-made EMFs used in the studies are totally polarized, and at the same time (especially the microwave telecommunication EMFs) highly variable (alternating, pulsed) with unexpected changes exceeding 100% of their normal average intensities.

4.4. Conclusions

It comes that variability in the EMF exposure is an extremely important factor in order for the specific type of polarized EMF to be able to induce biological/health effects.

It seems that the bioactive parameters of EMFs are: 1) Polarization (combined with coherence), 2) ELFs, 3) Intensity, 4) Variability (unexpected changes exceeding 20–30 % of average/normal intensity). Once the EMF is polarized, includes ELFs, and has adequate intensity, the parameter that makes the difference is variability.

The extreme and unpredictable variability of the real-life MT signals that apparently seems to be the reason for the corresponding intense bioactivity, does not concern only the 2nd generation (GSM) MT signals tested in our experiments and in the present review, but all existing types of digital MT signals (2nd, 3rd, 4th generation), and all types of modern digital microwave telecommunication signals/EMFs (DECT phones, Wi-Fi routers, etc.), since they all operate under the same principles combining RF carrier signals with ELF pulsing and modulation of similar frequency bands, emitting variable information each moment which in turn makes the emission variable in intensity, frequency, waveform etc. In fact, with every new generation of telecommunication devices (e.g. 3rd, 4th, 5th generation mobile phones or base antennas) the amount of information transmitted each moment (speech, text, images, video, internet, etc.) is increased, resulting in higher variability and complexity of the signals with the living cells/organisms even more unable to adapt. The result of the recent study that found a real 3rd generation (UMTS) MT EMF to be more bioactive than real 2nd generation (GSM) MT EMF emitted by the same device [36] is in line with this fact.

Thus, the present study makes the point that once a specific EMF is polarized (and coherent), includes ELFs, and has adequate intensity, then variability in its parameters (especially in its intensity) is of decisive importance in terms of its bioactivity. In the present study this was shown, a) by the direct comparison between six different EMFs in terms of their ability to induce DNA fragmentation in my studies, b) by indirect comparison between the effects of real MT EMFs in my studies and simulated MT EMFs in other studies, both directly compared with corresponding effects of a 50 Hz alternating MF, and c) by the large difference in bioactivity between simulated MT signals with invariable parameters and real MT (highly variable) ones from a great number of reviewed studies. This important point in terms of biological activity and public health protection should be further confirmed experimentally by direct comparison of effects between simulated and real MT EMFs of the same average parameters.

The importance of exposure variability shown in the present study implies the need to define EMF-exposures not only by frequency components and average intensity values, but by reporting maximum and minimum intensity as well, frequency variations, pulsing or continuous wave, modulation, and - of course - polarization. Moreover, in published reviews of experimental studies employing MT and other types of microwave telecommunication EMFs such as DECT phones, Wi-Fi etc, it must be explicitly reported whether the exposures were real from commercially available devices or simulated from generators, test phones, etc.

The present study further confirms my previous results and conclusions that experiments should employ real-life and not simulated EMFs, and human/animal exposure to microwave telecommunication EMFs should be drastically reduced by prudent use, and establishment of much stringer exposure limits by the responsible health authorities.

Declarations of interest

None.

Appendix 1 List of frequently used Abbreviations in the text

CW: continuous wave
ELF: extremely low frequency (0–3000 Hz)
EMF: electromagnetic field
FC: follicle cell
G: Gauss (magnetic field unit)
g: germarium
GSM: Global System for Mobile telecommunications
MF: magnetic field
MT: mobile telephony
NC: nurse cell
OC: oocyte
PEF: pulsed electric field
RF: radio frequency
S: stages of oogenesis
SAR: Specific Absorption Rate
SD: Standard Deviation
TUNEL: Terminal deoxynucleotide transferase dUTP Nick End Labeling
UMTS: Universal Mobile Telecommunication System

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Perspective

Disturbing Honeybees' Behavior with Electromagnetic Waves: a Methodology

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Abstract

Mobile phone companies and policy makers point to studies with contradictory results and usually claim that there is a lack of scientific proof of adverse effects of electromagnetic fields on animals. The present perspective article describes an experiment on bees, which clearly shows the adverse effects of electromagnetic fields on these insects' behavior. The experiment should be reproduced by other researchers so that the danger of manmade electromagnetism (for bees, nature and thus humans) ultimately appears evident to anyone.

INTRODUCTION

A pollinator crisis, especially concerning the honeybees, has been occurring during these last two to three decades [1]. Several causes have been proposed to explain the worldwide disappearance of the honeybees: the varroa mite, viral and bacterial infections, single-crop farming, pesticides, mobile apiaries, too severe winters, or genetically modified plants. There is no doubt that all these factors are harmful for the bees.

On the other hand, several reviews deal with the ecological effects of radiofrequency electromagnetic fields (RF-EMF), e.g. [2]. There are reasonable grounds for admiting that RF-EMF severely impacts the nature, the health of all living organisms (plants, insects, birds, mammals, ...) [3], honeybees included [4]. The latter hymenoptera fly often far from their hive, and rather high. Doing so, they approach RF-EMF of high intensities (due to the presence of masts), are impacted by the electromagnetism, and can no longer find their way. Indeed, it is known that honeybees possess magnetite crystals in their fat body cells and that they present magnetic remanence; these magnetite structures are active parts of the magnetoreception system in honeybees. Indeed, the presence of a mobile phone handsets in a hive has a dramatic impact on the bees' behavior: it induces the worker piping signal (a sound produced by the wings of the honeybees). Worker piping either announces the swarming process of the bee colony or signifies that the colony is perturbed [5]; this signal in a bee colony is not frequent, and when it occurs in a colony that is not in a swarming process, no more than two bees are simultaneously active.

Little attention, if any, has been given to the potential harmful effects of electromagnetic waves on nature in general and above all on honeybees. Therefore, a simple and affordable method for studying in more details the effects of RF-EMF on honeybees in the apiary was set up. It consisted in locally collecting and amplifying the ambient RF-EMF and in focusing this amplified signal on individual hives, with well established, commercially available techniques (Figure 1a & 1b) and using intensities approved by international regulations [6]. The bees' behavior then observed was the sound the workers emitted under radiation. The technique being clearly detailed in the present perspective paper, other researchers are invited to reproduce the experiment for confirming (or infirming) the effects of EMF on bees' behavior. Note that bees (as well as birds) fly and are thus susceptible to be exposed to EMF of rather high intensities.

MATERIALS AND METHODS

Bees' produced sounds

An acoustical method based on sound analysis for classification was used for precising the change of behavior triggered by the amplified RF-EMF on the honeybee *Apis mellifera carnica*. This method is essentially described in [5]. Briefly, the recording device consisted of a bidirectional compact microphone (Olympus ME-31) with frequency response from 70 Hz to 14000 Hz connected to a vocal recorder (Olympus LS-11). The recorded signals were digitized as a Waveform audio file format sound file with 160 kilobits per second (kbps) and 44 kHz sampling. The computer programs Audacity© (open-source software at SourceForge.net) and FFT Properties 5.0 (Dew Research LLC, SLO-3210 Slovenske

Konjice, Slovenia) were employed for the manual analysis of the sound files and for the generation of the audiograms (also called sonograms), spectrograms (oscillograms) and frequency spectra, or for the generation of the orbital phase (which is a visualization of the signal strength during a given period; Δt = 2 min for the latter two analyses), respectively. Note that, apart the sound analysis, other behavioral studies can be performed, as reviewed in [7,8].

The EMF exposure

The ambient RF-EMF spectrum was collected with a receiving antenna. This signal was filtered to remove all the frequencies below 800 MHz. The filtered GSM (Global System for Mobile communications) roaming signal was then adequately amplifed and was finally re-emitted onto the external back side of the hive containing honeybees. Other frequencies could easily be chosen using this experimental setup, for example: the Wireless Fidelity (WiFi), the Digital Enhanced Cordless Telecommunications (DECT), the Universal Mobile Telecommunications System (UMTS), the Digital Code Squelch (DCS), or the Terrestrial Trunked Radio (TETRA).

The receiving HF59B antenna (range 800 MHz to 3000 MHz), the emitting HF38B antenna (range 800 MHz to 3000 MHz), the high-pass filter HP800 G3 (to suppress the frequencies lower than 800 MHz), the RF-preamplifiers HV10_27G3 or HF30_27G3 (to increase the intensity of the signal by a factor of 10 or 30 dB, respectively) and the selective frequency filter FF6E were obtained from Gigahertz Solutions (D-90579 Langenzenn, Germany). The UHF-Bias Tee diplexer MKU BT 270 was obtained from Kuhne Electronic GmbH (D-95119 Berg, Germany). The SMA adapters (31 SMA-50-0-1 ; 32 SMA-50-0-1), the 10-meters-long WLAN cable (SMA ST-SMA 76110), the 0.25-meter-long cable (SMA 0-1337808-1) and the 12 Volts/25Ah lead accumulator (A512/25.0 G5) were obtained from Distrelec (CH-8606 Nänikon, Switzerland).

The ambient RF-EMF and the re-emitted RF-EMF signal described above were measured using a high frequency analyser HF59B (Gigahertz Solutions).

RESULTS

The intensities of the ambient RF-EMF ranged from 0.05 to 0.15 μW/m^2 (below 0.01 V/m) before amplification. The GSM-filtered and amplified RF-EMF had a value in the 80-100 μW/m^2 (0.17 to 0.19 V/m) range directly in the front of the emitting antenna and around 1 to 2.5 μW/m^2 (0.02 to 0.03 V/m) in the front side of the hive. These intensities are found in ambient environments [6]. Animals, including honeybees, are expected to be exposed to such or even higher intensities in the apiary, and above all while flying near masts.

Sound analysis in the beehive revealed that the bees initially remained calm for about 45 min after the onset of the amplified RF-EMF, but started to produce sounds that were higher in both frequency and amplitude about one hour after the onset of this amplification (Figure 1c). This observation is confirmed by the comparison of the frequency spectra of quiet and disturbed honeybees: the 110 Hz frequency peak was present with the former but missing in the latter (Figure 1d). A shift to higher frequencies was also observed (from 370 Hz to 405 Hz). The intensity of the sound in the hive was also higher for disturbed honeybees, as compared to quiet honeybees (Figure 1e; see also the y-axis in the frequency spectra in Figure 1d). This so-called worker piping signal (a behavioral signal) is naturally produced by disturbed honeybees (not shown; see [5] for details). Similar data were obtained with the other four experiments (not shown).

DISCUSSION AND CONCLUSION

The experimental design proposed in the present perspective article was set up in order to enable beekeepers and researchers in the field to easily reproduce the experiments with the use of conventional materials and userfriendly computer programs.

The present data strongly suggest that honeybee colonies are affected and disturbed by electromagnetic waves (RF-EMF). Few experiments (n = 5) using the experimental setup were performed; ethical questions arose after I was attacked by furious honeybees when a second experiment was performed at a week interval on the same hive. This honeybees' behavior might reflect the emotional nature of the worker honeybee: according to Lipinsky [9], a rich collection of symptoms of bee emotional agitation similar to that in "higher animals" and in man can be observed, such as specific postures, moves (runs), excitations of the Vegetative Nervous System (VNS), specific pheromone release, stereotypies (dances), freezing behavior, clustering, specific sounds release, engorgement with honey, and warm ups (a non-visible physiological symptom). Bees under different emotional agitation produce different sounds: hissings (3000 Hz), pipings (300 - 600 Hz), quackings (1000 Hz), tootings (1200 Hz) squeakings (300 Hz) etc.

Other parameters can be analyzed, such as the queen prolificacy (the egg laying rate of the queen), the brood area (comprising eggs, larvae and sealed brood), the bee strength (the total number of bee frames per colony), the honey stores (the area containing sealed and unsealed nectar), the pollen stores (the portion of comb containing cells filled with stored pollen), and the flight activity (the number of worker bees leaving the hive entrance per minute before, during and after exposure to RF-EMF). In order to perform robust statistical analyses, researchers in the field should follow published and established guidelines [10] for obtaining a valid number of experiments.

Bee colonies living in hives acting as Faraday cages (what should drastically reduce the delivered amplified electromagnetic waves) might be protected from these exogenous electromagnetic waves and might consequently not present that induced sounds production. Experiments are under way to test this hypothesis. Negative controls, apart the Faraday hive, could also be performed using the so-called Swiss Shield® NATURELL™ cotton fibre spun with a gossamer-thin 0.02 mm silvered copper thread, allowing effective shielding from electromagnetic radiation.

Public discussion focuses on the influence of electromagnetic

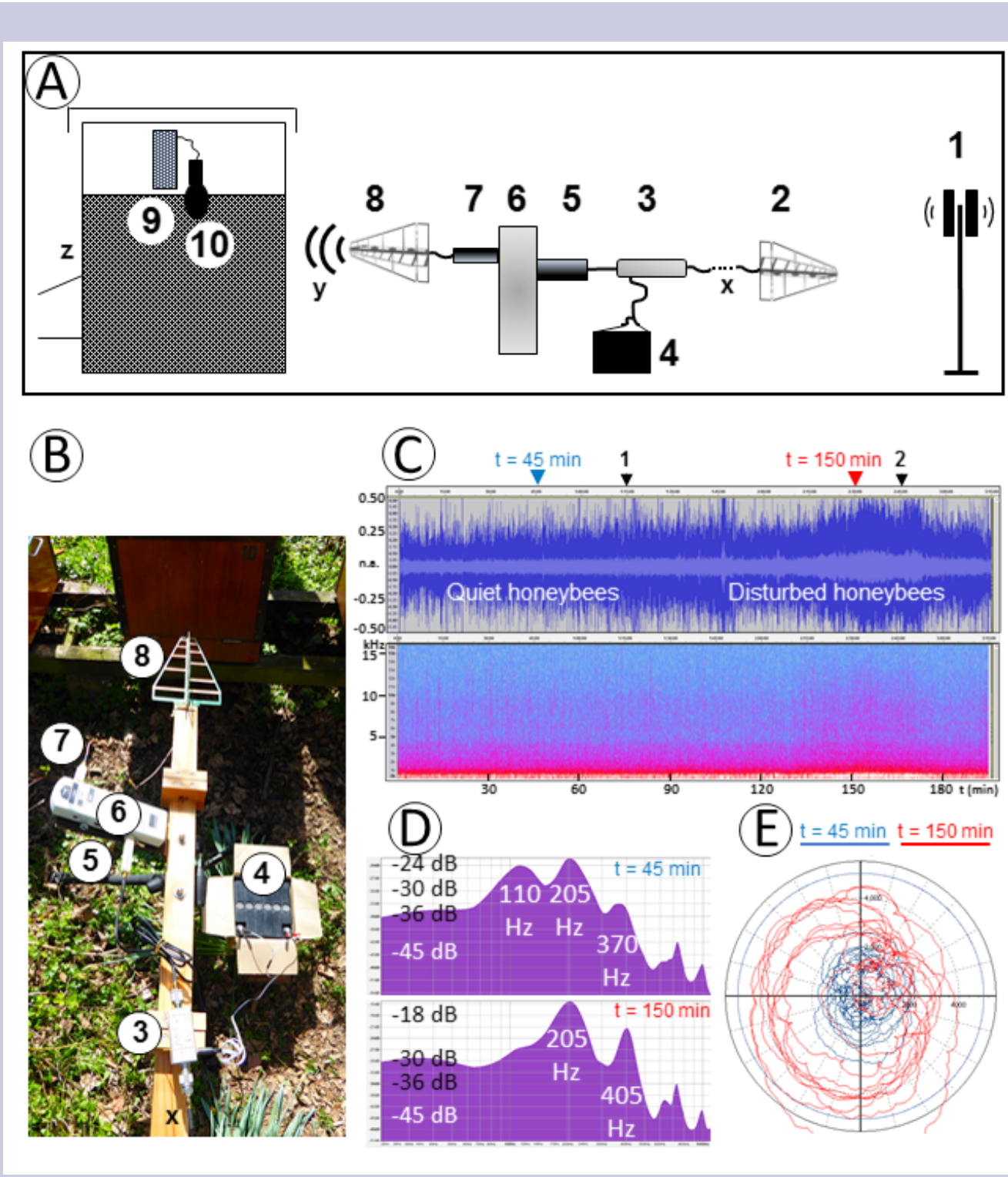

Figure 1. (**A**) Schematic drawing of the apparatus set in the field close to the hive. *1* Mast antenna in the near geographical area. *2* Receiving antenna. *3* UHF-Bias Tee diplexer. *4* Battery. *5* High-pass filter. *6* Selective frequency filter. *7* RF-preamplifier. *8* Emitting antenna. *9* Sound recorder. *10* Microphone. **x** denotes the 10-m-long SMA cable. **y** denotes a 3 to 4-cm distance between the antenna and the hive. **z** denotes the front side of the hive, about 60 cm away from the emitting antenna *8*. (**B**) Apparatuses in the field. (**C**) Audiogram (top; normalized: -0.5 to +0.5) and spectrogram (reported in kiloHertz (kHz)) of hive sounds. Time (t) is indicated in minutes. **1** and **2**: beginning and end of the RF-EMF emission, respectively. Blue and red triangles: sound samples lasting 2 min for analyses. (**D**) Frequency spectra (decibels, dB). (**E**) Orbital phase analysis of honeybees' sounds. For details, see text.

fields on the natural environment [11,12]. Mobile phone companies and policy makers point to studies with contradictory results and usually claim that there is a lack of scientific proof for negative effects of electromagnetic fields on animals and plants. The procedure presented in this work will allow its implementation, under scientific expertise. It should be used by several researchers. It could even be used for showing the effects of EMF on a wide range of living organisms. For the honeybees, a different experimental approach [reported in 13] might also be employed in parallel by a large number of beekeepers and researchers on the potential effects of manmade electromagnetism.

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DISCLOSURE

The author declares having no conflicts of interest.

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ii) Golden ratio (Sectio Aurea) in the Elliptical Honeycomb (J Nat Sci (JNSCI), 2(1):e173, 2016)

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ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

Public Consultation Template - ICNIRP Draft RF Guidelines, Appendix A, Appendix B

Comments to be uploaded until 9.10.2018

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Thank you for participating in the public consultation of the ICNIRP draft guidelines.

Please note that it is important that ICNIRP understands exactly the points that you are making. To facilitate our task and avoid misunderstandings, please:

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	Document (Guidelines, App A, App B)	Line Number #	Type of comment (General/ Technical/ Editorial)	Comment. Proposed change. Context.
1	Guidelines	1-1006	General	ICNIRP has explicitly addressed the issue of non-ionizing radiation (NIR) environmental effects at a workshop in 1999 (see https://www.icnirp.org/en/publications/article/emf-living-environment-2000.html), but has not yet incorporated potential effects on the environment in any of its Guidelines. Since the ICNIRP « provides scientific advice and guidance on the health and environmental effects of non-ionizing radiation (NIR) to protect people **and the environment** from detrimental NIR exposure », these **effects on wildlife** (on both vertebrates and invertebrates) should now be incorporated in the forthcoming Guidelines. The effects on invertebrates and insects in general, and on honeybees in particular, should be especially empasized. The honeybee, as a « sentinel of the environment », is an organism perfectly suited for the analysis of the effects of the NIR. EVALUATION OF THE GUIDELINES For the discussion of the EMF, RF and ELF tresholds, the scientific articles mentioned in the EMF-Portal website https://www.emf-portal.org/en/topics/profile/COM should be taken into consideration, with particularly : • 2018, Koh WJ, Moochhala SM Non-ionizing EMF hazard in the 21th century. IEEE International Symposium on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility (EMC/APEMC), 2018.: 518-522 • 2018, Rubtsova N, Paltsev Y, Perov S, Bogacheva E Intensity-time dependence dosing criterion in the EMF exposure guidelines in Russia. Electromagn Biol Med 37 (1): 43-49 • 2018, Tell RA, Tell CA Perspectives on setting limits for RF contact currents: a commentary. Biomed Eng Online 17 (1): 2 • 2017, Foster KR, Ziskin MC, Balzano Q Thermal Modeling for the Next Generation of Radiofrequency Exposure Limits: Commentary. Health Phys 113 (1): 41-53 • 2017, Bisceglia B, Valbonesi S Electromagnetic fields: Scientific basis of regulatory frameworks. IEEE International Applied Computational Electromagnetics Society Symposium - Italy (ACES), 2017. • 2016, Morega M, Calota VC From directive 2013/35/EU to national legislation: Transposition, implementation and assessment work. IEEE International Conference on Applied and Theoretical Electricity (ICATE), 2016.

The scientific article entitled « EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses", from Belyaev, I. et al., is providing EMF Guideline in an "overview of the current knowledge regarding EMF-related health risks and provides recommendations for the diagnosis, treatment and accessibility measures of EHS to improve and restore individual health outcomes as well as for the development of strategies for prevention."
https://www.degruyter.com/downloadpdf/j/reveh.2016.31.issue-3/reveh-2016-0011/reveh-2016-0011.pdf
The precautionary guidance values given in this article should be considered not only for humans, but also for other vertebrates and invertebrates. These values are provided in the following Tables 3 and 6 :

Table 3: Precautionary guidance values for radio-frequency radiation.

RF source Max Peak/ Peak Hold	Daytime exposure	Nighttime exposure	Sensitive populations[1)]
Radio broadcast (FM)	10,000 µW/m²	1000 µW/m²	100 µW/m²
TETRA	1000 µW/m²	100 µW/m²	10 µW/m²
DVBT	1000 µW/m²	100 µW/m²	10 µW/m²
GSM (2G) 900/1800 MHz	100 µW/m²	10 µW/m²	1 µW/m²
DECT (cordless phone)	100 µW/m²	10 µW/m²	1 µW/m²
UMTS (3G)	100 µW/m²	10 µW/m²	1 µW/m²
LTE (4G)	100 µW/m²	10 µW/m²	1 µW/m²
GPRS (2.5G) with PTCCH* (8.33 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²
DAB+ (10.4 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²
Wi-Fi 2.4/5.6 GHz (10 Hz pulsing)	10 µW/m²	1 µW/m²	0.1 µW/m²

*PTCCH, packet timing advance control channel.

Based on: BioInitiative (9, 10); Kundi and Hutter (260); Leitfaden Senderbau (221); PACE (42); Seletun Statement (40). [1)]Precautionary approach by a factor of 3 (field strength)= a factor of 10 (power density). See also IARC 2013 (24) and Margaritis et al. (267).

Precautionary guidance values

In areas where people spend extended periods of time (>4 h per day), minimize exposure to VLF electric fields to levels as low as possible or below the precautionary guidance values specified below.

Table 6: Precautionary guidance values for VLF electric fields.

VLF electric field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	0.1 V/m[1)]	0.01 V/m[1)]	0.003 V/m[2)]

Based on: [1)]The current density induced in the human body increases with increasing frequency in an approximately linear relationship (266). Therefore, the guidance value of the electric field in the VLF frequency range should be lower than the one of the 50/60 Hz electric field, e.g. for 10 V/m/100 = 0.1 V/m. For the rationale of 10 V/m and 1 V/m, see section ELF electric fields. [2)]Precautionary approach by a factor of 3 (field strength). See also TCO Development (265).

The precautionary guidance values for the 5G technology should also be incorporated in the Guidelines.

The “definition of biological harmful interference” proposed by the EMR Policy Institute in its September, 2013, Comment to the FCC should also be considered ; see :
http://www.electronicsilentspring.com/definition-biological-harmful-interference/
where the definition of the harmful interference can be found, i.e. :
“Harmful interference includes acute, chronic or prolonged exposure to RF signals and emissions that endanger, degrade, obstruct or repeatedly interrupt biological functioning of a person, plant, animal or ecosystem, or that result in adverse health effects or malfunctioning of medical devices or equipment.
Biological harmful interference shall be defined as any negative change in a measurable biological, physiological or ecological parameter (outside the range within which it is regulated in normal circumstances with no exposure to the influence in question).
Examples of parameters that demonstrate biological effects caused by exposure to magnetic fields or RF fields include:
a. the EEG spindle frequency during sleep (reproducible within a person, not necessarily across a population);
b. the brain metabolic rate based on brain scans of glucose metabolism;
c. the rate of DNA breakage in healthy cells;

				d. disruption of the rate of calcium efflux through a cell's membrane; e. melatonin production and metabolism; f. insulin production and metabolism; g. heart rate and blood pressure variability; h. temperature. (Note that a temporary temperature change of 0.2 degrees Fahrenheit shall be considered a biological effect, because a healthy body normally regulates temperature within a range smaller than this.) Examples of parameters that demonstrate harmful biological effects caused by magnetic and/or RF fields exposed to the environment include: i. the mortality rate of plants or animals; j. the incidence of deformed offspring of plants or animals; k. altered growth or morphology in plants or animals; l. behavioral changes (such as nesting, increased piping signaling of bees or altered feeding habits by any animal)." It's « Comments to the EMR policy Institute » can be found here : http://emrpolicy.org/regulation/united_states/index.htm EFFECTS ON WILDLIFE IN GENERAL The following scientific articles and references, among others, should be considered : Cucurachi, S et al. A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF). Environment International 51 :116-140, 2013. https://www.sciencedirect.com/science/article/pii/S0160412012002334?via%3Dihub Abstract : Objective: This article presents a systematic review of published scientific studies on the potential ecological effects of radiofrequency electromagnetic fields (RF-EMF) in the range of 10 MHz to 3.6 GHz (from amplitude modulation, AM, to lower band microwave, MW, EMF). Methods: Publications in English were searched in ISI Web of Knowledge and Scholar Google with no restriction on publication date. Five species groups were identified: birds, insects, other vertebrates, other organisms, and plants. Not only clear ecological articles, such as field studies, were taken into consideration, but also biological articles on laboratory studies investigating the effects of RF-EMF with biological endpoints such as fertility, reproduction, behaviour and development, which have a clear ecological significance, were also included. Results: Information was collected from 113 studies from original peer-reviewed publications or from relevant existing reviews. A limited amount of ecological field studies was identified. The majority of the studies were conducted in a laboratory setting on birds (embryos or eggs), small rodents and plants. In 65% of the studies, ecological effects of RF-EMF (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. No clear dose–effect relationship could be discerned. Studies finding an effect applied higher durations of exposure and focused more on the GSM frequency ranges.

				Conclusions: In about two third of the reviewed studies ecological effects of RF-EMF was reported at high as well as at low dosages. The very low dosages are compatible with real field situations, and could be found under environmental conditions. However, a lack of standardisation and a limited number of observations limit the possibility of generalising results from an organism to an ecosystem level.We propose in future studies to conduct more repetitions of observations and explicitly use the available standards for reporting RF-EMF relevant physical parameters in both laboratory and field studies. Balmori, A. Electrosmog and species conservation. Science of The Total Environment 496:314-316, 2014. https://doi.org/10.1016/j.scitotenv.2014.07.061 Abstract. Despite the widespread use of wireless telephone networks around the world, authorities and researchers have paid little attention to the potential harmful effects of mobile phone radiation on wildlife. This paper briefly reviews the available scientific information on this topic and recommends further studies and specific lines of research to confirm or refute the experimental results to date. Controls must be introduced and technology rendered safe for the environment, particularly, threatened species. Leach, V. et al. A novel database of bio-effects from non-ionizing radiation. Rev Environ Health. 2018 Jun 6. pii: /j/reveh.ahead-of-print/reveh-2018-0017/reveh-2018-0017.xml. doi: 10.1515/reveh-2018-0017. https://www.degruyter.com/view/j/reveh.ahead-of-print/reveh-2018-0017/reveh-2018-0017.xml Abstract. A significant amount of electromagnetic field/electromagnetic radiation (EMF/EMR) research is available that examines biological and disease associated endpoints. The quantity, variety and changing parameters in the available research can be challenging when undertaking a literature review, meta-analysis, preparing a study design, building reference lists or comparing findings between relevant scientific papers. The Oceania Radiofrequency Scientific Advisory Association (ORSAA) has created a comprehensive, non-biased, multi-categorized, searchable database of papers on non-ionizing EMF/EMR to help address these challenges. It is regularly added to, freely accessible online and designed to allow data to be easily retrieved, sorted and analyzed. This paper demonstrates the content and search flexibility of the ORSAA database. Demonstration searches are presented by Effect/No Effect; frequency-band/s; in vitro; in vivo; biological effects; study type; and funding source. As of the 15th September 2017, the clear majority of 2653 papers captured in the database examine outcomes in the 300 MHz-3 GHz range. There are 3 times more biological "Effect" than "No Effect" papers; nearly a third of papers provide no funding statement; industry-funded studies more often than not find "No Effect", while institutional funding commonly reveal "Effects". Country of origin where the study is conducted/funded also appears to have a dramatic influence on the likely result outcome. See also : https://n432.fmphost.com/fmi/webd#Research_Review_V4 Pall, M.L. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev Environ Health. 2015;30(2):99-116. doi: 10.1515/reveh-2015-0001. https://www.degruyter.com/downloadpdf/j/reveh.2015.30.issue-2/reveh-2015-0001/reveh-2015-0001.pdf

				Abstract. This review considers a paradigm shift on microwave electromagnetic field (EMF) action from only thermal effects to action via voltage-gated calcium channel (VGCC) activation. Microwave/lower frequency EMFs were shown in two dozen studies to act via VGCC activation because all effects studied were blocked by calcium channel blockers. This mode of action was further supported by hundreds of studies showing microwave changes in calcium fluxes and intracellular calcium [Ca2+]i signaling. The biophysical properties of VGCCs/similar channels make them particularly sensitive to low intensity, non-thermal EMF exposures. Non-thermal studies have shown that in most cases pulsed fields are more active than are non-pulsed fields and that exposures within certain intensity windows have much large biological effects than do either lower or higher intensity exposures; these are both consistent with a VGCC role but inconsistent with only a heating/thermal role. Downstream effects of VGCC activation include calcium signaling, elevated nitric oxide (NO), NO signaling, peroxynitrite, free radical formation, and oxidative stress. Downstream effects explain repeatedly reported biological responses to non-thermal exposures: oxidative stress; single and double strand breaks in cellular DNA; cancer; male and female infertility; lowered melatonin/sleep disruption; cardiac changes including tachycardia, arrhythmia, and sudden cardiac death; diverse neuropsychiatric effects including depression; and therapeutic effects. Non-VGCC non-thermal mechanisms may occur, but none have been shown to have effects in mammals. Biologically relevant safety standards can be developed through studies of cell lines/cell cultures with high levels of different VGCCs, measuring their responses to different EMF exposures. The 2014 Canadian Report by a panel of experts only recognizes thermal effects regarding safety standards for non-ionizing radiation exposures. Its position is therefore contradicted by each of the observations above. The Report is assessed here in several ways including through Karl Popper's assessment of strength of evidence. Popper argues that the strongest type of evidence is evidence that falsifies a theory; second strongest is a test of "risky prediction"; the weakest confirms a prediction that the theory could be correct but in no way rules out alternative theories. All of the evidence supporting the Report's conclusion that only thermal effects need be considered are of the weakest type, confirming prediction but not ruling out alternatives. In contrast, there are thousands of studies apparently falsifying their position. The Report argues that there are no biophysically viable mechanisms for non-thermal effects (shown to be false, see above). It claims that there are many "inconsistencies" in the literature causing them to throw out large numbers of studies; however, the one area where it apparently documents this claim, that of genotoxicity, shows no inconsistencies; rather it shows that various cell types, fields and end points produce different responses, as should be expected. The Report claims that cataract formation is produced by thermal effects but ignores studies falsifying this claim and also studies showing [Ca2+]i and VGCC roles. It is time for a paradigm shift away from only thermal effects toward VGCC activation and consequent downstream effects. Not only the so-called " voltage-gated calcium channel (VGCC) activation" mentioned above should be considered, but also the effects of NIR on the so-called cryptochromes, see : http://oscillatorium.com/sitebuildercontent/sitebuilderfiles/emfcryptochrome112216.pdf https://ecfsapi.fcc.gov/file/7520958012.pdf A list of scientific references dealing with the environmental aspects of NIR can be found here : https://fr.scribd.com/document/63829925/Is-Electrosmog-hurting-our-wildlife-149-references The recent book from Arthur Firstenberg, entitled "The invisible rainbow – a history of electricity and life", should also be taken into consideration :

				http://www.cellphonetaskforce.org/buy-the-invisible-rainbow/ The book entitled "The Electronic Silent Spring: Facing the Dangers and Creating Safe Limits", from Katie Singer, should also be taken into consideration, see : http://www.electronicsilentspring.com/about/ EFFECTS ON HONEYBEES IN PARTICULAR The following scientific article should be taken into consideration : Favre D. Mobile phone-induced honeybee worker piping. Apidologie 42:270–279, 2011. https://link.springer.com/article/10.1007%2Fs13592-011-0016-x Abstract : The worldwide maintenance of the honeybee has major ecological, economic, and political implications. In the present study, electromagnetic waves originating from mobile phones were tested for potential effects on honeybee behavior. Mobile phone handsets were placed in the close vicinity of honeybees. The sound made by the bees was recorded and analyzed. The audiograms and spectrograms revealed that active mobile phone handsets have a dramatic impact on the behavior of the bees, namely by inducing the worker piping signal. In natural conditions, worker piping either announces the swarming process of the bee colony or is a signal of a disturbed bee colony. The early warnings from Barrie Trower should be considered : https://ecfsapi.fcc.gov/file/7520941855.pdf The arguments of the h.e.s.e. project (The international scientific Internet platform on topical issues) should also be taken into consideration : http://bemri.org/hese-uk/en/issues/nature3e83.html?id=bees
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À l'Organisation des Nations Unies, à l'OMS, à l'Union européenne, au Conseil de l'Europe et aux gouvernements de tous les pays,

Nous soussignés, médecins, scientifiques, membres d'organisations environnementales et citoyens de (x) pays, demandons urgemment l'arrêt du déploiement du réseau sans fil de 5G (cinquième génération) y compris depuis les satellites spatiaux. En effet, la 5G entraînera une augmentation considérable de l'exposition au rayonnement de radiofréquence, qui s'ajoutera au rayonnement induit par les réseaux de télécommunications 2G, 3G et 4G déjà en place. Or on a déjà la preuve des effets nocifs du rayonnement de radiofréquence pour les êtres humains et l'environnement. Le déploiement de la 5G revient à mener des expériences sur les êtres humains et l'environnement, ce qui est considéré comme un crime en vertu du droit international.

Sommaire

Les entreprises de télécommunications à l'échelle mondiale sont bien résolues, avec l'appui des gouvernements, à déployer dans les deux prochaines années, le réseau sans fil de cinquième génération (5G). Cette décision produira ce qui est considéré comme un changement sociétal sans précédent à l'échelle mondiale. Nous aurons ainsi des maisons « intelligentes », des entreprises « intelligentes », des autoroutes « intelligentes », des villes « intelligentes » et des voitures autonomes. Pratiquement tout ce que nous achetons et possédons, depuis les réfrigérateurs et les machines à laver jusqu'aux cartons de lait, en passant par les brosses à cheveux et les couches pour bébés, contiendra des antennes et des micropuces et sera connecté sans fil à l'Internet. Toute personne sur terre aura accès instantanément à des communications sans fil à très haut débit et à faible latence, et ce dans les coins les plus reculés de la planète, jusque dans les forêts pluviales, au milieu de l'océan et dans l'antarctique.

Ce que la plupart des gens ignorent, c'est que cette nouvelle réalité entraînera aussi un changement *environnemental* sans précédent à l'échelle planétaire. Il est impossible d'imaginer la densité prévue des émetteurs de radiofréquences. Outre les millions de nouvelles stations de base terrestres 5G qui seront installées et les 20 000 nouveaux satellites qui seront lancés dans l'espace, 200 milliards d'objets émetteurs, selon nos estimations, feront partie de l'internet des objets d'ici 2020, et un *billion* d'objets quelques années plus tard. Il y a eu un déploiement commercial de la 5G à basse fréquence et à faible débit au Qatar, en Finlande et en Estonie mi-2018. Quant au déploiement de la 5G à très hautes fréquences (ondes millimétriques), il devrait commencer dès la fin 2018.

Malgré un déni généralisé, nous disposons déjà de preuves accablantes indiquant que le rayonnement des radiofréquences (RF) est nuisible à la vie. Les données cliniques accumulées sur

des personnes malades ou ayant des troubles de santé, les preuves expérimentales de dommages à l'ADN, aux cellules et aux organes d'une grande variété de végétaux et d'animaux et les données épidémiologiques qui prouvent que les grandes maladies de la civilisation moderne – le cancer, les maladies du cœur et le diabète – sont en grande partie provoquées par la pollution électromagnétique, constituent un corpus de plus de 10 000 études publiées dans des revues dotées de comités de lecture.

Si les plans de l'industrie des télécommunications pour la 5G se concrétisent, pas un être humain, pas un mammifère, pas un oiseau, pas un insecte et pas un brin d'herbe sur terre, quel que soit le lieu de la planète où il se trouve, ne pourra se soustraire à une exposition, 24 heures sur 24 et 365 jours par an, à des niveaux de rayonnement de radiofréquence qui sont des dizaines voire des centaines de fois supérieurs à ceux que l'on connaît aujourd'hui. Toutes les issues de secours seront barrées. Ces plans pour la 5G risquent d'avoir des effets graves et irréversibles sur les êtres humains et de causer des dommages permanents à tous les écosystèmes terrestres.

Des mesures immédiates doivent être prises pour protéger l'humanité et l'environnement, conformément aux impératifs éthiques et aux conventions internationales.

(N. B. : Les références sont indiquées sous la forme de
liens hypertextes et de notes en fin de texte.)

Le déploiement de la 5G entraînera une augmentation massive de l'exposition involontaire et incontournable au rayonnement du sans-fil

Stations de base terrestres de la 5G

De façon à transmettre les énormes quantités de données nécessaires pour l'internet des objets, la technologie 5G, une fois pleinement déployée, utilisera des ondes millimétriques, qui ne traversent pas aisément la matière solide. Il faudra donc que les entreprises de télécommunications installent des stations de base tous les 100 mètres[1] dans toutes les zones urbaines du monde entier. À la différence de la technologie sans fil des générations précédentes où une seule antenne diffuse des ondes sur une superficie importante, les stations de base de la 5G et les équipements connexes seront dotés d'antennes à balayage électronique actif[2,3] qui, ensemble, émettront des faisceaux d'ondes électromagnétiques focalisés, orientables, analogues aux faisceaux laser qui se chevauchent entre eux.

Chaque téléphone 5G renfermera des dizaines d'antennes minuscules, qui ensemble, essaieront de capter un faisceau étroitement focalisé auprès du pylône le plus proche. La US Federal Communications Commission (FCC) a adopté des règles[4] autorisant que la puissance effective de ces faisceaux atteigne 20 watts, soit dix fois de plus que les niveaux autorisés pour les téléphones actuels.

Chaque station de base de la 5G renfermera des centaines voire des milliers d'antennes pointant simultanément de multiples faisceaux d'ondes électromagnétiques, analogues aux faisceaux laser, vers tous les téléphones mobiles et les autres appareils de son aire de service. Cette technologie est dite à « entrées et à sorties multiples » ou MIMO. Selon les règles de la FCC,

la puissance rayonnée effective des faisceaux d'une station de base de la 5G pourrait atteindre 30 000 watts pour 100 MHz du spectre, ce qui équivaut à 300 000 watts par GHz de spectre, c'est-à-dire des niveaux de puissance des dizaines voire des centaines de fois supérieurs aux niveaux autorisés pour les stations de base actuelles.

Stations de base spatiales de la 5G

Au moins cinq entreprises[5] proposent d'offrir la 5G depuis l'espace, à partir de 20 000 satellites regroupés en basse et moyenne orbite qui couvriront la terre de puissants faisceaux d'ondes électromagnétiques focalisés et orientables (balayage électronique actif). Chaque satellite émettra des ondes millimétriques ayant une puissance effective de rayonnement pouvant atteindre 5 millions de watts[6] depuis des milliers d'antennes disposées en réseaux à commandes de phase (permettant un balayage électronique). Même si l'énergie qui frappe le sol à partir des satellites est moins puissante que celle transmise par les antennes terrestres, elle touchera des régions qui échappent au balayage d'autres émetteurs et s'ajoutera au rayonnement induit par les milliards d'objets connectés grâce aux antennes relais de la 5G basées au sol. Mais qui plus est, les satellites stationneront dans la magnétosphère de la Terre, qui exerce une influence importante sur les propriétés électriques de l'atmosphère.
L'altération de l'environnement électromagnétique de la Terre pourrait bien représenter une menace encore plus grande pour la vie que le rayonnement des antennes basées au sol (voir ci-après).

On a déjà la preuve des effets nocifs du rayonnement de radiofréquence

Avant même que la 5G soit envisagée, des dizaines de pétitions et d'appels [7] émanant de scientifiques de différents pays, dont l'Appel de Fribourg signé par plus de 3 000 médecins, avaient demandé l'arrêt de l'expansion de la technologie sans fil et l'adoption d'un moratoire pour toute nouvelle station de base[8].

En 2015, 215 scientifiques de 41 pays ont fait part de leurs préoccupations aux Nations Unies et à l'Organisation mondiale de la santé (OMS) [9], en faisant valoir que de « nombreuses publications récentes ont montré que les [champs électromagnétiques] CEM affectent les organismes vivants à des niveaux bien inférieurs à ceux que préconisent la plupart des lignes directrices internationales et nationales ». Plus de 10 000 études scientifiques publiées dans des revues dotées de comités de lecture montrent les dommages du rayonnement de radiofréquence causés à la santé humaine[10,11]. Ces effets prennent diverses formes, notamment :

- Palpitations cardiaques[12]
- Altération de l'expression génique[14]
- Altération du métabolisme[16]
- Altération du développement des cellules souche[18]
- Cancers[20]
- Maladies cardiovasculaires [22]
- Déficience cognitive[24]
- Lésions de l'ADN[26]
- Incidence sur le bien-être général[13]
- Multiplication du nombre de radicaux libres[15]
- Difficultés d'apprentissage et pertes de mémoire[17]
- Infertilité et altération de la qualité du sperme[19]
- Fausse couche[21]
- Dommages neurologiques[23]
- Obésité et diabète[25]
- Stress oxydant[27]

Parmi les effets sur les enfants, mentionnons l'autisme[28], le trouble d'hyperactivité avec déficit de l'attention (THADA)[29,30] et l'asthme[31].

Les dommages vont bien au-delà de ceux causés à la race humaine, comme en témoignent quantité de preuves de dommages causés à divers végétaux et à la faune[32,33] , de même qu'aux animaux de laboratoire, notamment :

- Les fourmis[34]
- Les oiseaux[36,37]
- Les forêts[39]
- Les grenouilles[42]
- Les mouches à fruits[44]
- Les abeilles[46]
- Les insectes[35]
- Les mammifères[38]
- Les souris[40,41]
- Les végétaux[43]
- Les rats[45]
- Les arbres[47]

Des effets microbiologiques néfastes[48] ont également été constatés.

Le Centre international de Recherche sur le Cancer de l'OMS a conclu en 2011 que le rayonnement de radiofréquence, dans la gamme de fréquence de 30 kHz à 300 GHz, était peut-être cancérigène pour l'homme (Groupe 2B)[49] .Toutefois, selon des preuves récentes, y compris les dernières études sur l'utilisation du téléphone mobile et les risques de cancer du cerveau, il est avéré que le rayonnement de radiofréquence est cancérigène pour les humains[50] et devrait être classé en tant que « cancérigène du Groupe 1 », au même titre que la fumée du tabac et l'amiante.

La plupart des signaux sans fil actuels sont modulés par impulsion. Les dommages sont causés à la fois par l'onde porteuse modulée par la haute fréquence et par les pulsations basse fréquence [51].

Le déploiement des satellites de la 5G doit être interdit

La Terre, l'ionosphère et la basse atmosphère instaurent ensemble le circuit électrique planétaire[52] dans lequel nous vivons. Il est bien établi que les rythmes biologiques – des êtres humains,[53,54] des oiseaux,[55] des hamsters,[56] et des araignées[57,58] – sont contrôlés par l'environnement électromagnétique naturel de la Terre et que le bien-être de tous les organismes dépend de la stabilité de cet environnement, notamment des propriétés électriques de l'atmosphère.[59,60,61,62] Cherry, dans un article qui fait date[63], a expliqué l'importance des résonances Schumann[64] et la raison pour laquelle les perturbations ionosphériques peuvent altérer la tension artérielle et la mélatonine et provoquer « le cancer, des pathologies du système reproductif, des cardiopathologies, des maladies neurologiques et la mort ».

Ces éléments de notre environnement électromagnétique ont déjà été altérés par le rayonnement des lignes de transport d'électricité. Le rayonnement des harmoniques[65] provenant des lignes électriques atteint l'ionosphère et la magnétosphère de la Terre, où il est amplifié par l'interaction onde-corpuscule[66,67]. En 1985, Robert O. Becker (PhD) a lancé un avertissement disant que le rayonnement des harmoniques des lignes électriques avait déjà modifié la structure de la magnétosphère et que l'expansion continue de cet effet « constitue une menace pour la viabilité de toute la vie sur Terre »[68]. Le positionnement de dizaines de milliers de satellites

directement à la fois dans l'ionosphère et la magnétosphère, émettant des signaux modulés à des millions de watts et à des millions de fréquences risque bien d'altérer notre environnement électromagnétique à un degré dépassant de beaucoup notre capacité d'adaptation[69].

Des suivis officieux de la situation actuelle ont déjà fourni des preuves indiquant de graves effets sur les êtres humains et les mammifères d'environ 100 satellites qui assurent le service des téléphones 2G et 3G depuis 1998, en basse orbite. Or, de tels effets ne sauraient s'expliquer si l'on considère exclusivement les faibles niveaux de rayonnement au sol. Les connaissances issues d'autres disciplines scientifiques pertinentes doivent être prises en compte, y compris les domaines de la physique atmosphérique et de l'acuponcture[70,71,72,73]. Si l'on ajoute 20 000 satellites 5G, on polluera encore plus le circuit électrique planétaire[74,75] et l'on pourrait altérer les résonances de Schumann[76] avec lesquelles toute la vie sur Terre a évolué. Les effets seront universels et pourraient être profondément délétères.

La 5G est différente de la 4G, tant sur le plan qualitatif que quantitatif

L'idée que nous pouvons tolérer de dix à cent fois plus de rayonnement à des longueurs d'ondes millimétriques se fonde sur une modélisation erronée du corps humain considéré comme s'il s'agissait d'une coquille remplie d'un liquide homogène[77,78]. L'hypothèse selon laquelle les ondes millimétriques ne traversent pas la barrière cutanée fait totalement abstraction des nerfs[79], des vaisseaux sanguins[80,81] et d'autres structures conductrices d'électricité qui peuvent transporter les courants induits par le rayonnement profondément dans le corps[82,83,84]. Une autre erreur qui pourrait être plus grave encore veut que les antennes à balayage électronique actif soient des antennes ordinaires. Or il n'en est rien. Lorsqu'un champ électromagnétique ordinaire pénètre dans le corps, il déplace des charges et induit la circulation de courants. Mais lorsque des impulsions électromagnétiques extrêmement courtes pénètrent dans le corps, un autre phénomène se produit : les charges mobiles elles-mêmes deviennent de petites antennes qui rerayonnent le champ électromagnétique plus profondément dans le corps. Ces ondes sont appelées précurseurs de Brillouin[85]. Elles deviennent importantes lorsque soit la puissance ou la phase des ondes change suffisamment rapidement[86]. La 5G remplira probablement ces deux critères.

En outre, la pénétration profonde en soi se révèle plus particulièrement dangereuse pour les yeux et pour les organes du corps les plus gros, la peau, de même que pour les créatures très petites. Des études ont récemment été publiées dans des revues dotées de comités de lecture, prédisant des brûlures cutanées par énergie thermique[87] chez les êtres humains par le rayonnement 5G et une absorption de la résonance par les insectes[88] qui absorbent jusqu'à 100 fois plus de rayonnement à des ondes millimétriques qu'ils ne le font aux longueurs d'ondes actuellement en usage. Étant donné que les populations d'insectes volants ont décliné de 75 à 80 p. 100 depuis 1989, même dans les zones naturelles protégées[89], le rayonnement de la 5G pourrait avoir des effets catastrophiques sur les populations d'insectes à travers le monde. Une étude menée en 1986 par Om Gandhi prévenait que les ondes millimétriques sont fortement absorbées par la cornée oculaire et que les vêtements ordinaires, dont l'épaisseur est de l'ordre du millimètre, augmentent l'absorption de l'énergie par la peau par un effet de type résonance[90]. Russell (2018) se penche sur les effets connus des ondes millimétriques sur la peau, les yeux (y compris la cataracte) le rythme cardiaque, le système immunitaire et l'ADN.

Les organismes de réglementation ont délibérément exclu les preuves scientifiques d'effets nocifs

L'industrie et les gouvernements sont les seules parties prenantes au débat sur le développement de la 5G, tandis que les scientifiques spécialistes des champs électromagnétiques internationaux de renom qui ont documenté les effets biologiques sur les êtres humains, les mammifères, les insectes et les végétaux, ainsi que les effets alarmants sur la santé et l'environnement dans des milliers d'études publiées dans des revues dotées de comités de lecture ont été exclus. La raison qui explique le caractère inadéquat des lignes directrices actuelles applicables à la sécurité est que les conflits d'intérêt des organismes chargés d'établir les normes « en raison de leurs relations avec les compagnies de télécommunication ou d'électricité empêchent de parvenir à l'impartialité qui devrait régir l'établissement des normes d'exposition publique au rayonnement non ionisant »[91]. Le professeur émérite Martin L. Pall décrit de manière détaillée les conflits d'intérêt, et il dresse la liste des études importantes qui ont été exclues, aux chapitres 1, 5 et 6 de son examen de la littérature[92].

L'hypothèse du réchauffement est obsolète – de nouvelles règles de sécurité s'imposent

Les lignes directrices actuelles régissant la sécurité s'appuient sur l'hypothèse obsolète que le réchauffement est le seul effet préjudiciable des champs électromagnétiques. Mais comme Markov et Grigoriev l'ont affirmé, « Les normes actuelles ne prennent pas en compte la pollution réelle de l'environnement par le rayonnement non ionisant »[93].Des centaines de scientifiques, dont de nombreux signataires de l'appel, ont prouvé que de nombreux types différents de maladies graves ou chroniques ou de lésions sont provoqués sans chaleur (« effet non thermique ») par des niveaux de rayonnement bien inférieurs à ceux prescrits par les lignes directrices internationales[9]. Des effets biologiques surviennent même à des niveaux de puissance pratiquement nuls. On a observé que parmi les effets à 0,02 picowatt (billionnième de watt) par centimètre carré ou moins, on retrouvait une structure génétique altérée dans E. coli[94] et chez les rats,[95] un EEG altéré chez les êtres humains[96] , une stimulation de la croissance chez les plants de haricots,[97] et une stimulation de l'ovulation chez les poulets[98].

Pour assurer une protection contre les effets non thermiques, il faut prendre en compte la durée d'exposition. Or, la 5G exposera tout le monde à beaucoup plus de transmissions simultanément et continuellement, jour et nuit sans interruption. De nouvelles normes de sécurité s'imposent donc, lesquelles devraient être fondées sur *l'exposition cumulative* et, *non seulement sur les niveaux de puissance cumulative,* mais également sur la fréquence, la largeur de bande, la modulation, la forme d'onde, la largeur de l'impulsion et d'autres propriétés qui sont importantes sur le plan biologique. Les antennes doivent être installées exclusivement à des endroits bien précis et connus du public. Pour protéger les êtres humains, les antennes doivent être installées loin des quartiers d'habitation et des lieux de travail de la population et interdites dans les voies publiques ou autres où les gens se déplacent. Pour protéger la faune, leur installation doit être interdite dans les parcs ou autres sanctuaires de la vie sauvage et leur nombre strictement réduit dans les endroits reculés de la Terre. Pour protéger toutes les formes de vie, le nombre de satellites de communications commerciales doit être limité et leur installation interdite en basse et moyenne orbite. Tout balayage électronique actif doit être interdit sur Terre et dans l'espace.

Le rayonnement de radiofréquence a des effets aigus et chroniques

Le rayonnement de radiofréquence a des effets immédiats et à long terme. Le cancer et les cardiopathies sont des exemples d'effets à long terme. La perturbation du rythme cardiaque[99] et des changements dans le fonctionnement du cerveau (EEG)[100] sont des exemples d'effets immédiats. Un syndrome qui s'appelait maladie des ondes radioélectriques[101] dans l'ex-Union soviétique et désormais intitulé électrohypersensibilité (EHS) dans le monde d'aujourd'hui[102] a fait son apparition, lequel peut être aigu ou chronique. Le professeur Karl Hecht a publié un historique détaillé de ces syndromes, compilé à partir de la revue de plus de 1 500 articles scientifiques russes et l'histoire clinique de plus de 1 000 de ses propres patients en Allemagne. Parmi les constatations objectives, mentionnons des troubles du sommeil, une tension artérielle anormale et des palpitations cardiaques, des troubles digestifs, la perte des cheveux, des acouphènes et des éruptions cutanées. Les symptômes subjectifs incluent les vertiges, la nausée, les maux de tête, la perte de mémoire, l'incapacité de se concentrer, la fatigue, des symptômes de rhumes et des douleurs cardiaques [103].

Les Lignes directrices 2016 de l'EUROPAEM CEM énoncent que l'électrohypersensibilité se développe car de plus en plus de personnes sont « continuellement exposées au quotidien » à des niveaux croissants de CEM. Il faudrait se focaliser « sur la réduction ou la prévention des expositions aux CEM » pour restaurer la santé de ces patients[104]. L'électrohypersensibilité ne devrait plus par conséquent être considérée comme une maladie, mais comme un dommage causé par un environnement toxique qui touche une proportion de plus en plus importante de la population, estimée déjà à 100 millions de personnes dans le monde[105,106], et qui pourrait bientôt toucher tout le monde[107] si le déploiement de la 5G à travers le monde est autorisé.

La Déclaration scientifique internationale sur l'électrohypersensibilité et la sensibilité aux produits chimiques multiples (PCM), 2015, Bruxelles, indique que « *l'inaction a un coût pour la société et n'est plus une option désormais* [...] nous déclarons que cette situation représente un danger sérieux pour la santé publique et [exigeons d'urgence] que *les mesures* majeures *de prévention primaire soient adoptées et priorisées, dans la perspective de cette pandémie mondiale* » (c'est nous qui soulignons)[108].

Les gouvernements nationaux manquent à leur obligation de diligence à l'égard des populations qu'ils gouvernent

Dans leur hâte à mettre en œuvre la 5G et encourager l'utilisation sans contraintes de l'espace, l'Union européenne, les États-Unis et les gouvernements nationaux à l'échelle mondiale prennent des mesures pour assurer un environnement réglementaire « libre d'obstacles »[109]. Aussi interdisent-ils aux autorités locales d'appliquer les lois environnementales [110], et, « dans l'intérêt d'un déploiement rapide et rentable », ils suppriment « les fardeaux inutiles … comme les procédures de planification locales [et] toute la gamme des valeurs limites particulières applicables aux émissions des champs électromagnétiques et des méthodes requises pour les regrouper »[111].

Par ailleurs, les gouvernements promulguent des lois pour une utilisation autorisée des installations sans fil dans toutes les emprises publiques[112]. À ce jour, la plupart des installations sans fil ont été situées sur des terrains privés à une certaine distance des habitations et des

entreprises. Or, comme la 5G requiert que ces équipements soient installés à moins de 100 mètres d'intervalle, ils seront maintenant situés sur le trottoir directement devant les maisons et les entreprises et près des têtes des piétons, sans exception pour les mères et leurs bébés.

Les obligations d'avis public et d'audiences publiques sont supprimées. Même s'il y a une audience et que 100 experts scientifiques présentent un témoignage contre la 5G, des lois ont été adoptées rendant illégal pour les autorités locales de prendre en considération leur témoignage. La loi américaine, par exemple, interdit aux municipalités de réglementer la technologie sans fil « sur la base des effets environnementaux du rayonnement de radiofréquences »[113], et les tribunaux ont renversé des décisions réglementaires concernant l'emplacement des stations de base pour la simple raison que la plupart des témoignages publics concernaient la santé[114]. Les assureurs n'offriront aucune protection contre les risques des CEM[115], et il n'y a aucune clarté quant à savoir qui seront les responsables devant la loi de dommages à la vie, aux membres ou aux biens découlant de l'exposition à la 5G, que les stations soient terrestres ou situées dans l'espace[116].

En l'absence d'un régime juridique exhaustif convenu régissant les activités dans l'espace extra-atmosphérique, la responsabilité légale de ces activités est inexistante, et ce malgré les risques qui s'ensuivent pour des continents entiers, l'atmosphère et les océans.

Des ententes internationales sont violées

Enfants et devoir de diligence

Selon la Convention relative aux droits de l'enfant des Nations Unies, « Les États parties s'engagent à assurer à l'enfant la protection et les soins nécessaires à son bien-être » (art. 3), « assurent dans toute la mesure possible la survie et le développement de l'enfant » (art. 6) et « à lutter contre la maladie et la malnutrition **[…]** compte tenu des dangers et des risques de pollution du milieu naturel » (art. 24 c)).

Le Code de Nuremberg (1949) s'applique aux expériences sur les êtres humains, ce qui inclut par conséquent le déploiement de la 5G lequel introduit un niveau d'exposition plus élevé et inédit au rayonnement de radiofréquence, dont l'innocuité n'a pas fait l'objet de test au préalable. Or, « le consentement volontaire du sujet humain est absolument essentiel » (art. 1). L'exposition à la 5G sera involontaire. « L'expérience ne doit pas être tentée lorsqu'il y a une raison a priori de croire qu'elle entraînera la mort ou l'invalidité du sujet » (art. 5). Les conclusions de plus de 10 000 études scientifiques et la voix de centaines d'organisations internationales représentant des centaines de milliers de membres ayant subi des dommages invalidants et ayant été déplacées de leurs foyers par les installations de communications sans fil déjà en place, sont « des raisons a priori de croire que la mort ou l'invalidité » pourraient survenir.

Obligation d'informer et champs électromagnétiques

L'Assemblée mondiale de normalisation des télécommunications (2012) de l'Union internationale des télécommunications indique qu'« il est nécessaire d'informer le public des effets que pourrait avoir l'exposition aux champs électromagnétiques » et invite les États membres « à adopter des mesures appropriées pour garantir le respect des recommandations internationales pertinentes visant à protéger la santé contre les effets néfastes des champs électromagnétiques ».

Dans la résolution de 2008 de l'Évaluation à mi-parcours du plan d'action européen en matière d'environnement et de santé 2004-2010 , « le Parlement européen [...] constate que les limites d'exposition aux champs électromagnétiques fixées pour le public sont obsolètes, [...] que ces limites ne tiennent évidemment pas compte de l'évolution des technologies de l'information et de la communication ni, d'ailleurs des recommandations préconisées par l'Agence européenne pour l'environnement ou encore des normes d'émission plus exigeantes prises, par exemple, par la Belgique, l'Italie ou l'Autriche et qu'elles ne tiennent pas compte de groupes vulnérables comme les femmes enceintes, les nouveau-nés et les enfants; »

D'après la Résolution 1815 (Conseil de l'Europe 2011), il faut « Prendre toutes les mesures raisonnables pour réduire l'exposition aux champs électromagnétiques, notamment aux radiofréquences émises par les téléphones portables, et tout particulièrement l'exposition des enfants et des jeunes [...] ».

Environnement

La Déclaration de Stockholm de la Conférence des Nations Unies sur l'environnement (1972) énonce que « Les rejets de matières toxiques ou d'autres matières [...] en des quantités ou sous des concentrations telles que l'environnement ne puisse en neutraliser les effets doivent être interrompus de façon à éviter que les écosystèmes ne subissent des dommages graves ou irréversibles » (principe 6).

La Charte mondiale de la nature (1982) préconise que « les activités qui risquent de causer des dommages irréversibles à la nature seront évitées [...] [et lorsque les effets nuisibles éventuels de ces activités ne sont qu'imparfaitement connus, ces dernières ne devraient pas entreprises » (art. 11).

D'après la Déclaration de Rio sur l'environnement et le développement (1992), « Les États ont [...] le devoir de faire en sorte que les activités exercées dans les limites de leur juridiction ou sous leur contrôle ne causent pas de dommages à l'environnement dans d'autres États ou dans les zones ne relevant d'aucune juridiction nationale. » (principe 2).

Le Rapport du Sommet mondial pour le développement durable (2002) des Nations Unies fait état du besoin urgent de « Lancer des initiatives internationales [...] pour trouver des solutions politiques nationales et régionales plus efficaces aux risques que fait peser l'environnement sur la santé [par. 54 k)].

La Convention africaine sur la conservation de la nature et des ressources naturelles (2017) recommande que « Les Parties [...] prennent toutes les mesures appropriées pour prévenir, atténuer et éliminer, le plus possible, les effets nuisibles sur l'environnement, notamment ceux causés par les substances radioactives, toxiques et autres substances et déchets dangereux. » (art. 13).

Santé et droits de l'homme

La Déclaration universelle des droits de l'homme énonce que « Tout individu a droit à la vie, à la liberté et à la sûreté de sa personne **»** (art. 3).

La Stratégie mondiale pour la santé de la femme, de l'enfant et de l'adolescent (2016-2030) des Nations Unies a pour objectifs et pour mots d'ordre « transformer », c'est-à-dire étendre les environnements favorables; « survivre », c'est-à-dire réduire la mortalité maternelle et néonatale; et « s'épanouir », c'est-à-dire assurer la santé et le bien-être et réduire les décès et les pathologies liés à la pollution.

L'espace

Selon les Traités et principes des Nations Unies relatifs à l'espace extra-atmosphérique (1967), les activités prenant place dans l'espace extra-atmosphérique doivent être menées « de manière à éviter les effets préjudiciables de leur contamination ainsi que les modifications nocives du milieu terrestre » (art. IX).

Les Lignes directrices aux fins de la viabilité à long terme des activités spatiales (2018) indiquent que « Les États et les organisations internationales intergouvernementales devraient [...] tenir compte, dans la mesure du possible, des risques, pour les personnes, les biens, la santé publique et l'environnement, associés au lancement, à l'exploitation en orbite et au retour des objets spatiaux » [ligne directrice 2.2 *c*)].

Les gouvernements nationaux jouent avec la vie sur Terre

La phrase célèbre d'Albert Einstein affirmait que « dieu ne joue pas aux dés »[117]. Pourtant, en poursuivant le déploiement de la radiodiffusion d'ondes millimétriques de 5G sur Terre et à partir de l'espace, alors que cette technologie inédite n'a été utilisée auparavant que sous la forme d'armes à énergie dirigée dans le cadre d'opérations militaires et de dispersion des rassemblements[118], les gouvernements nationaux jouent aux dés de manière inconsidérée avec l'avenir de la vie sur la Terre.

Or, le refus de prendre en compte et d'appliquer des connaissances scientifiques pertinentes valables ne saurait se justifier sur le plan éthique. Les travaux de recherche actuels montrent que la 5G – et plus particulièrement à partir de stations de base spatiales – contrevient aux principes consacrés dans une foule de conventions internationales.

Nous exhortons l'ONU, l'OMS, l'Union européenne, le Conseil de l'Europe et les gouvernements de tous les pays,

(a) *À prendre* des mesures immédiates pour arrêter le déploiement de la 5G sur la Terre et dans l'espace de façon à protéger tous les êtres humains, et plus particulièrement les embryons, les bébés, les adolescents et les femmes enceintes, de même que l'environnement;

(b) *À respecter* la Convention relative aux droits de l'enfant et la résolution 1815 du Conseil de l'Europe en informant les citoyens, notamment les enseignants et les médecins concernant les risques sanitaires (pour les adultes et les enfants) du rayonnement de radiofréquence, ainsi que des raisons et de la façon dont ils peuvent éviter la communication sans fil et les stations de base, en particulier à proximité des crèches ou des garderies, des écoles des hôpitaux, des habitations et des lieux de travail;

(c) *À préférer et à mettre en œuvre* des télécommunications câblées à la place du sans-fil;

(d) *À empêcher* les entreprises du domaine du sans-fil ou des télécommunications par l'intermédiaire de leurs lobbyistes d'amener les responsables à prendre des décisions autorisant la poursuite de l'expansion du rayonnement de radiofréquence, notamment le déploiement de la 5G à partir de stations terrestres et spatiales;

(e) *À nommer immédiatement* – en dehors de toute influence de l'industrie – des groupes internationaux de scientifiques indépendants, véritablement impartiaux, spécialistes des CEM et de la santé, exempts de conflits d'intérêts[119], dans le but d'établir de nouvelles normes de sécurité internationales applicables au rayonnement de radiofréquence, qui ne soient pas fondées uniquement sur les niveaux de puissance, qui prennent en compte les effets cumulatifs de l'exposition et qui protègent contre tous les effets sanitaires et environnementaux, plutôt que seulement sur les effets thermiques et seulement sur les effets touchant les êtres humains;

(f) *À nommer immédiatement* – en dehors de toute influence de l'industrie – des groupes internationaux de scientifiques ayant une expertise dans le domaine des CEM, de la santé, de la biologie et de la physique atmosphérique, dans le but d'élaborer un cadre réglementaire exhaustif propre à garantir que l'espace extra-atmosphérique est sûr pour les êtres humains et l'environnement, et prenant en compte le rayonnement de radiofréquence, les gaz d'échappement des fusées, la suie noire ainsi que les débris dans l'espace et leurs conséquences pour l'ozone,[120] le réchauffement global,[121] l'atmosphère el la sauvegarde de la vie sur la Terre. Non seulement la technologie basée à terre, mais aussi la technologie spatiale doit être viable[122] pour les adultes, les enfants, les animaux et les végétaux.

Veuillez répondre à l'administrateur de l'appel dont le nom est indiqué ci-dessous,

précisant les mesures que vous avez l'intention de prendre pour protéger la population mondiale de l'exposition au rayonnement de radiofréquence, en particulier la 5G. Cet appel ainsi que votre réponse seront rendus public sur le site www.5GSpaceAppeal.org

Respectueusement,

***Arthur Firstenberg,* administrateur de l'appel**, info@5gSpaceAppeal.org

et les premiers signataires:

AFRIQUE

***Lauraine Margaret Helen Vivian*,** Doctorat en anthropologie et psychiatrie ; Adjointe de recherche honoraire à la Faculté de médecine et des sciences de la santé de l´Université de Copenhague, Danemark. Signataire pour l´**Afrique du Sud**.

ASIE

***Girish Kumar*,** Doctorat en génie électrique de l´Institut indien de technologie de Kampur et professeur à l´Institut de technologie de Mumbai (Bombay), **Inde.**

AUSTRALIE

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Alfonso Balmori, Licence et maîtrise en éducation de l´environnement, Biologiste. Valladolid, **Espagne**.

Klaus Buchner, Dr. ès sciences, Professeur, député européen, ONG *Kompetenzinitiative* (ONG pour la protection de l´humanité, l´environnement et la démocratie) de Munich, **Allemagne.**

Daniel Favre, Doctorat en biologie, Président de l´Association Romande Alerte aux Ondes Électromagnétiques (ARA), **Suisse.**

Annie Sasco, Médecin (deux maîtrises et un doctorat en santé publique et en épidémiologie). Ancien chef du service de la recherche de l´unité d´épidémiologie pour la prévention du cancer du Centre international de recherche sur le cancer (CIRC, Lyon) ; ancien chef intérimaire du programme de lutte contre le cancer de l´Organisation mondiale de la santé (OMS); ancien directeur de recherche de l´Institut National de la Santé et de la Recherche Médicale (INSERM), **France.**

AMÉRIQUE DU NORD

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AMÉRIQUE DU SUD

Carlos Sosa, Médecin, Université d´Antioquia, Medellín, **Colombie.**

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[113] Mobile services, 47 U.S.C. § 332(c)(7)(B)(iv). Lien URL (anglais seulement): « Aucun État ou gouvernement local ou organe de celui-ci ne peut réglementer les installations de services personnels sans fil sur la base des effets environnementaux des émissions de radiofréquences dans la mesure où ces installations sont conformes à la réglementation de la FCC concernant ces émissions. » Les tribunaux ont annulé la réglementation sur les décisions concernant le placement des antennes simplement parce que la plupart des témoignages publics portaient sur la santé ».

[114] *Cellular Telephone Company v. Town of Oyster Bay*, 166 F.3d 490, 495 (2nd Cir. 1999). Lien URL (anglais seulement). Consulté le 10 juin 2018.; T-Mobile Northeast LLC v. Loudoun County Bd. of Sup'rs, 903 F.Supp.2d 385, 407 (E.D.Va. 2012). Lien URL (anglais seulement). Consulté le 10 juin 2018.

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[116] *Swiss Re: SONAR - New emerging risk insights.* Juillet 2014, p. 22. Lien URL (anglais seulement). Consulté le 10 juin 2018. « Un niveau croissant d'interconnectivité et la prévalence croissante des systèmes de pilotage et de rétroaction numériques génèrent également de nouvelles vulnérabilités. Celles-ci pourraient entraîner des effets en cascade avec dommages multiples ainsi que des interruptions durables si les problèmes s'avéraient complexes et / ou difficiles à réparer. L'interconnectivité et la génération permanente de données suscitent des inquiétudes quant à la confidentialité des données. L'exposition aux champs électromagnétiques peut également augmenter ».

[117] Albert Einstein, lettre à Max Born, 4 déc. 1926.

[118] *Active Denial Technology. Non-Lethal Weapons Program*. Lien URL (anglais seulement). Publié le 11 mai 2016. Consulté le 10 juin 2018.

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Agenda item 3
Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development

Written statement* submitted by Planetary Association for Clean Energy, Inc., The, a non-governmental organization in special consultative status

The Secretary-General has received the following written statement which is circulated in accordance with Economic and Social Council resolution 1996/31.

[11 February 2019]

* Issued as received, in the language(s) of submission only.

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5G is cruel, inhuman and degrading treatment under resolution 39/46

In 1954, the tobacco industry founded the precursor to what is known today as the Council for Tobacco Research. This organization financed hundreds of so-called independent researchers, who published several thousand peer-reviewed studies the goal of which, as we now know, was to create controversy and doubt about a causal link between smoking and a wide array of grave illnesses. [1]

They used arguments which claimed to be "scientific" although industry insiders knew as early as 1950 that their product was dangerous. In 1969, an internal note from a subsidiary of a leading tobacco firm stated, "Doubt is our product". [1]

These techniques are still extensively used today by telecommunications companies. The parallels with the tobacco industry are striking although the tactics subsequently improved with relentless lobbying. [2]

However, this is where the comparison between the tobacco and telecommunications industries stops. Electromagnetic radiation (EMR) has no smell and you cannot see it. It is everywhere, you cannot escape it, thus the consequences of biased science combined with the impalpable nature of EMR are far more insidious and far-reaching. [3]

Dr. Richard Horton, Editor of *The Lancet*, after a symposium held in April 2015 on the *Reproducibility and Reliability of Medical Research*, wrote as follows: "A lot of what is published is incorrect [...] The case against science is straightforward: much of the scientific literature, perhaps half, may simply be untrue. Afflicted by studies with small sample sizes, tiny effects, invalid exploratory analyses, and flagrant conflicts of interest [...] science has taken a turn towards darkness." [4]

Among others, Professor Emeritus Henry Lai, a leading bioengineer at the University of Washington who produced groundbreaking work on the effects of low-level radiation on DNA, faced full-scale efforts to discredit his work when he published it in 1995. [5]

In an internal company memo leaked to a scientific publication, Motorola described its plan to "war-game" and undermine his research. [5]

After accepting industry funding for continued research from the Wireless Technology Research (WTR) programme, Professor Lai wrote an open letter to *Microwave News* questioning restrictions placed on his research by the funders. [5]

The head of WTR then asked University of Washington president Richard McCormick to fire Professor Lai, which he refused to do. [5]

Professor Lai says that without government funding, most scientific research is funded by private industry and "you don't bite the hand that feeds you. The pressure is very impressive." [5]

In 2006, faced with contradictory research, Professor Lai did an analysis of 326 studies on cell phone radiation conducted between 1990 and 2006, and where their funding came from. [5]

He found that 56 per cent of the 326 studies showed a biological effect from radio-frequency radiation and 44 per cent did not. But when he looked at their funding, he discovered that 73 per cent of independently-funded studies found an effect, as opposed to only 27 per cent of industry-funded studies. [5]

Despite what is being portrayed in the mainstream, wireless radiation has biological effects and this is not a subject for debate. [6]

This was already established more than 60 years ago when the United States of America Department of Defense tested the impact of EMR on animals and human beings under a variety of conditions. [7]

These biological effects are seen in all life forms—plants, animals, insects and microbes. [8]

There are more than 10,000 peer-reviewed studies pertaining to the health impacts of EMR and substantial evidence for the cumulative nature and eventual irreversibility of some effects, whether neurological/neuropsychiatric, reproductive, cardiac, mutations in DNA, or hormonal effects. Some may affect the evolution of the human race. [9]

In humans, there is clear evidence that EMR is causing not only cancer but a wide array of debilitating ailments including cognitive impairment, learning and memory deficits, neurological damage, miscarriage, impaired sperm function and quality, obesity, diabetes, tinnitus, impacts on general well-being, alteration of heart rhythm, and cardiovascular diseases. At the cellular level EMR causes alterations in metabolism and stem cell development, gene and protein expression, increased free radicals, oxidative stress and DNA damage. [9]

Effects in children are important and include some of the above plus autism, attention deficit hyperactivity disorder (ADHD) and asthma. [9]

EMR has immediate effects on certain aspects of biology. These may be expressed faster in people already suffering from electrosensitivity (ES) and electrohypersentivivity (EHS). Although these are not medical terms, they refer to up to 13% of people globally who have happened to discover what is making them sick in spite of the disbelief of others. Many such people cannot work, are homeless, or have committed suicide because they had nowhere to hide from the radiation. [10]

The impact of wireless telecommunication technologies on humans and their environment was never tested before each and every new generation was globally deployed. Average adults and their children have been used as experimental guinea pigs without ever being informed or asked for their consent. On the contrary, the public has been actively misled. [11]

Economic interests have prevailed over the precautionary principle and precautionary approaches.[12]

There is no opt-out. With the advent of 5G, everyone is indiscriminately irradiated in ever-increasing doses. [13]

Those responsible for keeping this industry in check, including the World Health Organisation, US Federal Communications Commission and other national and international bodies have not ever been forthcoming about the dangers of radio-frequency radiation. Instead they have protected the industry’s interests, with total disregard of known health impacts. [14]

Working groups focused on health impacts of EMR at the International Commission on Non-Ionising Radiation Protection (ICNIRP), the Scientific Committee on Emerging and Newly Identified Health Risks, the Institute of Electrical and Electronics Engineers, the International Electrotechnical Commission and the International Telecommunication Union, for example, are notoriously plagued by conflicts of interests and/or directly working with the industry. [15]

Despite the unequivocal consequences, the media are still actively misleading the public. [16]

All the elements of a scientific experiment gone wrong are present, along with a profit and liability motive for a cover-up. Economic interests now worth over 3.4 trillion USD in assets have prevailed over public health. [17]

To deploy 5G, not only will the density of antennas be increased by at least a factor of 5 on average, but the current ICNIRP radiation limits will have to be increased by 30 to 40% in order to make its deployment technologically feasible. [18]

This won't be enough to ensure total 5G coverage, so thousands of low earth orbit (LEO) satellites will beam the signal from above. This implies radiation impacts not only on our health but also on the earth’s atmosphere. LEOs will be emitting modulated signals at millions of watts of effective power straight into the atmosphere, whose nature is inherently electrical. [19]

5G networks will exist alongside previous generations of wireless technology, but unlike them, will pulse millimetre waves from phased-array antennas at levels of EMR tens to hundreds of times greater than those existing today. The idea that the human body can tolerate 5G radiation is based on the faulty assumption that shallow absorption by the skin is harmless. [20]

When an ordinary electromagnetic field enters the body, it causes charges to move and currents to flow. But when extremely short electromagnetic pulses enter the body, the moving charges themselves become little antennas that re-radiate the electromagnetic field and send it deeper into the body. They become more significant when either the power or the phase of the waves changes rapidly, and 5G will likely satisfy both criteria. [21]

Shallow penetration of millimetre waves also poses a unique danger to the eyes and skin, as well as to very small creatures. Peer-reviewed studies recently published predict thermal skin burns in humans from 5G and resonant absorption by insects, which absorb much more radiation at millimetre wavelengths than they do at wavelengths presently in use. [22]

Since populations of flying insects have declined by 75-80 per cent since 1989, which also coincides with early deployments of cellular networks, 5G radiation could have catastrophic effects worldwide. [23]

PACE believes that 5G, together with previous generations of wireless technology, is an experiment on humanity that constitutes cruel, inhuman and degrading treatment under General Assembly resolution 39/46 of 10 December 1984. [24]

The deployment of 5G violates over 15 international agreements, treaties and recommendations, including article 7 of the International Covenant on Civil and Political Rights, which derives from the Nuremberg Code of 1947. [25]

It also violates the Declaration of Helsinki of 1964 and its several revisions, as well as other international guidelines that have been translated into national laws in various countries. [26]

For references, please see: www.guineapigsappeal.org/un/references.pdf

5G is cruel, inhuman and degrading treatment under resolution 39/46

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The Nüremberg Code applies to all experiments on humans, thus including the deployment of 5G with new, higher RF radiation exposure that has not been pre-market tested for safety. “The voluntary consent of the human subject is absolutely essential” (art. 1). Exposure to 5G will be involuntary. “No experiment should be conducted, where there is an a priori reason to believe that death or disabling injury will occur” (art. 5).

The findings of over 10,000 scientific studies and the voices of hundreds of international organizations representing hundreds of thousands of members who have suffered disabling injury and been displaced from their homes by already-existing wireless telecommunications facilities, are "a priori reasons to believe that death or disabling injury will occur". Also, we are light years away from "Informed consent".

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Additional international agreements, treaties , guidelines and recommendations being violated:

1. The Universal Declaration of Human Rights (1948).

"Everyone has the right to life, liberty and security of person" (art. 3).

"No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment" (art. 5).

https://www.ohchr.org/EN/UDHR/Documents/UDHR_Translations/eng.pdf

2. European Convention for the Protection of Human Rights and Fundamental Freedoms of November 4th 1950.

Everyone's right to life shall be protected by law (art 2.1).

No one shall be subjected to torture or to inhuman or degrading treatment or punishment (art. 3).

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3. European Social Charter of October 18th 1961.

Part I The Contracting Parties accept as the aim of their policy, to be pursued by all appropriate means, both national and international in character, the attainment of conditions in which the following rights and principles may be effectively realized:

3. All workers have the right to safe and healthy working conditions.

7. Children and young persons have the right to a special protection against the physical and moral hazards.

8. Employed women, in case of maternity, and other employed women as appropriate, have the right to a special protection in their work.

11. Everyone has the right to benefit from any measures enabling him to enjoy the highest possible standard of health attainable.

Article 7 – The right of children and young persons to protection.

With a view to ensuring the effective exercise of the right of children and young persons to protection, the Contracting Parties undertake:

10. to ensure special protection against physical and moral dangers to which children and young persons are exposed, and particularly against those resulting directly or indirectly from their work.

Article 11 – The right to protection of health

With a view to ensuring the effective exercise of the right to protection of health, the Contracting Parties undertake, either directly or in co operation with public or private organizations, to take appropriate measures designed inter alia:

1. to remove as far as possible the causes of ill health;

2. to provide advisory and educational facilities for the promotion of health and the encouragement of individual responsibility in matters of health;

3. to prevent as far as possible epidemic, endemic and other diseases.

https://www.cvce.eu/content/publication/2003/3/7/e71c737f-4afb-41e3-9426-43bbf1cd0f00/publishable_en.pdf

4. The right to the highest attainable standard or physical and mental health

As set out in article 12 of the International Covenant on Economic, Social and Cultural Rights.

Article 12 provides as follows:

1. The States Parties to the present Covenant recognize the right of everyone to the enjoyment of the highest attainable standard of physical and mental health.

2. The steps to be taken by the States Parties to the present Covenant to achieve the full realization of this right shall include those necessary for:

(a) The provision for the reduction of the still birth-rate and of infant mortality and for the healthy development of the child;

(b) The improvement of all aspects of environmental and industrial hygiene;

(c) The prevention, treatment and control of epidemic, endemic, occupational and other diseases;

(d) The creation of conditions which would assure to all medical service and medical attention in the event of sickness.

https://www.ohchr.org/EN/ProfessionalInterest/Pages/CESCR.aspx

5. The United Nations Global Strategy for Women's, Children's and Adolescents' Health (2016-2030)

[…] has as objectives and targets to "transform", by expanding enabling environments; to "survive", by reducing maternal and newborn mortality; and to "thrive" by ensuring health and well-being and reducing pollution-related deaths and illnesses.

https://www.who.int/life-course/partners/global-strategy/globalstrategyreport2016-2030-lowres.pdf

6 . Convention on the Rights of Persons with Disabilities (CRPD, 2006).

Preamble:

(a) Recalling the principles proclaimed in the Charter of the United Nations which recognize the inherent dignity and worth and the equal and inalienable rights of all members of the human family as the foundation of freedom, justice and peace in the world,

(b) Recognizing that the United Nations, in the Universal Declaration of Human Rights and in the International Covenants on Human Rights, has proclaimed and agreed that everyone is entitled to all the rights and freedoms set forth therein, without distinction of any kind,

(c) Reaffirming the universality, indivisibility, interdependence and interrelatedness of all human rights and fundamental freedoms and the need for persons with disabilities to be guaranteed their full enjoyment **without discrimination**,

(d) Recalling the International Covenant on Economic, Social and Cultural Rights, the International Covenant on Civil and Political Rights, the International Convention on the Elimination of All Forms of Racial Discrimination, the Convention on the Elimination of All Forms of Discrimination against Women, **the Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment**, the Convention on the Rights of the Child, and the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families,

(e) Recognizing that disability is an evolving concept and that disability results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others,

etc.

http://www.un.org/disabilities/documents/convention/convoptprot-e.pdf

7. The Standard Rules on the Equalization of Opportunities for Persons with Disabilities (1993).

Fundamental concepts in disability policy (Page 6).

17. The term "disability" summarizes a great number of different functional limitations occurring in any population in any country of the world. People may be disabled by physical, intellectual or sensory impairment, medical conditions or mental illness. Such impairments, conditions or illnesses maybe permanent or transitory in nature.
18. The term "handicap" means the loss or limitation of opportunities to take part in the life of the community on an equal level with others. It describes the encounter between the person with a disability and the environment. The purpose of this term is to emphasize the focus on the short comings in the environment and in many organized activities in society,for example, information, communication and education, which prevent persons with disabilities from participating on equal terms.

19. The use of the two terms "disability" and "handicap", as defined in paragraphs 17 and 18 above, should be seen in the light of modern disability history. During the 1970s there was a strong reaction among representatives of organizations of persons with disabilities and professionals in the field of disability against the terminology of the time. The terms "disability" and"handicap" were often used in an unclear and confusing way, which gave poor guidance for policy-making and for political action. The terminology reflected a medical and diagnostic approach, which ignored the imperfections and deficiencies of the surrounding society.

22. The term "prevention" means action aimed at preventing the occurrence of physical, intellectual, psychiatric or sensory impairments (primary prevention) or at preventing impairments from causing a permanent functional limitation or disability (secondary prevention). Prevention may include many different types of action, such as primary health care, prenatal and postnatal care, education in nutrition, immunization campaigns against communicable diseases, measures to control endemic diseases, safety regulations , programs for the prevention of accidents in different environments, including adaptation of workplaces to prevent occupational disabilities and diseases, and prevention of disability resulting from pollution of the environment or armed conflict.

… And just about every rule stated thereafter are violated.

http://www.un.org/disabilities/documents/gadocs/standardrules.pdf

8. The United Nations Convention on the Rights of the Child (1989).

States shall "undertake to ensure the child such protection and care as is necessary for his or her well-being" (art. 3),

States Parties recognize the right of the child to the enjoyment of the highest attainable standard of health and to facilities for the treatment of illness and rehabilitation of health. States Parties shall strive to ensure that no child is deprived of his or her right of access to such health care services (art. 24.1).

States Parties shall pursue full implementation of this right and, in particular, shall take appropriate measures (art. 24.2):

(c) To combat disease and malnutrition, including within the framework of primary health care, through, inter alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water, taking into consideration the dangers and risks of environmental pollution;

https://www.ohchr.org/en/professionalinterest/pages/crc.aspx

9. Resolution 72 – Measurement concerns related to human exposure to electromagnetic fields of the International Telecommunications Union (2012).

It stated that "There is a need to inform the public of the potential effects of exposure to electromagnetic fields (EMFs)" and invited Member States "to adopt suitable measures in order to ensure compliance with relevant international recommendations to protect health against the adverse effect of EMF". https://www.itu.int/dms_pub/itu-t/opb/res/T-RES-T.72-2012-PDF-E.pdf

10. The Mid-term review of the European Environment and Health Action Plan 2004-2010 (2008):

"The European Parliament notes that the limits on exposure to electromagnetic fields which have been set for the general public are obsolete, … obviously take no account of developments in information and communication technologies, of the recommendations issued by the European Environment Agency or of the stricter emission standards adopted, for example, by Belgium, Italy and Austria, and do not address the issue of vulnerable groups, such as pregnant women, newborn babies and children."

https://publications.europa.eu/en/publication-detail/-/publication/2d11e9cb-4797-44be-a423-a2d9ad94b09a/language-en

11. Resolution 1815 (Council of Europe, 2011).

The potential dangers of electromagnetic fields and their effect on the environment: "Take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people."
Also worth noting, Part 4: While electrical and electromagnetic fields in certain frequency bands have wholly beneficial effects which are applied in medicine, **other non-ionising frequencies, whether from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals as well as the human body, even when exposed to levels that are below the official threshold values.**

http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994

12. The Declaration of the United Nations Conference on the Human Environment (1972):

"The discharge of toxic substances… in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems" (principle 6).
http://www.un-documents.net/unchedec.htm

13. The World Charter for Nature (1982):

"Activities which are likely to cause irreversible damage to nature shall be avoided… [W]here potential adverse effects are not fully understood, the activities should not proceed" (art. 11).

http://www.un.org/documents/ga/res/37/a37r007.htm

14. The Rio Declaration on Environment and Development (1992):

PRINCIPLE 1: Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

PRINCIPLE 2: States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, **and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.**

PRINCIPLE 3: The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

PRINCIPLE 4: In order to achieve sustainable development, **environmental protection shall constitute an integral part of the development process** and cannot be considered in isolation from it.

http://www.unesco.org/education/pdf/RIO_E.PDF

15. The United Nations World Summit on Sustainable Development (2002):

"There is an urgent need to… create more effective national and regional policy responses to environmental threats to human health" (para. 54(k)).

https://sustainabledevelopment.un.org/milesstones/wssd

16. Revised African Convention on the Conservation of Nature and Natural Resources (2017):

"The Parties shall… take all appropriate measures to prevent, mitigate and eliminate to the maximum extent possible, detrimental effects on the environment, in particular from radioactive, toxic, and other hazardous substances and wastes" (art. 13).

https://au.int/sites/default/files/treaties/7782-treaty-0029_-_revised_african_convention_on_the_conservation_of_nature_and_natural_resources_e.pdf

17. The Outer Space Treaty (1967)

Which requires that the use of outer space be conducted "so as to avoid [its] harmful contamination and also adverse changes in the environment of the Earth"(art. IX).

http://www.unoosa.org/pdf/gares/ARES_21_2222E.pdf

18. The United Nations Guidelines for The Long-Term Sustainability of Outer Space Activities (2018):

Address, to the extent practicable, risks to people, property, public health and the environment associated with the launch, in-orbit operation and re-entry of space objects (Guideline A.2,2 c).

http://www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf

L'avertissement de 15 000 scientifiques à l'humanité sur l'état de la planète – version française intégrale

Pour la deuxième fois après 25 ans, la communauté scientifique mondiale lance un avertissement, qui est aussi un véritable cri d'alarme à l'ensemble de l'humanité : nous exploitons collectivement la planète d'une manière qu'elle ne peut supporter, le rythme des dégradations que nous infligeons à la biosphère s'est accéléré depuis le premier appel en 1992, et en refusant et reportant par confort matériel ou intellectuel les transformations indispensables, nous sommes en train de scier la branche sur laquelle nous sommes assis, nous condamnant ainsi que nos descendants à de grandes souffrances.

Voici en version libre de tout droit et reproductible sans restriction la traduction intégrale de l'appel en français.

Publication originelle en anglais – William J. Ripple, Christopher Wolf, Thomas M. Newsome, Mauro Galetti, Mohammed Alamgir, Eileen Crist, Mahmoud I. Mahmoud, William F. Laurance - Texte signé par 15 364 scientifiques issus de 184 pays

Traduction officielle du texte - Luiz Marques *(fichier ZIP contenant les versions anglaise, espagnole et portugaise en plus de la française ainsi que la liste complète des signataires)*

Adaptation, traduction des figures et des notes explicatives - Alexis Toulet

Il y a vingt-cinq ans, l'*Union of Concerned Scientists* et plus de 1500 scientifiques indépendants, y compris la majorité des lauréats du prix Nobel dans les sciences, ont écrit l'Avertissement des scientifiques du monde à l'humanité de 1992. Ces professionnels inquiets ont appelé l'humanité à réduire la destruction de l'environnement et ont plaidé qu'*« un changement radical dans notre gestion de la Terre et de la vie terrestre s'avère nécessaire pour éviter des souffrances humaines à grande échelle ».* Dans leur manifeste, ils ont montré que les êtres humains étaient sur une trajectoire de collision avec le monde naturel. Ils se sont dits préoccupés par les dommages existants, imminents ou potentiels sur la planète Terre, avec pour conséquence la réduction de l'ozone et de l'eau douce disponible, l'effondrements des pêches, l'extension des zones mortes de l'océan, la perte de forêts, la destruction de la biodiversité, le changement climatique et la croissance indéfinie de la population humaine. Ils ont proclamé que des changements fondamentaux étaient nécessaires de toute urgence pour éviter les conséquences de notre trajectoire actuelle.

Les auteurs de la déclaration de 1992 craignaient que l'humanité ne pousse les écosystèmes terrestres au-delà de leurs capacités à soutenir le tissu de la vie. Ils ont décrit notre approche rapide de plusieurs des limites de ce que la planète peut tolérer sans dommage substantiel et irréversible. Les scientifiques ont plaidé pour la stabilisation de la population humaine, en décrivant comment notre nombre important - augmenté de 2 milliards de personnes supplémentaires depuis 1992, une augmentation de 35% - exerce des pressions sur la Terre qui peuvent annuler les efforts pour construire un avenir durable (1). Ils ont imploré de réduire les émissions de gaz à effet de serre (GES), d'éliminer les combustibles fossiles, de réduire la déforestation et d'inverser la tendance à l'effondrement de la biodiversité.

À l'occasion du 25ème anniversaire de leur appel, nous lançons un regard rétrospectif sur cet avertissement afin d'évaluer la réponse que l'humanité y a apportée, tout en explorant les données disponibles en séries chronologiques. **Depuis 1992, à l'exception de la stabilisation de la couche d'ozone stratosphérique, l'humanité n'a pas réussi à faire des progrès suffisants dans la résolution générale de ces défis**

environnementaux qui avaient été prévus et, de façon alarmante, **la plupart d'entre eux ont largement empiré** (voir les figures plus bas). Particulièrement inquiétante, la trajectoire actuelle du changement climatique est potentiellement catastrophique en raison de la hausse des GES poussée par la combustion des combustibles fossiles (2), par la déforestation (3) et par la production agricole - en particulier les ruminants pour la consommation de viande (4). En outre, nous avons déclenché un événement d'extinction de masse, le sixième en environ 540 millions d'années, si bien que de nombreuses formes de vie actuelles pourraient être anéanties ou au moins placées sur la voie de l'extinction d'ici la fin de ce siècle.

L'humanité reçoit maintenant un deuxième avis, comme le montrent ces tendances alarmantes. Nous mettons en péril notre avenir en ne contrôlant pas notre consommation matérielle intense, quoique géographiquement et démographiquement inégale, et en ne prenant pas conscience de la croissance rapide et continue de la population en tant que principal moteur de nombreuses menaces écologiques et même sociales (1). Faute de limiter comme il le faudrait la croissance de la population, réévaluer le rôle d'une économie basée sur la croissance, réduire les gaz à effet de serre, inciter à l'utilisation des énergies renouvelables, protéger les habitats naturels, restaurer les écosystèmes, mettre fin à la défaunation et restreindre les espèces exotiques envahissantes, l'humanité ne prend pas les mesures urgentes nécessaires pour sauvegarder notre biosphère en péril.

Étant donné que la plupart des dirigeants politiques répondent à la pression, les scientifiques, les prescripteurs médiatiques et les citoyens en général doivent exiger que leurs gouvernements prennent **des mesures immédiates, car c'est un impératif moral pour les générations actuelles et à venir** de l'humanité et des autres espèces. Avec une vague d'efforts populaires organisés depuis la base, les oppositions les plus obstinées peuvent être surmontées et les dirigeants politiques forcés de faire ce qu'il faut. Il est également grand temps de réexaminer et de modifier nos comportements individuels, y compris en limitant notre propre reproduction (de préférence, tout au plus au niveau du remplacement) et en diminuant drastiquement notre consommation par habitant de combustibles fossiles, de viande et d'autres ressources.

Le déclin mondial rapide des substances détruisant la couche d'ozone montre que nous pouvons faire des changements positifs lorsque nous agissons résolument. Nous avons également fait des progrès dans la réduction de la pauvreté extrême et de la faim (5). Parmi d'autres progrès remarquables (pas encore visibles dans les données globales des figures) : la baisse rapide des taux de fécondité dans de nombreuses régions, conséquence des investissements dans l'éducation des filles et des femmes (6), le déclin prometteur du taux de déforestation dans certaines régions et la croissance rapide du secteur des énergies renouvelables. Nous avons beaucoup appris depuis 1992, mais le progrès des transformations urgentes dans la politique environnementale, le comportement individuel et les inégalités mondiales est encore loin d'être suffisant.

Les transitions vers le développement durable peuvent se dérouler de manières diverses, mais toutes exigent une pression de la société civile et un plaidoyer fondé sur des preuves, un leadership politique et une compréhension solide des instruments politiques, des marchés et d'autres facteurs. Parmi les exemples des diverses mesures efficaces que l'humanité peut prendre pour passer au développement durable, il faut citer (pas par ordre d'importance ni d'urgence) :

- prioriser la mise en place de réserves connectées, bien financées et bien gérées, pour une proportion significative des habitats naturels terrestres, marins, d'eau douce et aériens dans le monde
- préserver les services écosystémiques de la nature en arrêtant l'artificialisation des forêts, des prairies et d'autres habitats naturels

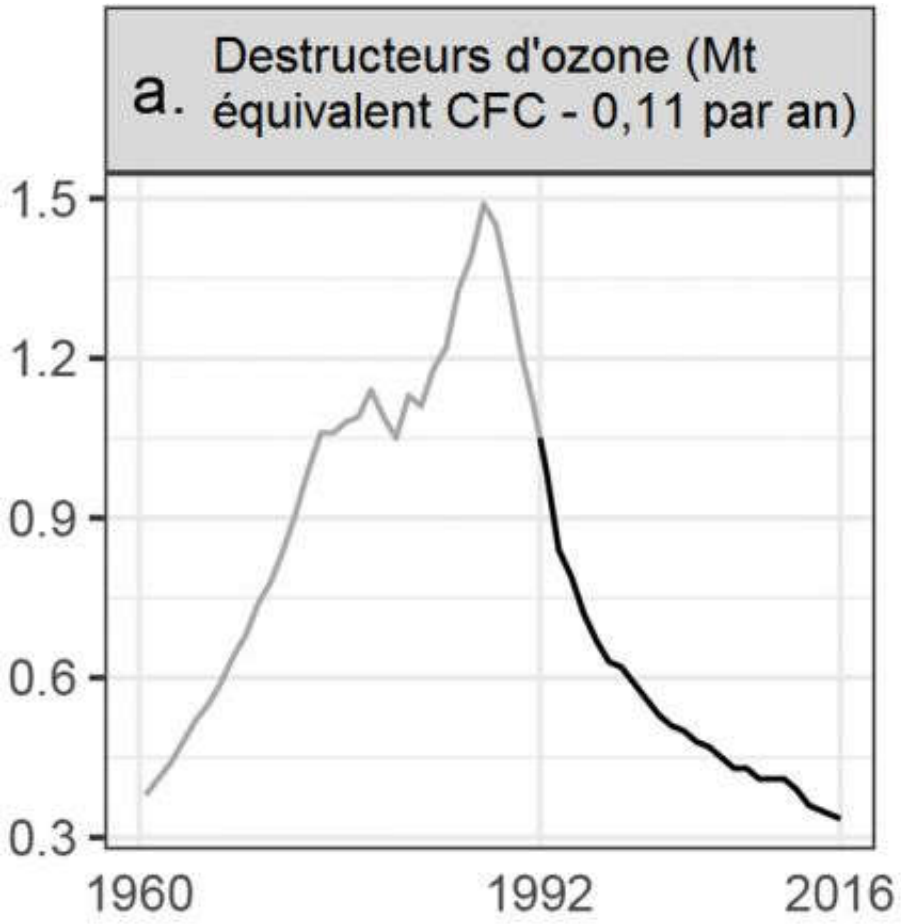
- restaurer les communautés de plantes à grande échelle, en particulier les paysages forestiers
- réimplanter les espèces natives dans leurs habitats, en particulier les super-prédateurs, pour rétablir les processus et dynamiques écologiques
- élaborer et adopter des instruments politiques adéquats pour remédier à la défaunation, au braconnage et à l'exploitation et au trafic d'espèces menacées
- réduire le gaspillage alimentaire grâce à l'éducation et à une meilleure infrastructure
- promouvoir des changements alimentaires, en particulier vers des aliments à base de plantes
- réduire davantage les taux de fécondité en veillant à ce que les femmes et les hommes aient accès à l'éducation et aux services volontaires de planification familiale, en particulier là où ces ressources manquent encore
- renforcer l'éducation en plein air pour les enfants ainsi que l'engagement global de la société à apprécier la nature comme elle le mérite
- réorienter les investissements financiers et diminuer la consommation pour encourager des changements environnementaux positifs
- concevoir et promouvoir de nouvelles technologies vertes et adopter massivement les sources d'énergie renouvelables, tout en supprimant progressivement les subventions à la production d'énergie issues des combustibles fossiles
- réviser notre économie pour réduire les inégalités de richesse et veiller à ce que les prix, la fiscalité et les systèmes incitatifs tiennent compte des véritables coûts que les modes de consommation imposent à notre environnement et
- estimer de manière scientifique une taille de population humaine durable à long terme tout en forgeant un consensus entre les nations et les dirigeants pour travailler à cet objectif vital

Pour éviter des souffrances généralisées et une perte catastrophique de biodiversité, l'humanité doit adopter des pratiques alternatives plus durables sur le plan environnemental que les arrangements et les routines actuelles. Cette recommandation a été bien formulée par les plus grands scientifiques du monde il y a 25 ans, mais, à bien des égards, nous n'avons pas tenu compte de leur avertissement. Bientôt, il sera trop tard pour dévier de notre trajectoire vers l'échec, et le temps est compté. Nous devons accepter, par notre vie quotidienne et par nos institutions gouvernementales, que la Terre avec toute la vie qu'elle contient est notre seul foyer.

Figures et Explications

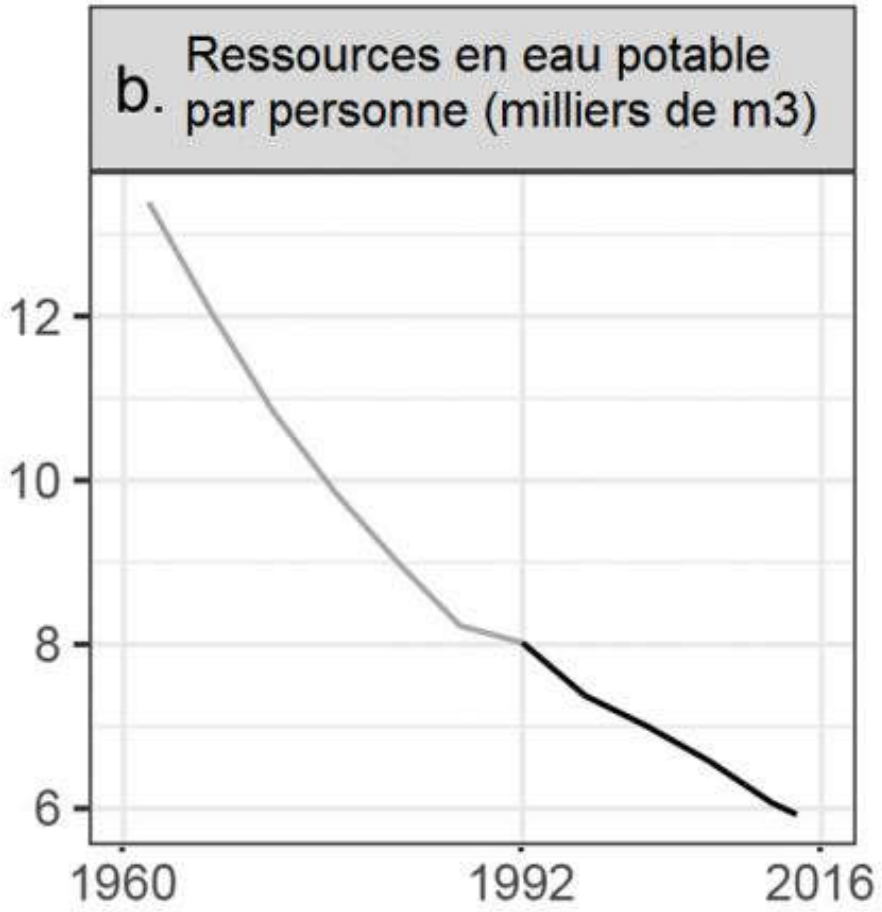
Voici **comment ont évolué les questions environnementales identifiées dans l'avertissement de 1992**.

Les années avant et après ce premier appel sont en gris et en noir respectivement. Depuis 1992, les changements sont respectivement : (a) –68.1%; (b) –26.1%; (c) –6.4%; (d) +75.3%; (e) –2.8%; (f) –28.9%; (g) +62.1%; (h) +167.6%; et (i) êtres humains +35.5%, ruminants +20.5%



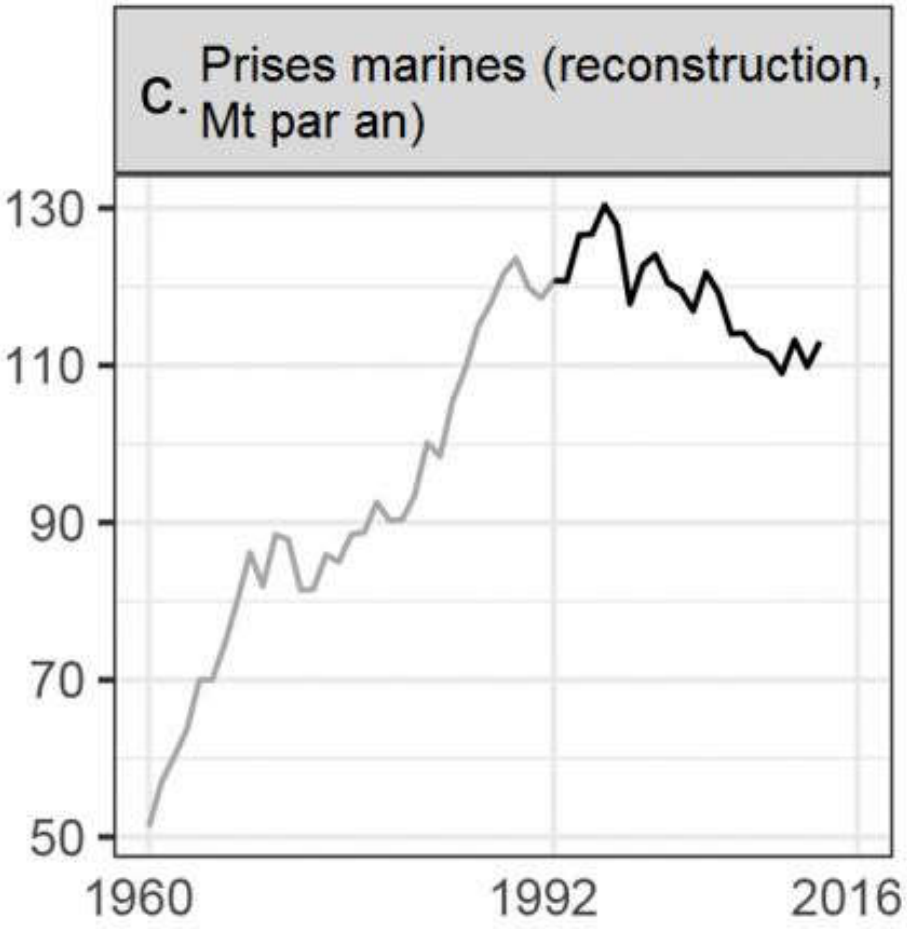
a - Pendant les années 1970, des produits chimiques d'origine humaine appelés destructeurs d'ozone, principalement les chlorofluorocarbones, réduisaient rapidement la couche d'ozone atmosphérique. En 1987, les gouvernements du monde se rassemblèrent et établirent le Protocole de Montréal des Nations Unies, tentative de s'attaquer au problème à l'échelle mondiale. Le respect de ce protocole a fait que les émissions de gaz halogènes (destructeurs d'ozone et sources naturelles estimées à 0,11 Mt d'équivalent-CFC par an) ont atteint un pic à la fin des années 1980 et ont depuis nettement baissé. La couche d'ozone ne se réduit plus, et elle devrait s'être en grande partie réparée d'ici le milieu de ce siècle

Source : Hegglin, M. I., D. W. Fahey, M. McFarland, S. A. Montzka, and E. R. Nash. 2015. Twenty questions and answers about the ozone layer: 2014 Update: Scientific assessment of ozone depletion: 2014. World Meteorological Organization, Geneva, Switzerland



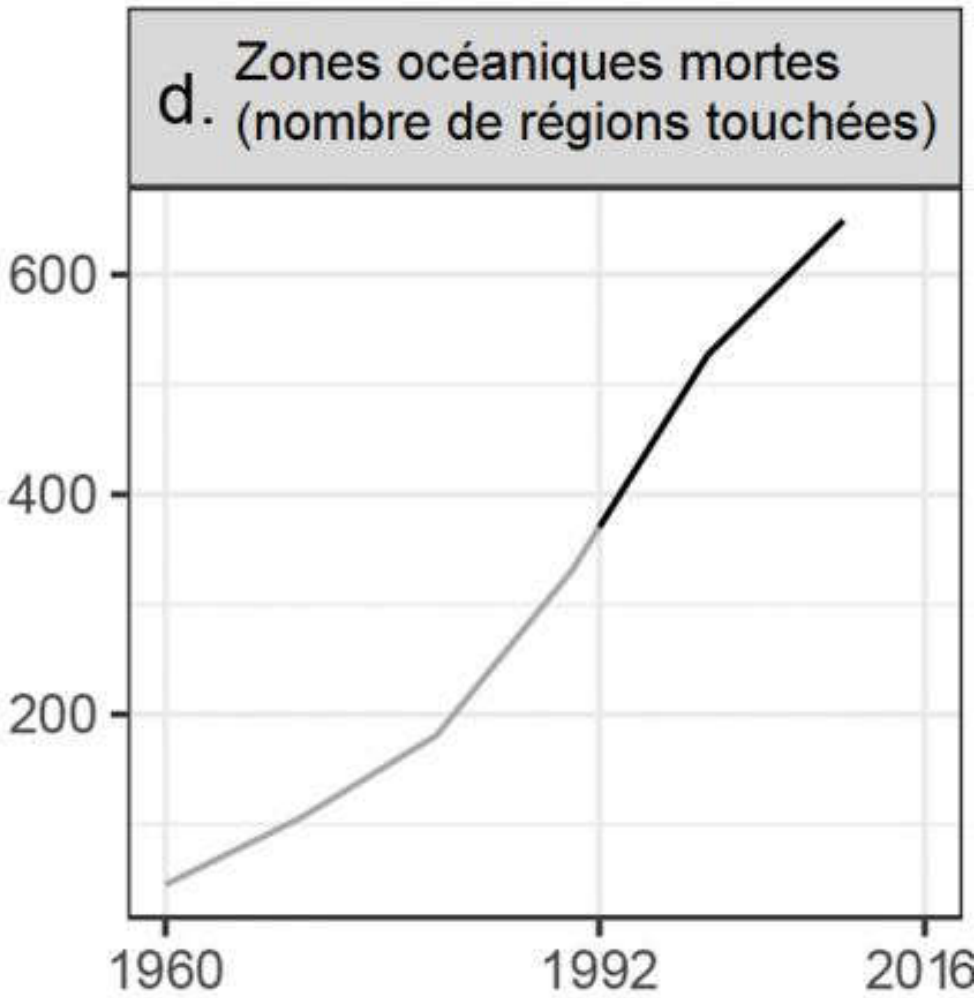
b - Les ressources en eau potable par personne sont moins de la moitié de ce qu'elles étaient au début des années 1960, beaucoup de personnes souffrent d'un manque en eau potable. La cause en est avant tout la croissance rapide de la population. Il est probable que le changement climatique ait un impact écrasant sur les ressources en eau, par altération du cycle hydrologique. Les futures pénuries seront néfastes, touchant à la fois l'eau de consommation, la santé, l'hygiène et la production de céréales pour la nourriture.

Source : AQUASTAT. 2017. AQUASTAT - FAO's Information System on Water and Agriculture.



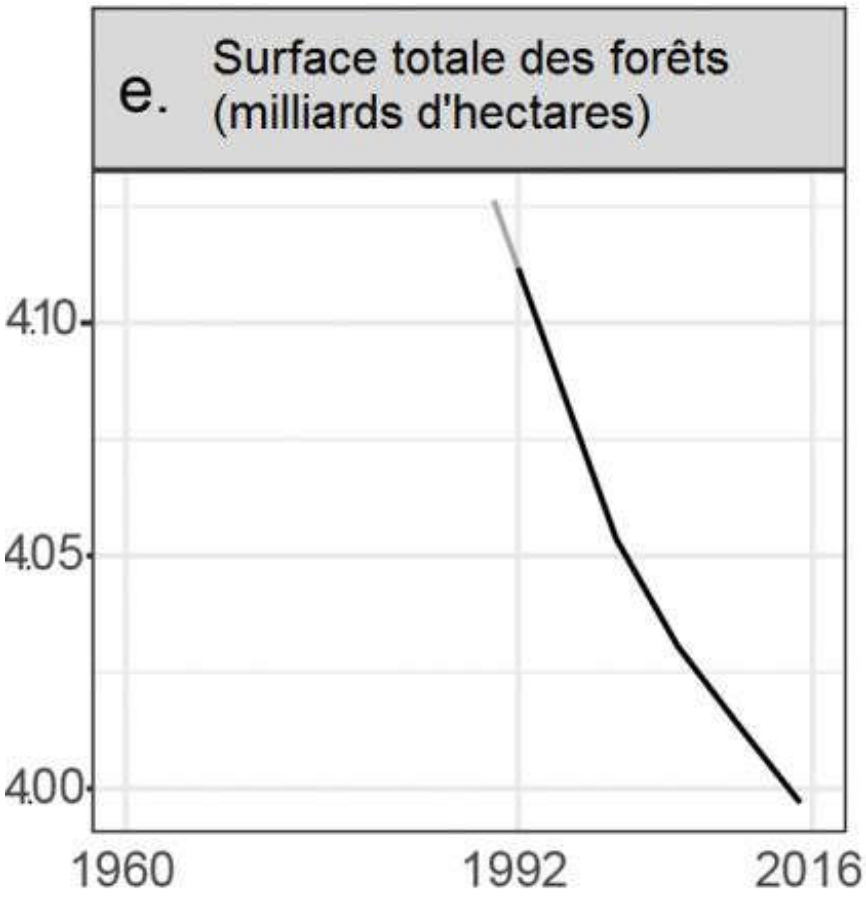
c - En 1992, le total des prises était égal ou supérieur au rythme maximum soutenable et les pêcheries étaient au bord de la rupture. La reconstruction des séries chronologiques montre que les prises ont culminé à 130 millions de tonnes en 1996 et décru continûment depuis. Ce déclin s'est imposé malgré les efforts redoublés de pêche et malgré l'extension des zones de pêche des pays développés aux eaux des pays en développement.

Source : Pauly, D., and D. Zeller. 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Updated. Nature Communications 7:10244



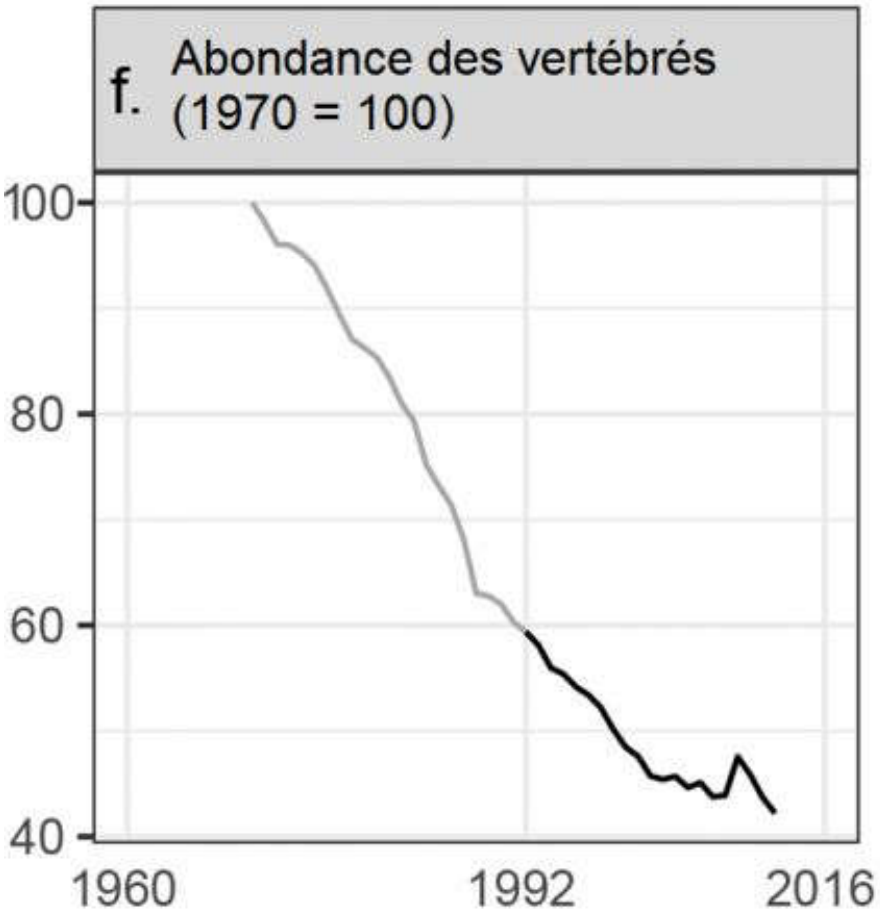
d - Les zones mortes côtières sont causées principalement par l'écoulement des fertilisants et l'utilisation de carburants fossiles, qui éradiquent de grandes bandes de vie marine. Les zones mortes, aux eaux hypoxiques pauvres en oxygène sont un facteur de stress important sur les milieux naturels marins. Beaucoup plus ont été repérées que dans les années 1960, plus de 600 en 2010.

Source : Diaz, R. J., and R. Rosenberg. 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. Updated. Science 321:926–929



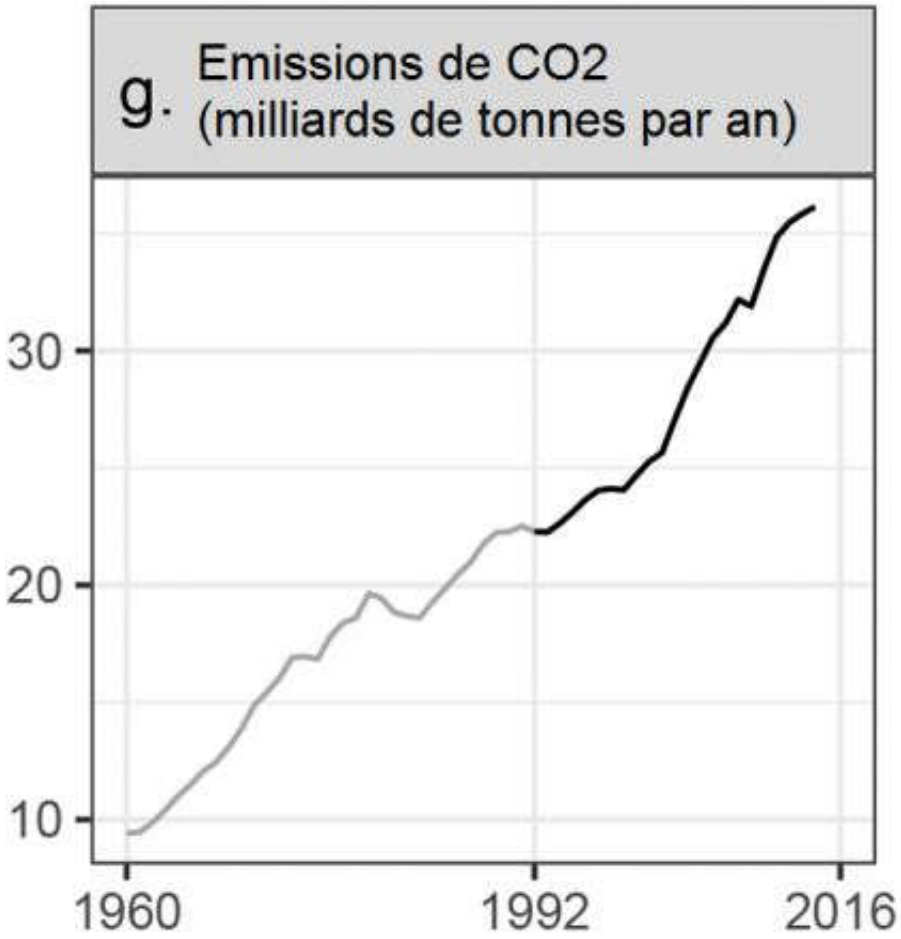
e - Les forêts sont primordiales pour séquestrer du carbone et préserver la biodiversité et les ressources en eau potable. Entre 1990 et 2015, la surface totale des forêts a décru de 4 128 à 3 999 millions d'hectares, une perte de 129 millions d'hectares soit nettement plus que deux fois la France métropolitaine. C'est dans les pays tropicaux en développement que les pertes ont été les pires, beaucoup de forêts étant maintenant converties en terres agricoles

Source : Food and Agriculture Organization of the United Nations. 2015. Global forest resources assessment 2015



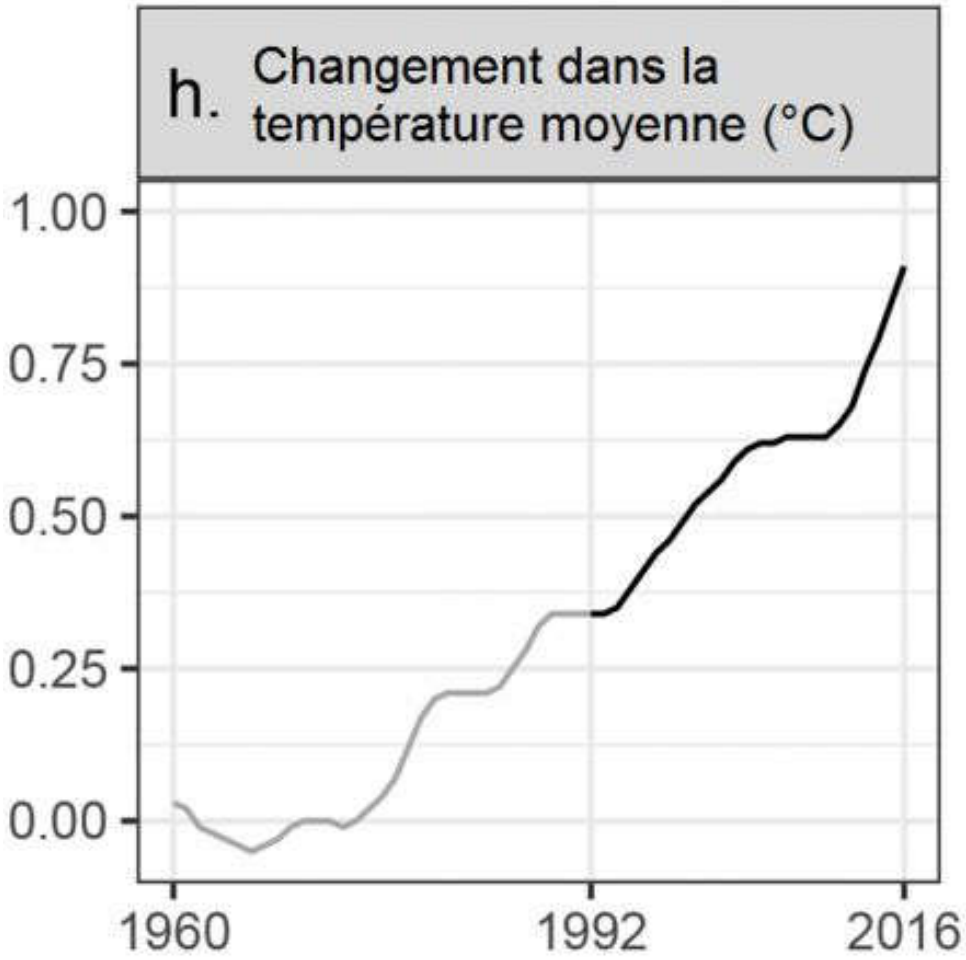
f - La biodiversité s'épuise à un rythme alarmant et les populations de vertébrés sont en cours d'effondrement rapide (voir World Wildlife Fund 2016). Prises dans leur ensemble, les populations de mammifères, oiseaux, reptiles, amphibiens et poissons ont décru de 58% entre 1970 et 2012. Nous affichons ici un index Planète Vivante tenant compte de la diversité et ajusté pour compenser les biais taxonomique et géographique. Les populations en eau douce, en mer et sur terre ont décru respectivement de 81%; 36% et 35%.

Source : World Wildlife Fund. 2016. Living planet report 2016: risk and resilience in a new era. McRae, L., Deinet, S. and Freeman, R., 2017. The Diversity-Weighted Living Planet Index: Controlling for Taxonomic Bias in a Global Biodiversity Indicator. PloS one, 12(1), p.e0169156



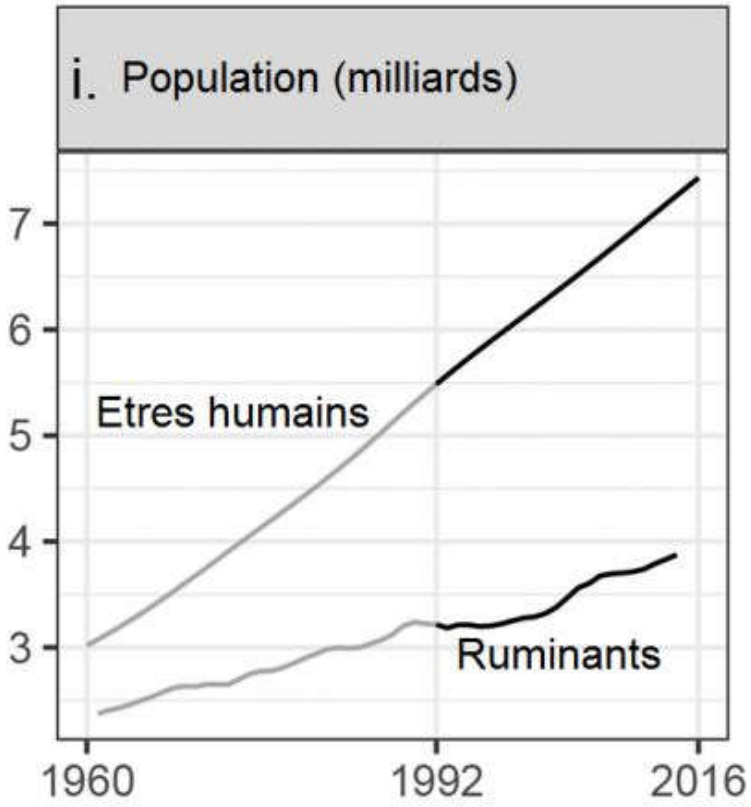
g - Les émissions mondiales de CO2 résultant de l'utilisation d'énergies fossiles ont considérablement augmenté depuis 1960

Source : Boden, T. A., G. Marland, and R. J. Andres. 2017. Global, regional, and national fossil-fuel CO2 emissions, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory. US Department of Energy, Oak Ridge, Tenn., USA 2009. doi 10.3334/CDIAC 1



h - Il s'agit ici de moyennes glissantes sur cinq ans. Par rapport à la moyenne 1951-1980, les températures moyennes en surface moyennées à l'échelle mondiale ont considérablement augmenté, en parallèle aux émissions de CO2. Les 10 années les plus chaudes parmi les 136 pour lesquelles on dispose de données directes sont toutes postérieures à 1988. L'année la plus récente, 2016, est la plus chaude des 136. L'augmentation des températures causera probablement un déclin de la production mondiale des principales céréales, une augmentation de l'intensité des grandes tempêtes, et une augmentation importante du niveau des océans, inondant des métropoles importantes

Source : NASA's Goddard Institute for Space Studies (GISS). 2017. Global Temperature



i - Depuis 1992, la population mondiale a augmenté d'environ 2 milliards d'individus, soit 35%. La population ne devrait pas cesser d'augmenter en ce siècle, et il est estimé très probable qu'elle passe de 7,5 à entre 9,6 et 12,3 milliards d'ici 2100. Tout comme la population humaine, celle des cheptels de ruminants a augmenté ces dernières décennies à environ 4 milliards d'individus, avec leurs propres impacts majeurs sur environnement et climat.

Source : FAOSTAT. 2017. FAOSTAT Database on Agriculture

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5 - Voir les études sur la faim de la Banque Mondiale

6 - Voir les données des Nations Unies sur la population