COMMUNICATIONS

Distributed at the March 29, 2011 Committee of the Whole (Working Session) Meeting

C1. Ms. Tina Catalano, BioInitiative Report (Full report available in the City Clerk's Office)
(Refer to Item 2)

C2. Ms. Maria Bonfini, dated March 27, 2011.
(Refer to Item 2)

C3. Mr. Mario Bonfini, dated March 27, 2011.
(Refer to Item 2)

C4. Dr. Magda Havas, dated March 28, 2011.
(Refer to Item 2)

C5. Ms. Tina Catalano, Information Package.
(Refer to Item 2)

Received at the March 29, 2011 Committee of the Whole (Working Session) Meeting

C6. Ms. Tina Catalano, Information Package 2.
(Refer to Item 2)

C7. Ms. Von Chaleunsouk-Marsden, dated March 29, 2011.
(Refer to Item 2)

C8. Ms. Angela Gibson, presentation material entitled, *"South Yonge Street Corridor Streetscape Master Plan"*.
(Refer to Item 1)

C9. Mr. Stephen J. D'Agostino, presentation material entitled, *"Telecom Resources and Safety Code 6 and RF Exposure"*, dated March 29, 2011.
(Refer to Item 2)

Please note there may be further Communications.

C 1
CW (Working Session) -
March 29, 2011
Item # 2

Full Report available in the City Clerk's Office.

Release Date: August 31, 2007

BioInitiative Report:
A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)

Organizing Committee:
Carl Blackman, USA
Martin Blank, USA
Michael Kundi, Austria
Cindy Sage, USA

Participants:
David Carpenter, USA
Zoreh Davanipour, USA
David Gee, Denmark
Lennart Hardell, Sweden
Olle Johansson, Sweden
Henry Lai, USA
Kjell Hansson Mild, Sweden
Eugene Sobel, USA
Zhengping Xu and Guangdin Chen, China

Research Associate
S. Amy Sage, USA

PREFACE

The Organizing Committee thanks the participants of the BioIniative Working Group for their integrity and intellectual courage in dealing with this controversial and important topic; and for devoting the time and energy to produce their chapters. The information and conclusions in each chapter are the responsibilities of the authors of that chapter.

The Group has produced what the authors hope will be a benchmark for good science and public health policy planning. It documents bioeffects, adverse health effects and public health conclusions about impacts of non-ionizing radiation (electromagnetic fields including extremely-low frequency ELF-EMF and radiofrequency/microwave or RF-EMF fields).

Societal decisions about this body of science have global implications. Good public health policy depends on acting soon enough, but not without cause, and with enough information to guide intelligent actions. To a great degree, it is the definition of the standard of evidence used to judge the scientific reports that shapes this debate. Disagreement about when the evidence is sufficient to take action has more to do with the outcome of various reviews and standard-setting proceedings than any other single factor. Whatever "standard of evidence" is selected to assess the strength of the science will deeply influence the outcome of decisions on public policy.

We are at a critical juncture in this world-wide debate. The answers lie not only in the various branches of science; but necessarily depend on the involvement of public health and policy professionals, the regulatory, legal and environmental protection sectors, and the public sector.

This has been a long-term collaboration of international scientists employing a multi-disciplinary approach to problem assessment and solving. Our work has necessarily relied on tools and approaches across the physical, biological and engineering sciences; and those of the environmental scientist and public health professional. Only when taken together can we see the whole and begin to take steps that can prevent possible harm and protect future generations.

Signed: David O. Carpenter Signed: Cindy Sage

David Carpenter, MD
Co-Editor
BioInitiative Report

Cindy Sage, MA
Co-Editor
BioInitiative Report

BioInitiative: A Rationale for a Biologically-based Exposure Standard for Electromagnetic Radiation

C 2
COMMUNICATION
CW -(WS) March 29/11
ITEM - 2

From: M.Bonfini [mbonfini@rogers.com]
Sent: Sunday, March 27, 2011 10:09 PM
To: Bevilacqua, Maurizio; Racco, Sandra; Schulte, Deb; Carella, Tony; DeFrancesca, Rosanna; Di Biase, Michael; marylin.iafrate@vaughan.ca; Rosati, Gino; Shefman, Alan
Cc: Abrams, Jeffrey
Subject: Telecommunication Towers- Letter of Support

March 27th, 2011

Dear Mayor Bevilacqua and Vaughan Councillors,

I understand that a motion supporting the struggle of West Woodbridge Homeowner's Association Inc. is coming up to the Committee of the Whole on the 29th of March 2011.

The struggle addresses the concerns of residents with respect to placing Telecommunication Towers. The Association is requesting the Province take action and place tower sites 500 meters away from all Residential properties, Schools, Senior homes, Institutional buildings and Community Centers.

I expect that you and all the Councillors, will vote in favour of this motion.

Please support this very important struggle.

Yours truly,

Maria Bonfini
3 Southview drive
Concord, Ontario
L4k-2K8

C/c: Jeffrey A Abrams, City of Vaughan - City Clerk

C 3
COMMUNICATION
CW -(WS) March 29/11
ITEM - 2

From: M.Bonfini [mbonfini@rogers.com]
Sent: Sunday, March 27, 2011 10:55 PM
To: Bevilacqua, Maurizio; Schulte, Deb; Racco, Sandra; Rosati, Gino; Di Biase, Michael; Carella, Tony; DeFrancesca, Rosanna; marylin.iafrate@vaughan.ca; Shefman, Alan
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Subject: Telecommunication Towers- Letter of Support

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Yours truly,

Mario Bonfini
3 Southview drive
Concord, Ontario
L4k-2K8

C/c: Jeffrey A. Abrams, City of Vaughan - City Clerk

TRENT UNIVERSITY

Dr. Magda Havas, B.Sc., Ph.D.,

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www.magdahavas.org (academic)

Date:	March 28, 2011
Open Letter to:	Mayor and Members of Council, City of Vaughan
Regarding:	City of Vaughan Working Session Committee Meeting March 29, 2011 on Cell Tower Protocols

Open Letter re: Cell Tower Protocols, City of Vaughan, Ontario, Canada.

First let me introduce myself. I am an Associate Professor at Trent University in Peterborough and I have been doing research on the health effects of electromagnetic pollution since the mid 1990s and, for 20 years prior to that, on the environmental and health effects of chemical pollutants (including acid rain). You can get more information about my recent work at www.magdahavas.com.

As Mayor and Members of Council, you are in a difficult situation. You need to make choices about the placement of cell phone towers and antennas with the federal government (Health Canada) telling you this radiation is safe and with citizens in your community, who will be living or working near these antennas, concerned about the long-term health consequences of exposure to microwave radiation.

This type of conflict happened with acid rain, asbestos, cigarette smoking, x-rays, DDT, lead, mercury, etc. In each of these cases, the provincial or federal government eventually reduced their guidelines to protect the public and the environment, but they did this decades after solid scientific data were available that documented the harm caused by exposure to these pollutants. Often, misinformation was presented by "industry science" to keep the debate going so that policy decisions would be delayed. It worked. We are in the same situation with our wireless technology and our increasing exposure to microwave radiation.

These are some of the things you should consider before you make a decision about your policy on the placement of cell phone antennas in your community.

1. Canada's Guidelines are much less Protective than Guidelines in Other Countries

Canada's guidelines are 100 times higher (100 times less protective) than those in Switzerland, China, Russia and several European countries (1000 vs. 10 microW/cm^2). Why do these other countries have more protective guidelines than Canada? Either Canadians are more tolerant of this radiation (which is nonsense) or our government is less protective.

Canada's guidelines are based on an average 6-minute exposure of the general population. If the radiation doesn't heat your body during that period of time, it is considered safe. Even those without medical degrees can recognize the fallacy in this argument. Peak exposures are considered, only average exposure. Yet, living organisms respond to peak temperatures not averages. If you scald your hand under running hot water, lowering the temperature will not remove the damage.

2. Military vs. Public Exposure to Microwave Radiation

Military personnel were first exposed to radar (a form of microwave radiation) during the Second World War. The guidelines we have were originally designed to protect radar operators (200 lb healthy adult males in peak physical condition) from thermal (heating) effects. At that time, there was no concern for children or pregnant women being exposed to this radiation, because use was limited.

Today, we are surrounded by devices that emit microwave radiation (WiFi routers, cell phones, cordless phones, baby monitors, smart meters, and cell phone antennas). Indeed people who have become sensitive to this radiation are having a difficult time in their own homes because of neighbour s with WiFi routers and nearby cell phone antennas.

The key question is, "Are the levels-designed to protect healthy adult males exposed for a few hours each day-sufficient to protect infants, pregnant women, and the elderly exposed constantly to this radiation?" Health Canada says "yes" but scientific studies say "no".

In a recent review, Khurana et al. (2010) (see abstract in Appendix) examined the epidemiological evidence for health risk from mobile phone base stations. They reported the following:

> *"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.*

The "neurobehavioral symptoms" mentioned above resemble the symptoms experienced by radar operators. The symptoms were called "microwave sickness" and are now called "electrohypersensitivity" (EHS).

We cannot rely on guidelines that were designed to protect military personnel from occupational exposure to also protect the population from continuous exposure.

3. Laboratory Studies document Microwave damage at levels below Guidelines.

We have scientific evidence that microwave radiation generated by a cell phone (same frequencies as those produced by cell phone antennas) can damage DNA causing single and double strand breaks in brain cells of rats under controlled laboratory conditions (Lai and Singh 1996). DNA damage can be a precursor for cancer.

We have evidence that low-level, long-term exposure of rats exposed to the same microwave frequency used in microwave ovens, disrupts the immune system and leads to cancer growth (Chou et al. 1992).

We have evidence that this radiation affects the nervous system (heart), the blood brain barrier, the movement of calcium ions between cells, the levels of melatonin in the body (important in sleep and cancer prevention), the levels of stress proteins and a host of other biochemical reactions, once again, at levels well below federal guidelines (Carpenter and Sage 2007; Havas et al. 2010; Royal Society of Canada 1999)!

4. Toronto Public Health requests Lower Guidelines

Concern about the placement of cell phone antennas in the City of Toronto was a great concern to the Medical Officer of Health, Dr. Sheela Basrur, and in 1999 she held a public meeting to discuss this issue. Her recommendations were for prudent avoidance and that public exposure limits for radio frequency radiation (under Safety Code 6) should be made 100 times stricter. That would bring these guidelines to the same levels as in Switzerland (10 microW/cm^2).

Needless to say, Health Canada did not respond. Indeed they have failed to reduce the guidelines despite the growing scientific and anecdotal evidence of ill health with long-term, low-levels of exposure. See recent report and recommendations from MOH (2007) in Appendix 2.

5. Royal Society of Canada documents Biological Effects below Safety Code 6

Health Canada commissioned a report by the Royal Society of Canada (1999) to assess if the existing guidelines were adequate to protect public health. In that report, the Royal Society states the following:

- *Exposure to RF fields at intensities far less than levels required to produce measurable heating can cause effects in cells and tissues.*

- *These biological effects include alterations in calcium regulation, in the permeability of the blood-brain barrier, and in the activity of the ODC enzyme (ornithine decarboxylase) [an enzyme associated with cancer growth].*
- *Non-thermal exposure levels of RF could potentially be associated with adverse health effects.*

Despite this report and the Royal Society of Canada recommendations, Health Canada did **not** change the guidelines!

6. House of Commons Standing Committee on Health asks for monitoring of adverse reactions to electromagnetic Radiation.

In 2010, the House of Commons Standing Committee on Health (HESA) released a report entitled: *An Examination of the Potential Health Impacts of Radiofrequency Electromagnetic Radiation*. Among their recommendations is the following:

> *"Health Canada ensure that it has a process in place to receive and respond to reports of adverse reactions to electromagnetic radiation emitting devices."*

While this type of information gathering is important, it means that we are being treated a guinea pigs in a large experiment for which many of us have not given our consent. For the report and the submissions visit:
http://www2.parl.gc.ca/HousePublications/Publication.aspx?DocId=4834477&Language=E&Mode=1&Parl=40&Ses=3&File=27

Delay is deadly. How long it takes governments to do their job properly is a function of industry pressure to resist change, the revenue stream (via taxes, licensing fees, etc.), and public pressure to promote change. Currently industry pressure and the revenue stream far out-weight public pressure, because the public is unaware of the biological and health consequences of this radiation. It isn't until people start complaining about their health that they begin to realize they can no longer tolerate constant exposure to this radiation. By then it is too late as contracts, lasting decades, have been signed with no escape clauses attached.

Municipal governments have an important role to play. As representatives of your community you have the obligation to protect the nature of your community and the health of the people who live there. Industry Canada does NOT have the final say.

Please make your decision wisely with the health of the population in mind and not just the convenience of this technology or the revenue it will generate or pressure from the industry or from Industry Canada.

I would advise that antennas NOT be placed within 400 meters of schools and homes and where people spend considerable time each day. This may be difficult but the further away they are the less harmful they are.

If you do decide to give permission for the antennas then make certain you have an **escape clause** that allows you to remove the antennas in a timely fashion with no financial penalty if people nearby begin to experience adverse health effects. In Simcoe, Ontario the cell phone provider refused to remove an antenna from a water tower after people nearby became sick even after requested to do so by the local council. The cell phone provider eventually agreed to remove the antenna for a large sum of money that council was unable to provide. Don't let the same thing happen in your community.

Whatever decision is made about the siting of cell phone antennas, it should be based on the best available scientific evidence and with the long-term health of those immediately around those antennas firmly in mind.

References

Chou, C.-K et al. 1992. Long-Term, Low-Level Microwave Irradiation of Rats Bioelectromagnetics Vol 13:469-496.

Havas, M. et al. 2010. Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system. European Journal of Oncology. Vol 5:273-300.

HESA, 2010. An examination of the potential health impacts of Radiofrequency electromagnetic radiation. House of Commons Standing Committee on Health. http://www2.parl.gc.ca/HousePublications/Publication.aspx?DocId=4834477&Language=E&Mode=1&Parl=40&Ses=3&File=27

Khurana, V.G. et al. 2010. Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations. Int. J. Occup. Environ. Health. Vol 16:263-267.

Lai, H., and N.P. Singh, 1996. Single and double strand breaks in rats brain cells after acute exposure to radio frequency electromagnetic radiation, Int. J. Radiat. Biology Vol 69: 513-521.

Royal Society of Canada, 1999. Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices, An Expert Panel Report prepared at the request of the Royal Society of Canada for Health Canada, RSC.EPR 99-1, http://www.rsc.ca

Carpenter, D. and C. Sage (Eds). 2007. The BioInitiative Report. A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF), http://www.bioinitiative.org

Appendices

APPENDIX 1: Khurana, V.G. et al. 2010. Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations. Int. J. Occup. Environ. Health 16:263-267.

Abstract:
Human populations are increasingly exposed to microwave/radiofrequency (RF) emissions from wireless communication technology, including mobile phones and their base stations. By searching PubMed, we identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone base stations. 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 longterm mobile phone base station exposure are urgently required to more definitively understand its health impact. Key words: base stations; electromagnetic field (EMF); epidemiology; health effects; mobile phone; radiofrequency (RF); electromagnetic radiation.

APPENDIX 2: Staff Report Action Required. 2007. Prudent Avoidance Policy on Siting Telecommunications Towers and Antennas. Toronto Board of Health. http://www.toronto.ca/health/hphe/pdf/boh_report.pdf

The Medical Officer of Health recommends that:

1. the Board of Health reaffirm the Prudent Avoidance Policy approach for radiofrequencies (RF) that would keep levels in areas where people normally spend time at least 100 times lower than Health Canada's *Safety Code 6* limits when siting new telecommunication towers and antennas in the City of Toronto;
2. the Board of Health recommend that City Council endorse a Prudent Avoidance Policy and use the new City of Toronto Telecommunication Tower and Antenna Protocol as a mechanism for collecting information on the estimated levels of radiofrequencies around cell phone towers and antennas in areas where people normally spend time;
3. the Board of Health recommend to Health Canada that public exposure limits for radiofrequency fields under *Safety Code 6* be made 100 times more strict as previously recommended by the Board of Health;
4. the Board of Health recommend to cell phone carrier proponents to consider voluntary adoption of the Prudent Avoidance Policy when proposing sites for new telecommunication towers and antennas, including considering proposed alternative sites when the City's review identifies potential concerns; and

5. the Board of Health encourage Industry Canada to conduct regular monitoring for radiofrequencies arising from telecommunications structures in Toronto, and to make that information publicly available.

APPENDIX 3: HESA, 2010. An examination of the potential health impacts of Radiofrequency electromagnetic radiation. House of Commons Standing Committee on Health.
http://www2.parl.gc.ca/HousePublications/Publication.aspx?DocId=4834477&Language=E&Mode=1&Parl=40&Ses=3&File=27

Recommendations:

1. The Government of Canada consider providing funding to the Canadian Institutes of Health Research in support of long-term studies examining the potential health impacts of exposure to radiofrequency electromagnetic radiation.
2. Health Canada request that the Council of Canadian Academies or another appropriate independent institution conduct an assessment of the Canadian and international scientific literature regarding the potential health impacts of short and long-term exposure to radiofrequency electromagnetic radiation, which would include an examination of electromagnetic sensitivity and a comparison of public policies in other countries governing exposure to radiofrequency electromagnetic radiation; and report on its findings.
3. Health Canada and Industry Canada develop a comprehensive risk awareness program for exposure to radiofrequency electromagnetic radiation, which would include Health Canada making public in an accessible and transparent way all the studies and analyses undertaken by the Department on the impact of radiofrequency electromagnetic radiation on human health, as well as the provision of information promoting the safe use of wireless technologies.
4. Health Canada and Industry Canada offer to provide information, including awareness sessions on exposure to radiofrequency electromagnetic radiation.
5. Health Canada ensure that it has a process in place to receive and respond to reports of adverse reactions to electromagnetic radiation emitting devices.

C 5
COMMUNICATION
CW (WS) March 29/11
ITEM - 2

From: Abrams, Jeffrey
Sent: Tuesday, March 29, 2011 8:01 AM
To: Bellisario, Adelina
Cc: Fernandes, Sybil
Subject: FW: Vaughan Council Telecommunications Protocol
Attachments: 10 out of 14 peer-reviewed studies on base stations.pdf; Dr. Martin Blank, Open letter re Health Effects of Cell Phone Masts.doc; German Doctors unite on RF health effects from masts.doc; 1973 - NRC Canada microwave threat.pdf; Biological Effects of Electromagnetic Radiation IEEE 1984.pdf; 1 Cell phone radiation poses a serious biological and health risk Neil Cherry.doc; Vaughan Council Telecommunications Protocol - Final.doc

Additional communications.

J. A. Abrams

Jeffrey A. Abrams
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Tel: (905) 832-8585 Ext. 8281
Fax:(905) 832-8535
jeffrey.abrams@vaughan.ca

VAUGHAN

From: Tina Catalano [mailto:tina.catalano@sympatico.ca]
Sent: Monday, March 28, 2011 5:54 PM
To: Carella, Tony; Schulte, Deb; Rosati, Gino; Di Biase, Michael; maurizio.bevilaqua@vaughan.ca; Racco, Sandra; Iafrate, Marilyn; DeFrancesca, Rosanna; Shefman, Alan
Cc: Abrams, Jeffrey
Subject: Fw: Vaughan Council Telecommunications Protocol

Please see the email below.

A deputation will be made at tomorrow's meeting on behalf of Martin Weatherall.

Thanks,

Tina

----- Original Message -----
From: Martin Weatherall
To: Tina Catalano ; Tina Catalano
Sent: Monday, March 28, 2011 3:03 PM
Subject: Vaughan Council Telecommunications Protocol

Tina Catalano
Vaughan, Ontario.

Dear Tina

I have attached a letter and six documents for the City of Vaughan Telecommunications Protocol Committee, Session March 29, 2011, 9:30am.

Please present this information to the committee on my behalf.

Yours sincerely

Martin Weatherall

10 out of 14 peer-reviewed studies on base stations found significant increases in symptoms and conform to WHO standards of scientific quality

10 out of 14 peer-reviewed studies both found significant increases in the symptoms being analysed, and conformed to the specified WHO / ICNIRP standards of scientific quality, including their assessment criteria of consistency and replication. This review about studies on base stations will appear in a special issue of Pathophysiology. Included are only those studies that are about base station exposures and not those that used mobile phone radiation patterns but exposed in the far field. Therefore some studies that could in principle be included because they studied far field exposure are not among those considered in this review (presented by Dr Michael Kundi on Sept 23, 2008 at the London EMF International Conference).

1. **R. Santini**, P. Santini, J.M. Danze, P. Le Ruz, M. Seigne, Enquête sur la santé de riverains de stations relais de téléphonie mobile : I/Incidences de la distance et du sexe. Pathol Biol (Paris) 50 (2002) 369-373.
2. **R. Santini**, P. Santini, J.M. Danze, P. Le Ruz, M. Seigne, Enquête sur la santé de riverains de stations relais de téléphonie mobile : II/ Incidences de l'âge des sujets, de la durée de leur exposition et de leur position par rapport aux antennes et autres sources électromagnétiques. Pathol Biol (Paris) 51 (2003) 412-415.
3. **M. Blettner**, B. Schlehofer, J. Breckenkamp, B. Kowall, S. Schmiedel, U. Reis, P. Potthoff, J. Schüz, G. Berg-Beckhoff, **Querschnittstudie zur Erfassung und Bewertung möglicher gesundheitlicher Beeinträchtigungen durch die Felder von Mobilfunkbasisstationen**. BfS (2007).
4. **E.A. Navarro**, J. Segura, M. Portoles, C. Gomez-Perretta de Mateo, The microwave syndrome: a preliminary study in Spain. Electromagnetic Biol Med 22 (2003) 161-169.
5. **H-P. Hutter**, H. Moshammer, P. Wallner, M. **Kundi**, Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup Environ Med 63 (2006) 307_313.
6. **G. Abdel-Rassoul**, O. Abou El-Fatech, M. Abou Salem, A. Michael, F. Farahat, M. El-Batanouny, E. Salem, Neurobehavioral effects among inhabitants around mobile phone base stations. Neurotoxicology 28(2) (2006) 434-440.
7. **S. Heinrich**, A. Ossig, S. Schlittmeier, J. Hellbrück, Elektromagnetische Felder einer UMTS-Mobilfunkbasisstation und mögliche Auswirkungen auf die Befindlichkeit : eine experimentelle Felduntersuchung. Umwelt Med Forsch Prax 12 (2007) 171_180.
8. **S. Thomas**, A. Kühnlein, S. Heinrich, G. Praml, D. Nowak, R. von Kries, K. Radon, Personal exposure to mobile phone frequencies and well-being in adults: a cross-sectional study based on dosimetry. Bioelectromagnetics 29 (2008) 463-470.
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10. **H. Eger**, K.U. Hagen, B. Lucas, P. Vogel, H. Voit, Einfluss der räumlichen Nähe von Mobilfunksendeanlagen auf die Krebsinzidenz. Umwelt-Medizin-Gesellschaft 17 (2004) 273-356.
11. **R. Wolf**, D. Wolf, Increased incidence of cancer near a cellphone transmitter station. Int J Cancer Prev 1 (2004) 123-128.
12. **A.P.M. Zwamborn**, S.H.J.A. Vossen, B.J.A.M. van Leersum, M.A. Ouwens, W.N. Mäkel, Effects of Global Communication System Radio-Frequency Fields on Well being and Cognitive Functions of Human Subjects with and without Subjective Complaints. FEL-03-C148. The Hague, the Netherlands:TNO, 2003.
13. **S.J. Regel**, S. Negovetic, M. Röösli, V. Berdinas, J. Schuderer, A. Huss, U. Lott, N. Kuster, P. **Achermann**, UMTS base station like exposure, well being and cognitive performance. Environ Health Perspect 114 (2006) 1270_1275.
14. **S. Eltiti**, D. Wallace, A. Ridgewell, K. Zougkou, R. Russo, F. Sepulvelda, D. Mirshekar-Syahkal, P. Rasor, R. Deeble, E. Fox, Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomised provocation study. Environ Health Perspect 115 (2007) 1603_1608.

FEASABILITY STUDY: 1

NO SIGNIFIANT SYMPTOMS: 3

SIGNIFICANT SYMPTOMS: 10

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September 11, 2008

An open letter to
Mayor Young and the Langford Council
Langford, B.C.
Re: Health effects of cell tower radiation

I have been an active researcher on biological effects of electromagnetic fields (EMF) for over twenty five years at Columbia University. I was also one of the organizers of the 2007 online Bioinitiative Report on the subject. Because of this background, I have been asked to provide background information regarding current discussions about the proposed cell tower.
There is now sufficient scientific data about the biological effects of EMF, and in particular about radiofrequency (RF) radiation, to argue for adoption of precautionary measures. We can state unequivocally that EMF can cause single and double strand DNA breakage at exposure levels that are considered safe under the FCC guidelines in the USA. As I shall illustrate below, there are also epidemiology studies that show an increased risk of cancers associated with exposure to RF. Since we know that an accumulation of changes or mutations in DNA is associated with cancer, there is good reason to believe that the elevated rates of cancers among persons living near radio towers are probably linked to DNA damage caused by EMF. Because of the nature of EMF exposure and the length of time it takes for most cancers to develop, one cannot expect 'conclusive proof' such as the link between helicobacter pylori and gastric ulcer. (That link was recently demonstrated by the Australian doctor who proved a link conclusively by swallowing the bacteria and getting the disease.) However, there is enough evidence of a plausible mechanism to link EMF exposure to increased risk of cancer, and therefore of a need to limit exposure, especially of children.
EMF have been shown to cause other potentially harmful biological effects, such as leakage of the blood brain barrier that can lead to damage of neurons in the brain, increased micronuclei (DNA fragments) in human blood lymphocytes, all at exposure rates well below the limits in the current FCC guidelines. Probably the most convincing evidence of potential harm comes from living cells themselves when they start to manufacture stress proteins upon exposure to EMF. The stress response occurs with a number of potentially harmful environmental factors, such as elevated temperature, changes in pH, toxic metals, etc. This means that ***when stress protein synthesis is stimulated by radiofrequency or power frequency EMF, the body is telling us in its own language that RF exposure is potentially harmful.***
There have been several attempts to measure the health risks associated with exposure to RF, and I can summarize the findings with a graph from the study by Dr. Neil Cherry of all childhood cancers around the Sutro Tower in San Francisco between the years 1937 and 1988. Similar studies with similar results were done around broadcasting antennas in Sydney, Australia and Rome, Italy, and there are now studies of effects of cellphones on brain cancer. The Sutro tower contains antennas for broadcasting FM (54.7 kW) TV (616 kW) and UHF (18.3 MW) signals over a fairly wide area, and while the fields are not uniform, and also vary during the day, the fields were measured and average values estimated, so that one could associate the cancer risk with the degree of EMF exposure.

The data in the figure are the risk ratios (RR) for a total of 123 cases of childhood cancer from a population of 50,686 children, and include a 51 cases of leukaemia, 35 cases of brain cancer and 37 cases of lymphatic cancer. It is clear from the results that the risk ratio for all childhood cancers is elevated in the area studied, and while the risk falls off with radial distance from the antennas, as expected, it is still above a risk ratio of 5 even at a distance of 3km where the field was $1\mu W/cm^2$. This figure is what we can expect from prolonged RF exposure. In the Bioinitiative Report, we recommended $0.1\mu W/cm^2$ as a desirable precautionary level based on this and related studies, including recent studies of brain cancer and cellphone exposure..
As I mentioned above, many potentially harmful effects, such as the stress response and DNA strand breaks, occur at nonthermal levels (field strengths that do not cause a temperature increase) and are therefore considered safe. It is obvious that the safety standards must be revised down to take into account the nonthermal as well as thermal biological responses that occur at much lower intensities. Since we cannot rely on the current standards, it is best to act according to the precautionary principle, the approach advocated by the European Union and used by the scientists involved in the Bioinitiative report. In light of the current evidence, the precautionary approach appears to be the most reasonable for those who must protect the health and welfare of the public.

Martin Blank, Ph.D.
Associate Professor of physiology and cellular biophysics

German Doctors unite on RF health effects from masts

Summary:

A number of German doctors are combining together to put forward their observations of adverse health effects from pulsed high-frequency EMFs (microwave) to the Prime Minister, Dr. Edmund Stoiber. The health effects include headaches, tiredness, inability to concentrate and dizziness, and show an alarming trend.

The following is a foreword written by the doctor who is representing the group, **Dr. Cornelia Waldmann Selsam**:

http://www.tetrawatch.net/links/links.php?id=stoiberlet

http://www.tetrawatch.net/links/links.php?id=stoiberlet- Open letter to Edmund Stoiber, Prime Minister, Germany

These reports show that the people for years have been ill due to pulsed high frequency electromagnetic fields, without the treating doctors recognising the cause. For that reason, people who are receiving the high frequency at home or at work have suffered and are suffering and they receive no therapy. The deciding [effective] therapy is to end the exposure.

The continually repeated assertion in the media by the Radiological Protection Commission (Strahlenschutzkommission), that there is no proof for health risks under the present valid limits, has had the consequence that most doctors, (including myself until a year ago) have not drawn a relationship between the many unexplained illness patterns and high frequency radiation. The doctors do not know that at not one single mobile phone base station have investigations into the health-state of the people been carried out. Thus, the evaluation of the Strahlenschutzkommission in 2001 has no scientific basis.

In Oberfranken, we have just evaluated the medical complaints of 356 people who have had long-term [radiation] exposure in their homes.

- The pulsed high frequency electro magnetic fields (from mobile phone base stations, from cable-less DECT telephones, amongst others), led to a new, previously unknown pattern of illnesses with a characteristic symptom complex.

- People suffer from one, several or many of the following symptoms: Sleep disturbances, tiredness, disturbance in concentration, forgetfulness, problem with finding words, depressive mood, ear noises, sudden loss of hearing, hearing loss, giddiness, nose bleeds, visual disturbances, frequent infections, sinusitis, joint and limb pains, nerve and soft tissue pains, feeling of numbness, heart rhythm disturbances, increased blood pressure episodes, hormonal disturbances, night-time sweats, nausea.
- Even at **$10\mu W/m^2$** (only 0.06 V/m average) many people are becoming ill.
- The symptoms occur in temporal and spatial relationship to exposure. It is no way only a subjective sensitivity disturbance. Disturbances of rhythm, hearing problems, sudden deafness, hearing loss, loss of vision, increased blood pressure, hormonal disturbances, concentration impairments, and others can be proved using scientific objective measures.
- Some of the health disturbance disappears immediately the exposure ceases (removal of DECT telephone, temporary moving away from home, permanently moving away, using shielding).

Therefore, the expansion must be stopped immediately. Mobile phone base stations, in whose fields people are exposed to more than $10\mu W/m^2$ must be turned off.
DECT telephones must be changed.
Affected people, relatives and doctors must jointly commit themselves and work together with all their energy [to this end].
Evaluation of symptoms of 356 people under long time home exposure to high frequency pulsed electromagnetic fields (DECT,telephones, mobile phone base stations) versus the level of the power flux density in microwatts per square metre.

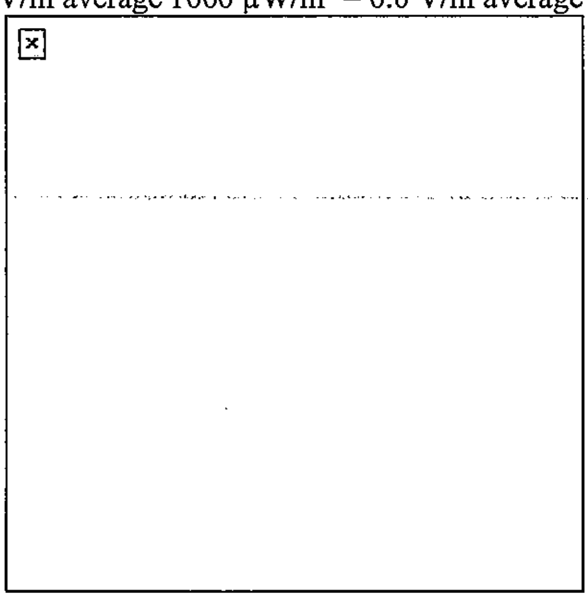
Foreword - Documented Health Damage under the Influence of High Frequency Electromagnetic Fields

Dr. Cornelia Waldmann Selsam, Karl-May-Str.48, 96049 Bamberg

The results of the evaluations are as follows: (* See below the graph for the definitions of the "Symptom Groups")

It is worth explaining the indicated levels. The values convert approximately as follows:

- $10\ \mu W/m^2$ = 0.06 V/m average
- $100\ \mu W/m^2$ = 0.2 V/m average $1000\ \mu W/m^2$ = 0.6 V/m average



*** The symptom groups are defined as follows:**
Group 1: No symptoms
Group 2: Sleep disturbance, tiredness, depressive mood
Group 3: Headaches, restlessness, dazed state, irritability, disturbance of concentration, forgetfulness, learning difficulties, difficulty finding words.
Group 4: Frequent infections, sinusitis, lymph node swellings, joint and limb pains, nerve and soft tissue pains, numbness or tingling, allergies
Group 5: Tinnitus, hearing loss, sudden hearing loss, giddiness, impaired balance, visual disturbances, eye inflammation, dry eyes
Group 6: Tachycardia, episodic hypertension, collapse
Group 7: Other symptoms (Hormonal disturbances, thyroid disease, night sweats, frequent urge to urinate, weight increase, nausea, loss of appetite, nose bleeds, skin complaints, tumours, diabetes)

If true, this is a very clear trend. For those where it is under 10 $\mu W/cm^2$ 70% of the sample (37 people) suffered no adverse health effects. For those where the power flux density is over 100 $\mu W/cm^2$ only 5-6% of the sample (172 people) did not experience adverse health effects. **Please look at <u>this</u> graph to see how these levels translate to exposure from a typical mast. Microwave signals are often above 0.6 V/m within 400 metres!** There are no counfounding factors listed in the data, but the strength of the trend is extremely pronounced.

This is further evidence to support the potential adverse health effects that may be synonymous with the pulsed Microwave technology that surround us in everyday life. Those in the medical profession are beginning to voice their concerns, and it is worth bearing in mind that they have first hand experience of real people with real problems. It is important not to discard this evidence due to lack of experimental control, as it seems that a number of qualified professionals have independently found the same trends. At the very least this should call for more organised research into these findings.

Romero-Sierra to J. Beal
8/7/73

DIVISION OF MECHANICAL ENGINEERING

DIVISION DE GÉNIE MÉCANIQUE

CANADA

PAGES / PAGES 26

FIG. / DIAG.

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ENVIRONMENTAL POLLUTION BY MICROWAVE RADIATION - A POTENTIAL THREAT TO HUMAN HEALTH

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PREFACE

This report concerns work that is part of a program of research on the effects of electromagnetic fields on living tissue conducted in collaboration with the Department of Anatomy, Queen's University, Kingston, Ontario, Canada.

ABSTRACT

Due to the ever-growing application of microwave devices in ind.ustry, research, for military purposes, and domestic appliances (encouraged in part by the advent of economic solid state microwave devices) microwave background radiation may increase to a dangerous level in the near future. This presents a potential threat to human health and measures must be taken to control the proliferation of these devices and their applications.

Power density, the presently accepted index of health hazard, is reviewed. Electric and magnetic field vectors are recommended in its place as meaningful parameters in the evaluation of non-ionizing radiation hazards.

A brief discussion on "weak interactions" between microwave radiation and biological systems is presented.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

It is only in recent years that man has become fully aware of the potential hazards created by his own generated pollution of the environment. Not only is he starting, to, gain full significance of its effects on his health but also on the complex chain of events that characterize natural ecosystems of which he is a small part.

Pollutants in general can be divided into two main groups according to their origin:

1. Man-made pollutants
1. Naturally occurring pollutants .

We are mainly concerned here with what we believe will be a major problem to mankind in the near future -that of microwave pollution of the environment by man-made microwave sources.

2. 0 MICROW AVE SOURCES

The term microwave refers to wavelength. The term is used to describe that portion of the electromagnetic spectrum ranging from about 30 centimeters to about 3 millimeters (i.e., from 1 GHz to 100 GHz in frequency terms, see Figure 1).

Microwaves are widely used. Some typical applications include:

1. Tracking and Navigation (radar installations).
2. Communications, i.e., telephone and television transmission (ground and satellite installations).
3. Research, i.e. , radioastronomy, spectroscopy, MW electron accelerators
4. Industrial appliances, i.e. , MWovens, freeze dryers, sterilizers, etc .
5. Domestic appliances, i.e. , MW ovens.

Since most of the above uses require very expensive MW power devices such as klystrons and magnetrons, only industrial, military and research establishments can operate these costly installations. However, the advent of radically new types of MW generators[1] introduced during the past few years will most probably dramatically change this state of affairs. The new MW generators are of the solid-state type and are considerably cheaper than MW tubes. They include:

1. Gunn oscillators
2. Limited space-charge accumulation diodes (L. S. A.)
3. Read diodes
4. Impatt diodes

These devices are practically battery operated and their cost is expected to drop to a few dollars per unit in the next few years. They are reliable and though their power output is at present limited to less than 1 watt in most cases, it is only a matter of time before solid state MW-technology will have advanced to much higher power MW devices.

From a cost point of view it is easy to foresee the many different domestic and other applications[2] that could be found for MW, so it may be anticipated that MW devices will become widely used in the near future. The uncontrolled proliferation of MW devices would considerably increase the ambient level of MW radiation in a highly complex and unpredictable fashion.

Since the object of this paper is to bring attention to the potential threat that uncontrolled and irresponsible use of these devices could place on human beings, animals and vegetation, we mention in passing a few of the possible major contributors to the MW radiation background:

1. Domestic and private uses of MW devices, i.e., MW ovens, etc.
2. Use in cars of collision avoidance radar systems, etc .
3. Traffic signalling systems
4. Utility poles
5. Extensive ground communications where the need of closely spaced repeaters is required due to MW attenuation
6. Large scale satellite-earth communications.

3.0 <u>BIOLOGICAL CONSIDERATIONS OF MICROWAVE RADIATION</u>

In view of the lack of knowledge on the biological effects of microwave radiation, the following actions are required:

1. A systematic study of the biologic al effects of MW radiation must be initiated, and
2. The maximum permissible MW radiation levels for occupational workers and public in general must be determined.

Extensive but somewhat inconclusive and controversial studies have been conducted in both areas. An excellent source of references up to 1965 is given by Pressman[3]. Since then, many other publications on this subject have appeared including our own contributions[4-23].

The interaction of microwaves with living systems13 is a subject of extreme complexity, as depicted by the block diagram of Figure 2. .In this diagram an arbitrary division has been made between wave and non-wave effects in order to point out some of the wave effects common , to all electromagnetic radiation. Some of these interactions can be correlated with the biological effects elicited. However, a considerable amount of work has yet to be done in this field to elucidate the subtleties that would lead to an understanding of the observed effects at very low radiation levels.

In the study of the effects of MW on living systems consideration must be given to (i) energy level of radiation and (ii) exposure time.

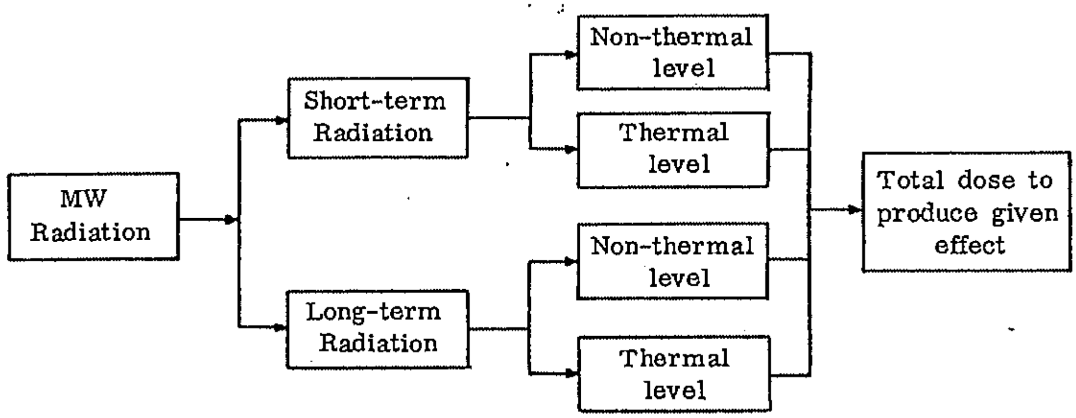
Radiation levels can be divided into two categories:

1. Thermal
2. Non-thermal.

This division requires some clarification. Irradiation intensities below 10 mW /cm2 are considered athermal (non-thermal) for both pulsed and CW beams, either with general or local irradiation of humans and animals. At a power level of 10 m W /cm2 , the energy transformed into heat in the body is roughly equal to the heat loss per square centimeter of body surface of humans and warm-blooded animals under normal environmental conditions.

Further, effects related to exposure time can be divided into two categories: (i) short-term and (ii) long-term.

Exposure time and energy level of radiation together with the observed biological effects are three of the factors which determine the maximum permissible radiation levels, as shown by the following block diagram.



Because of the dramatic effects produced by thermal MW levels resulting in permanent damage and/or death of the biological specimen under irradiation, the short-term thermal level combination has been the most fruitful area of experimentation. Little work has been done on the short-term non-thermal and long-term non-thermal modes of MW radiation.

Since it is reasonably easy to detect and monitor high radiation levels we emphasize the importance of the last two irradiation modes . From these we consider the long term non-thermal combination as being of the utmost importance in the near future because of the doubt we have expressed concerning the uncontrolled proliferation of MW devices .

With this in mlnd a systematic investigation should be undertaken to determine the "safe" levels of exposure for man, animals, plants and various other organisms.

4.0 SAFETY LEVELS

International accord has not been achieved as yet on safe exposure levels in the short and long-terms. Microwave radiation exposure levels for safe whole body radiation ranged from 100 cW/cm^2, originally established in the USA, to 10 $\mu W/cm^2$ established by the USSR, for exposure durations of one day. Recently 10 mW/cm^2 has been accepted in the USA as a safe level for a period of 0.1 h.[24,25].

The latter is a lower limit for thermal effects to take place and therefore does not take into account biological effects likely to occur at the non-thermal level. However, recent reports in the Russian literature describe harmful effects arising from MW radiation of low intensity on people living and working near radar installations. This confirms our own experimental findings in another area.

We mention in passing that although natural MW sources have received practically no attention, such natural pollutants may prove to be of utmost importance in the future.

The status quo of safety levels established by different countries is an indication of the lack of knowledge of the extent of biological effects. The presently accepted safety levels in several countries are summarised in Table I.

All the safety levels are given in terms of MW power (flux levels). Furthermore, and this is not apparent from Table I, these standards have been established by assuming plane waves of linear polarization travelling in free-space reaching points of interest located in the far zone of the radiating element, and far from any disturbing component -- including the biological specimen itself.

In addition, normal incidence of the wave on the specimen is usually assumed together with the fact that the size of the object is much larger than the wavelength of the incident radiation.

Also, standard environmental conditions of temperature, humidity and pressure are postulated and no previous history of the biological system is taken into consideration. In other words the system is assumed to be "normal".

These are indeed very strong assumptions that raise questions as to the validity of the nowadays commonly accepted standards of safe exposure.

5.0 QUANTIFICATION OF M!CROWAVE FIELDS

Power density (Real part of Poynting's vector) has traditionally been used as a parameter of the biological effects associated with a microwave field. Safety standards for levels of exposure have been set based on this concept. The usual procedure is to calculate the power density from the microwave source in the far zone (in free space) where the plane wave approximation is valid

Country	Radiation Level	Period	Remarks
USA and Western European Countries	10 mW/cm^2	0.1 h	
USSR	10 $\mu W/cm^2$	Working day*	
	10-100 $\mu W/cm^2$	2 h/day	Obligatory use of protective glasses
	1000 $\mu W/cm^2$	15-20 m/day	" " " "
Czechoslovakia	25 $\mu W/cm^2$	Working day	Occupational workers, CW
	10 $\mu W/cm^2$	Working day	" " , Pulsed
	2.5 $\mu W/cm^2$	Continuous**	Other workers, CW
	1.0 $\mu W/cm^2$	Continuous	" " , Pulsed

* 8 h/day
** 24 h/day

TABLE I : MAXIMUM MEAN VALUES OF SAFE MICROWAVE IRRADIATION ACCEPTED IN CERTAIN COUNTRIES and set an upper limit to this level as biologically significant for a given biosystem of known electromagnetic characteristics. In this approach the following is further assumed:

1. The object under illumination is semi-infinite in size.
2. The illuminated object and radiating element are far from any reflecting surfaces .
3. No reflection of radiation takes place from the illuminated object in the direction of the radiating element.
4. The radiation field is not affected by the object under illumination .

The above implies that no Electromagnetic Interference (EMI) takes place and that resonance effects are neglected.

It is not difficult to see that none of the above prêmise are satisfied. Firstly, the energy absorbed by an object is dependent upon its shape and physical dimensions[25], particularly when the wavelength of the incident radiation is of the same order of magnitude as the dimensions of the object itself. Secondly, the object (biosystem) creates a strong disturbance of the field. Thirdly, unless the object is completely transparent or a perfect absorber of microwaves, a standing. wave (SW) will be formed between the radiating element and the illuminated object. Fourthly, objects (including radiating elements) interact with partially reflecting surfaces such as walls , ground, etc. Thus complicated Interference Patterns (IP) arise in most cases.

Even in the far zone of a radiating element (where $D \geq n \frac{a^2}{\lambda}$ with > 1) power density measurements performed in the absence of the object are of very limited value. The situation is worsened because illumination takes place very often in the intermediate and near zones of radiating elements where complex multipath fields (MF) occur and where plane wave approximations are invalidated. For instance, wave-fronts due to cracks, slots, etc. , would be of spherical or cylindrical form for which certain parts of the body (or the body as a whole) cylindrically, or spherically shaped would respond differently from the case where the wavefront is a plane wave. Thus, in most cases information at a given point of the amplitude of the components and phase of the magnetic (electric) field gives no information regarding the electric (magnetic) field at that point.

The alternative of calculating the power density inside the illuminated object as representative of the biological effects induced by the radiation (apart from practical difficulties) is even more complicated and ambiguous. A simple fact will clarify the difficulties. For instance, once the wave front has reached the object of interest the transmitted electric and ~ magnetic fields are out of phase by an angle ϕ which depends upon the properties of the medium and the frequency of the imposed radiation. Because of this phase the power density concept loses its meaning since the maxima and minima of E and H does not take place at the same time and so E/H varies widely in time and from point to point at a given time.

Assuming that the fields inside the object are given by:

$$\underline{E} = E_o \; e^{-\beta \underline{n}.x} \; e^{i(\alpha \underline{n}.\underline{x} - \omega t)} \qquad \ldots.(1)$$

$$\underline{H} = \underline{H}_o \; e^{-\beta n.x} \; e^{i(\alpha \underline{n}.\underline{x} - \omega t)} \qquad \ldots.(2)$$

it is easy to show that for a conducting medium[26] (i.e., biological tissues and fluids)

$$\underline{H}_o = \sqrt{\frac{\epsilon}{\mu}} \left[1 + \left(\frac{4\pi\sigma}{\omega\epsilon}\right)^2\right]^{1/4} e^{i\phi} \; (\underline{n} \times \underline{E}_o) \qquad \ldots.(3)$$

where ϕ (phase angle) = $1/2 \tan^{-1}\left(\frac{4\pi\sigma}{\omega\epsilon}\right)$ ....(4)

Equation 3 simply means that $\underline{H}$ lags $\underline{E}$ in time by the phase angle ϕ.

In addition the ratio H_o/E_o is given by[26]

$$\frac{H_o}{E_o} = \sqrt{\frac{\epsilon}{\mu}} \left[1 + \left(\frac{4\pi\sigma}{\omega\epsilon}\right)^2\right]^{1/4} \qquad \ldots.(5)$$

which indicates that as σ increases the field energy is mainly magnetic in nature .

Due to the phase angle between the fields it is possible to have zero instantaneous power density (i. e ., one of the fields being zero at some instance of time) and arbitrarily large electric (magnetic) energy density, and electric (magnetic) field strength.

A. further complication arises from the fact that the ratio £/H varies along the path of the electromagnetic wave (£MW} due to the different absorption coefficients of the medium for electric and magnetic fields. For example, if one deals with a medium of high electrical conductivity the field will be magnetic itl nature due to the absorption of the electric field as the wave penetrates into the system. Conversely, in a medium of low electrical conductivity and high magnetic susceptibility the field will be predominantly electric .

To appreciate the intrinsic ambiguity of power density measurements in relation to biological effects, consider the following. In the near zone of a radiating element (few wavelengths from the source) the time-averaged power density is zero (energy bouncing back and forth) , yet the electric and magnetic fields associated with the wave may be arbitrarily large (and therefore their energy densities). In some regions near the antenna only a magnetic field exists with no electric field present. There,the power density is zero, but the magnetic energy density may be arbitrarily large.

The standing wave formed by two single plane waves travelling in opposite directions but of the same linear polarization and amplitude has a zero time-average power density. However, the magnetic and electric energy densities associated with the standing wave may be as high as four times that of the original waves at some points.

Once the fictitious nature of power density has been established it remains to decide what quantities are meaningful for quantifying MW fields in relation to their biological effects. In this regard energy density (electric U_E, magnetic U_M, and Total U), the strength and orientation .of the fields (electric and magnetic) and their squared magnitudes (E^2, and H^2) are likely candidates[13].

It is not an easy task to determine which of these parameters is more meaningful from the biological standpoint due to the fact that some biologic al effects are known to depend on the square of the electric and/or magnetic field intensities. Others are determined by the strength and orientation of the fields. Examples of the first kind are those effects depending on energy absorption (electric, magnetic, or both). It will be noted that energy density is proportional to the square of the field intensity where the proportionality factor is the real part of the complex dielectric and/or magnetic permeability. On the other hand some effects fall in the second category such as some magnetomechanical and electromechanical phenomena, field forces on charged particles (Lorentz force) , orientation effects, pearl chain formation, etc .

We believe that the field vectors (strength and orientation of E, and H) are more fundamental parameters than their corresponding squared magnitudes or energy densities because ultimately all biological effects (thermal, or non-thermal) are directly related to them.

The properties of an anisotropic medium with respect to an Electromagnetic Wave (EMW) are defined by the two tensors $\in_{ik}(\omega)$ and $\mu_{ik}(\omega)$ which give the relation between the inductions and the fields:

$$D_i = \epsilon_{ik}(\omega)\, E_k \quad \text{and} \quad B_i = \mu_{ik}(\omega)\, H_k \qquad \text{.....(6)}$$

where both ϵ_{ik} and μ_{ik} are symmetrical tensors.

For a transparent anisotropic medium, the internal Electromagnetic Energy (EME) per unit volume (energy density) is[27]

$$\bar{U} = \frac{1}{16\pi}\left[\frac{d}{d\omega}(\omega\epsilon_{ik})\, E^*_i E_k + \frac{d}{d\omega}(\omega\mu_{ik})\, H^*_i H_k\right] \qquad \text{.....(7)}$$

For the case where absorption of the EME takes place (i.e., electric losses), we have[27]

$$\frac{i\omega}{8\pi}\left[(\varepsilon^*_{ik}-\varepsilon_{ki})\,E_i\,E^*_k+(\mu^*_{ik}-\mu_{ki})\,H_iK_k^*\right] \quad \ldots.(8)$$

These expressions are greatly simplified for the case of an isotropic medium.

In the case of an isotropic transparent dispersive medium the energy density becomes[27]

$$\bar{U}=\frac{1}{16\pi}\left[\frac{d}{d\omega}(\omega\varepsilon)\,\underline{E}.\underline{E}^*+\frac{d}{d\omega}(\omega\mu)\,\underline{H}.\underline{H}^*\right] \quad \ldots.(9)$$

where ε and μ are functions of ω, i.e., $\varepsilon(\omega)$, and $\mu(\omega)$

Equation (8) can be further simplified for a non-dispersive medium to give

$$\bar{U}=\frac{1}{8\pi}\left[\varepsilon\,\underline{E}^2+\mu\,\underline{H}^2\right] \quad \ldots.(10)$$

In the case where absorption of electromagnetic energy takes place the losses are given by

$$\frac{\omega}{4\pi}\left[\varepsilon''\,\overline{\underline{E}}^2+\mu''\,\overline{\underline{H}}^2\right] \quad \ldots.(11)$$

where an accounting of the law of increase of entropy yields

$\varepsilon''(\omega) > 0$ and $\mu''(\omega) > 0$ except for $\omega = 0$ for all substances at all

frequencies. ε'' and μ'' are the imaginary part of the complex dielectric ε and magnetic permeability

$$\varepsilon = \varepsilon' + i\,\varepsilon''$$

$$\mu = \mu' + i\,\mu''$$

6.0 PERMISSIBLE LEVELS

I

Permissible levels are based on the appearance of some biological effect. Because heat is usually involved in the interaction of a MW field with the biosample, effects we.re first observed at MW levels that produced a measurable increase in the temperature of the specimens. Western countries based their maximum permissible levels on this level. Tissue and biological fluids being lossy materials of relative high electrical conductivity, high Ohmic losses occur in them which are proportional to σE^2. Thus the effect of an electric field (or its magnitude squared) has predominance over the magnetic field.

Strong experimental evidence of biological effects produced at much lower MW levels than those set by Western countries forced Eastern countries (where low-level studies were pioneered) to lower 1u those levels by a factor of 1000. In both cases, nevertheless, safety levels are mainly based on short-term irradiation whether or not they are thermal in nature. That is, effects that appear during an irradiation time much shorter than the life span of the system under consideration. It is therefore possible (and almost certain) that lower field levels may induce biological effects in the long term.

It is important to note that the effect that the magnetic field associated with the MW may have in the biological system has received very little consideration.

In the region where the predominant effects are thermal in nature it is obvious that the electric field plays a key role. In this region subtle non-thermal effects may be obscured by the thermal effects. But actually what happens in the non-thermal region ?

How are the electric and magnetic fields related to a specific non-thermal effect and what sort of interaction on a molecular or macroscopic level takes place? A number of theories have appeared in recent years proposing mechanisms whereby low intensity MW fields can affect biological systems, particularly in regard to effects on the central nervous system (CNS) .

Among the more advanced theories are the following:

1. Batteau[28] suggested as a result of his studies on the mechanism of hearing that sensation in the organisms may be caused by the shifting of the transition probability of electrons from an excited state to the ground state in some organic molecules.

2. A suggestion has been put forward by Berg[29] in which membranes and neural tissues may behave as wax electrets .

3. Wei's[30] theory suggests that the neuron has the potential profile and structure of a p-n-p transistor.

4. Based on experimental evidence of electron transfer taking place in biomolecules

(metabolites, hormones, etc.) Szent-Gyorgy[31] proposed a quantum mechanical theory in which the cell is treated as a solid state system in which the different energy levels that are possible can be occupied by valence electrons fusing into common energy bands.

7.0 WEAK INTERACTION

One can extend the Szent-Gyorgy theory to very large aggregations of like and unlike biomacromolecules to form tissue, organs, or even the whole body. Thus one may picture these as giant complex molecules endowed with practically unlimited numbers of quantum energy states approaching a continuous band distribution. Allowed transitions between different energy states probably constitute the rule and not the exception though this is difficult to foresee without detailed knowledge of transition probabilities between states.

The complicated energy spectrum of such a system is due to complex interactions between. different particles, atoms, functional groups, and molecules making up giant molecules. The structure of their energy spectra would probably consist of various quasicontinuous {or continous) bands (more or less separated by better defined quantum states , etc.) This is due to the different vibrational, rotational, spin, and possibly translational quantum states .

In principle, it is then possible for MW radiation to be absorbed by such a system, inducing in turn a change in quantum state; though only through experimentation is it possible to determine what biological effect would result from this type of interaction. The possibility of a cascade mechanism triggered by a MW photon or by photons of lower or higher energy cannot be ruled out.

Thus the possibility of direct interaction between an EM field and a- macroscopic system such as the human body may be significant.

There are other possibilities. The interaction of an external MW field generated by a living system should also be considered. Little is known about the MW spectrum generated by living organisms. We believe that apart from the so-called black body radiation (Planck's distribution) MW radiation may be produced through specific biophysical mechanisms and chemical reactions. If this is so the continuous spectrum should exhibit maxima and/or minima indicating the generation or absorption by the biological system of MW radiation of non-thermal origin. Currently we are conducting experiments along these lines with an X-band correlation radiometer[32].

Subtle biological effects may also be caused by the magnetic field associated with a MW field. The magnetic field, because of its highly pervasive nature, may in principle affect any, or every, cell in the body of a living system .

Pronounced effects are known to be induced by very weak magnetic fields[33] ranging from afraction of a Gauss to several Gauss. This is the same magnitude of intensity as that commonly encountered in MW fields of moderate energy density. Although most of the experiments have been conducted with DC fields there is no reason to believe that similar effects may not be induced by high frequency magnetic fields. It has been long maintained that the effects of a varying magnetic field are due to the induced emf and currents. However, a change in the magnetic field has been shown to produce direct biological effects[34]. Attention should also be given to the possible influence of the magnetic field on unbounded Ni and Fe. These elements appear in body fluids (plasma, intracellular and extracellular fluids, etc.) and in macromolecules containing ferromagnetic elements *(biomagnetite....jb)* such as iron (hemoglobin) where high magnetic fluxes may be induced.

Many other possibilities fall into what may be referred to as weak interactions. One area of investigation might be the effect of an external MW field on the very low magnetic field known to be produced by the heart, brain, and most recently by skeletal muscles[35]. These fields are in the order of 10^{-7} Gauss (one millionth of the earth's steady magnetic field).

Knowledge of weak interaction is sparse because of the minute strength of these interactions. The tendency is to disregard them on the assumption that they are insignificant. However, biology provides an incredible number of cases that prove otherwise.

We believe investigation into some of these interactions may yield useful and interesting information.

8.0 SOME REMARKS ON MICROWAVE DOSIMETRY

Microwave dosimetry as any other type of dosimetry, is a highly complex matter. Determination of electromagnetic fields inside the system under study is not an easy task because these fields are not related in a simple way to the fields that exist at the same point in space in the absence of the object. This means that either probes have to be implanted in the living system or inside a phantom simulating its characteristics and geometry.

To determine tolerances of MW levels in man one obviously must perform measurements on phantoms since no other animal has man's combined properties of size, shape, skin characteristics, ε^*, μ^*, σ, of tissues, etc. However, it is not possible to simulate (not even approximately) any living system. Not only is it necessary to reproduce the electromagnetic parameters but also the thermal characteristics, cooling mechanism (passive and active) etc., of the system.

Implantation of probes per se introduces a number of problems particularly when it is necessary to determine both field strength and field orientation simultaneously. The latter is very important in cases where field orientation is a determining factor in specific interactions. One further complication arises due to physical dimensions of the probes. Recall that the wavelength (in a medium other than free space) is given by $\lambda_0/\sqrt{\varepsilon'\mu'}$ where λ_0 is the free space wavelength. The complication is more apparent in the centimetric and millimetric regions where electrical performance is greatly affected by the physical size and construction of probes.

9.0 CONCLUSIONS

In view of the expected proliferation of MW devices in many different applications, a substantial increase in MW background activity is feared that may endanger human health. On this basis strict control of the use of these devices must be introduced while present safety standards are revised and extensive research is conducted into long term effects of exposure to low intensity MW radiation. In particular, a study of possible accumulative effects of MW radiation (directly or indirectly) through sensitization must be conducted .

The inadequacy of power density as an index of radiation hazard has been discussed. Meaningful parameters are energy densities (electric and magnetic), electric and magnetic field vectors and their squared magnitudes. We suggest the field vectors to be better quantitative measures to relate to biological effects (thermal or athermal) than their squared amplitudes or energy densities.

Systematic investigations of the weak interactions of MW fields with complex biological systems must be conducted together with exploratory experiments to determine the importance of the magnetic field associated with the EM wave.

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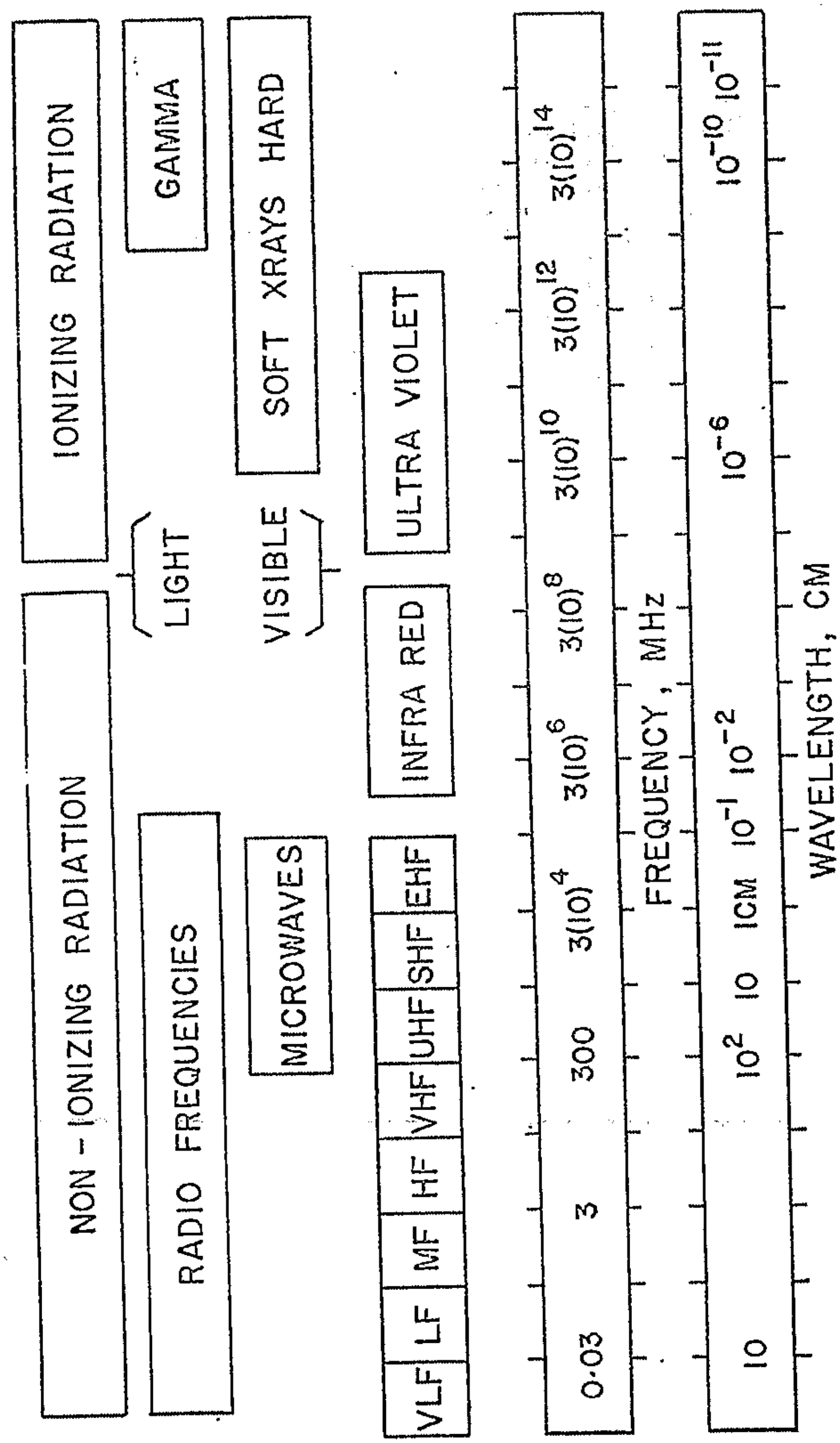
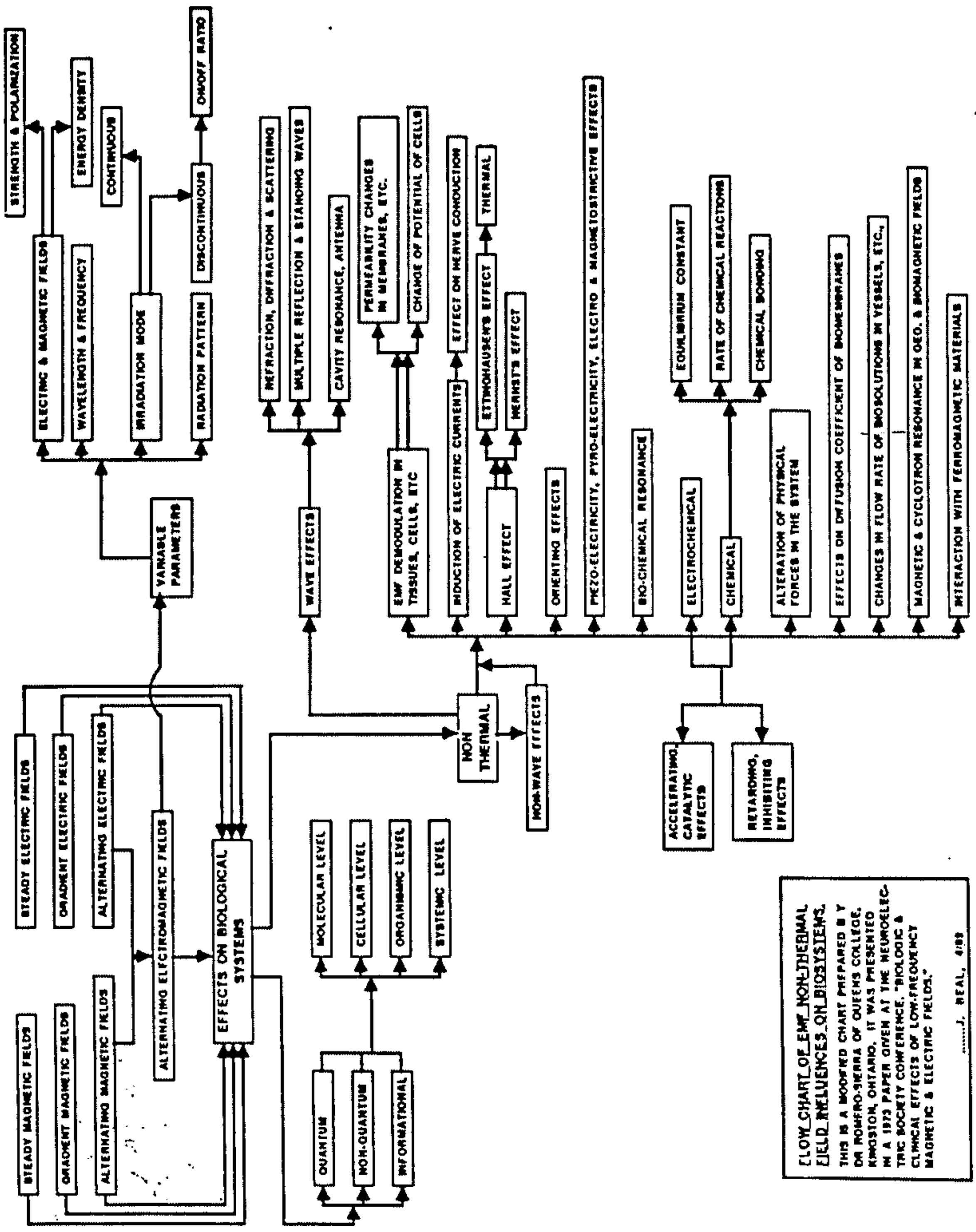


FIG.1: ELECTROMAGNETIC FREQUENCY SPECTRUM


STEADY MAGNETIC FIELDS
GRADIENT MAGNETIC FIELDS
ALTERNATING MAGNETIC FIELDS
ALTERNATING ELECTROMAGNETIC FIELDS
STEADY ELECTRIC FIELDS
GRADIENT ELECTRIC FIELDS
ALTERNATING ELECTRIC FIELDS
EFFECTS ON BIOLOGICAL SYSTEMS
QUANTUM
NON-QUANTUM
INFORMATIONAL
MOLECULAR LEVEL
CELLULAR LEVEL
ORGANISMIC LEVEL
SYSTEMIC LEVEL
VARIABLE PARAMETERS
ELECTRIC & MAGNETIC FIELDS
WAVELENGTH & FREQUENCY
IRRADIATION MODE
RADIATION PATTERN
STRENGTH & POLARIZATION
ENERGY DENSITY
CONTINUOUS
DISCONTINUOUS
ON/OFF RATIO
NON THERMAL
NON-WAVE EFFECTS
WAVE EFFECTS
REFRACTION, DIFFRACTION & SCATTERING
MULTIPLE REFLECTION & STANDING WAVES
CAVITY RESONANCE, ANTENNA
EMF DEMODULATION IN TISSUES, CELLS, ETC
PERMEABILITY CHANGES IN MEMBRANES, ETC.
CHANGE OF POTENTIAL OF CELLS
INDUCTION OF ELECTRIC CURRENTS
EFFECT ON NERVE CONDUCTION
HALL EFFECT
ETTINGHAUSEN'S EFFECT
THERMAL
NERNST'S EFFECT
ORIENTING EFFECTS
PIEZO-ELECTRICITY, PYRO-ELECTRICITY, ELECTRO & MAGNETOSTRICTIVE EFFECTS
BIO-CHEMICAL RESONANCE
ELECTROCHEMICAL
CHEMICAL
EQUILIBRIUM CONSTANT
RATE OF CHEMICAL REACTIONS
CHEMICAL BONDING
ALTERATION OF PHYSICAL FORCES IN THE SYSTEM
EFFECTS ON DIFFUSION COEFFICIENT OF BIOMEMBRANES
CHANGES IN FLOW RATE OF BIOSOLUTIONS IN VESSELS, ETC.,
MAGNETIC & CYCLOTRON RESONANCE IN GEO. & BIOMAGNETIC FIELDS
INTERACTION WITH FERROMAGNETIC MATERIALS
ACCELERATING, CATALYTIC EFFECTS
RETARDING, INHIBITING EFFECTS
FLOW CHART OF EMF NON-THERMAL FIELD INFLUENCES ON BIOSYSTEMS.
THIS IS A MODIFIED CHART PREPARED BY DR ROMERO-SIERRA OF QUEENS COLLEGE, KINGSTON, ONTARIO. IT WAS PRESENTED IN A 1973 PAPER GIVEN AT THE NEUROELECTRIC SOCIETY CONFERENCE, "BIOLOGIC & CLINICAL EFFECTS OF LOW-FREQUENCY MAGNETIC & ELECTRIC FIELDS."
......J. BEAL, 4/83

Reviews and Abstracts

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BOOK REVIEW

BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION edited by John M. Osepchuk, IEEE Press, 1983, 608 pages, member price $47.95.

INTRODUCTION

This IEEE Press book is a collection of about 100 papers on the physical, biological, medical, health, and safety-standards aspects of RF/microwave biological effects. It consists of reprints of papers written by engineers, physicists, and medical and biological professionals. There are seven sections, each compiled by an associate editor who has written a short overview, with its own list of references covering significant papers not reprinted in the book. The book was prepared by some members of the IEEE Committee on Man and Radiation (COMAR). All of the associate editors were on the Committee. While the title uses the term "electromagnetic radiation," this book only considers the RF portion of the EM spectrum.

A critical point that is made in the foreword of the book is the fact that while the book has a publication date of 1983, almost all materials were incorporated in the text in 1979, so the articles in the book are somewhat dated. In this rapidly-changing field, a delay of five years can seriously affect the relevance of this kind of a book. An attempt was made to solve this problem by breaking the book into sections, and having each section's associate editor incorporate an updated summary/bibliography of the literature on that section's subtopic, emphasizing more recent developments. This was only partially effective, as will be mentioned later.

Section I: QUANTITATION OF ELECTROMAGNETIC FIELDS IN BIOLOGICAL SYSTEMS by A. W. Guy

This section provides a good but somewhat incomplete coverage of RF/microwave dosimetry (measurement and theoretical prediction of fields inside biological bodies) via several "overview" papers, and several original works on theoretical and experimental dosimetry. The lack of authoritative overview papers on the important experimental tools for modern dosimetry weakens this section. These tools are the nonperturbing temperature probe, electric and magnetic field survey instruments, and the implantable E-field probe. While one short paper by Bowman is presented on the design of one particular temperature probe, the state of the art, as it now exists, is not covered adequately for any of these tools. Well-written overview papers such as those on thermometry (Cetas, Med. Phys. 5, 1978), on survey instruments (Aslan, IEEE IM-21, 1972) and on implantable E-field probes (Bassen, Radio Science (6S) 1979), should have been included or at least cited in the section's summary/bibliography.

Persons interested in the state-of-the-art of EM bilogical-effects measurements should read the comprehensive book from the National Council on Radiation Protection (NCRP Report 67, Washington, DC, 1981) on radiofrequency electromagnetic fields, properties, quantities and units, and biophysical interaction and measurements. This NCRP book can provide important contemporary material on the state of the art of EM bioeffects dosimetry.

Section II: BIOPHYSICAL CHEMICAL BASIS OF RF FIELD INTERACTIONS by J. W. Frazer

This section covers the complex and interdisciplinary area of the biophysical interaction of RF energy with molecular, cellular, and biological microsystems. Frazer concludes that most effects of RF and microwave radiation in biological systems seem adequately explained as a direct response to a temperature rise. This is a questionable conclusion in light of many recent findings and theories. In situations where the temperature dependence is carefully controlled, nonthermal, quantum-mechanical explanations are necessary, as in the work by Olcerst, quoted by Frazer. Persons interested in this subject should read the publication by Olcerst, et al. (Radiation Research 82, 2, 1980). Also, the excellent collection of papers on mechanisms of interaction entitled "Biological Effects of Nonionizing Radiation," edited by K. H. Illinger (American Chemical Society symposium series No. 157, Washington, DC, 1981) should be read by anyone delving into this subject. It is surprising that in the review paper by Frazer, no mention is made of the Frohlich theory, nor is any of K. H. Illinger's work quoted. An interesting inclusion in this section is a collection of papers entitled "Summaries of Selected Papers from USSR Academy of Sciences." It represents a school of thought on RF bioeffects that believes that effects are induced by levels of RF radiation that are considered insignificant by a majority of Western scientists in this field.

One important new area of RF biophysical interaction was not included in this section. Research on the basis of interactions of pulsed, extremely low frequency (ELF) magnetic fields and pulse-modulated RF fields with biological tissues has become a very active area in the past five years. Of key importance in this area is the concept of electro-chemical information transfer and the interference of electromagnetic fields with this process. Actually, the basic papers on this subject of Basset et al., Chiabrera et al., Pilla et al., span the period from late sixties to the present, and as such should have been cited. Those interested in this subject should read some or all of the following:

Pilla A. A., J. Biol. Physics 11, 51, 1983
Pilla A. A., Advances in Chemistry Series 188, 126, 1980
Pilla A. A., in Mechanism of Growth Control, R. D. Becher ed., C. C. Thomas, Springfield
Beltrame et al., Alta Frequenza 49, 101, 1980
Bassett, C. A. et al., Annals of the N.Y. Academy of Sciences 238, (1974) (242-262).

Section III: EFFECTS OF RADIO FIELDS ON THE CENTRAL NERVOUS SYSTEM AND BEHAVIOR by D. R. Justesen

The associate editor's overview of radiofrequency effects on the central nervous system and behavior is a well-written, concise presentation of most of the available information. Despite some obvious oversights, such as the lack of mention of microwave-drug interactions on behavior, this section's summary/bibliography covers most of the important topic areas and can serve as a starting point for those who wish to pursue specific areas more thoroughly.

The eight papers following this overview do not serve to fully represent the present state of the art on the central nervous system and behavioral effects of RF. For example, two of the eight papers deal with the subject of the "microwave hearing effect." It should be noted that recently, this phenomenon has been shown to be associated with thermoelastic pressure waves generated in the ear, and thus appears to represent a purely mechanical effect, rather than a direct CNS interaction, as was previously assumed. Another paper deals with dosimetric considerations in two RF exposure systems. While these latter three papers are interesting, one must question the wisdom of including many marginally-related papers in a section on central nervous system and behavioral effects. Because of the delay in the publication of this book, a significant portion of the CNS/behavioral papers presented in it were published in the early 1970's. Although such material may have served as a basis for subsequent work, today it is primarily of historical interest. It does not adequately represent the most current information in this critical area of research, nor does it reflect the current state of knowledge of the central nervous system and behavioral effects of RF.

Section IV: PATHOPHYSIOLOGIC ASPECTS OF MICROWAVE/RADIOFREQUENCY ENERGY EXPOSURE by S. M. Michaelson

This section deals with the harmful whole-body effects of RF energy. This is a vast area, so it is almost impossible to select a few papers and obtain an adequate collection. The brief introduction by S. M. Michaelson consists almost exclusively of caveats concerning the proper design and execution of experiments, and would apply to any area of biomedical research. One is left with the impression that very few, if any solid data on RF/MW bioeffects are available. This associate editor even states that in the appended bibliography, papers were included which "do not meet the criteria of sound scientific publications." It would be desirable for the associate editor to substantiate his opinion that "most of the experimental data support the concept that the effects of microwave exposure are primarily if not only, a response to hyperthermia or altered thermal gradients in the body." We noted that the conclusion of one of the reprints (Imig et al.) in this book is that in experiments on testicular degeneration "damage may result in part from factors other than heat." The important aspect of thermoregulatory responses is represented by a paper of peripheral vasodilation in the squirrel monkey by Adair, while the paper by Ely et al. has only historical interest. Recent papers by Way et al. (Bioelectromagnetics 2, 341, 1981) and Spiegel et al. (Bioelectromagnetics 1, 253, 1980) should be read for a more complete coverage of this area. To fully appreciate the subject, the papers on cataracts in this section should be supplemented by reading the excellent review of microwave cataractogenesis by Cleary (Proc. IEEE, 68, 49, 1980). In conclusion, this section contains a collection of papers of mixed quality and relevance, which do not provide a coherent representation of the present state of knowledge on the pathophysiologic aspects of RF energy.

Section V: MEDICAL APPLICATIONS OF ELECTROMAGNETIC FIELDS by O. P. Gandhi

This section includes papers on the classical medical application of RF fields - diathermy (the therapeutic heating of the musculature, tendons, etc. for physical therapy), and papers on most of the new, important areas such as Nuclear Magnetic Resonance (NMR) imaging (which may soon challenge the most sophisticated, computerized X-ray imaging modalities such as Computerized Tomography (CT), and RF hyperthermia for the treatment of cancer. Most of the areas of medical applications of RF are discussed adequately, but the coverage of the rapidly changing field of cancer hyperthermia does not present a comprehensive overview of the state-of-the-art of hyperthermia applicators. Those interested in the subject should read Kantor (J. Microwave Power 16 (2) 1981).

One significant flaw in this section is the lack of almost any mention of the subject of bone and wound healing that is induced through the application of strong, pulsed magnetic fields or pulse-modulated RF carrier signals. Recently a new technical society was formed (Biological Repair and Growth Society) to cover this area. Also, the book gives no indication that there has been a steady history of clinical practice in which Basset and others have been active for over twenty years. Many thousands of patients suffering from bone fractures that would not heal normally have been successfully treated by physicians with long-term, pulsed magnetic fields. In light of this, the Food and Drug Administration has recently approved one bone-healing device as being clinically safe and effective. Therefore, the lack of any mention of such interactions of EM fields with biological systems is a significant oversight in this and the other sections of the book. A reference to the papers by Basset et al. and Becker et al. (see section II) should have been made, and at least one reprint included in this section.

Section VI: SAFETY STANDARDS by J. M. Osepchuk

This section contains papers dealing with personnel exposure standards and guidelines, and the physical basis for such standards. A paper that covers the prevalent personnel exposure and product-emission standards in 1980 by S. Michaelson was included. It is brief and somewhat incomplete. We assume that this paper was incldued as an up-to-the-minute summary of the status of RF safety standards at the time of publication of the book (since it was reproduced directly from a typed and photocopied, rather than typeset, manuscript). Because of its "timeliness" it has a rough physical appearance and is difficult to read, with the tops of virtually each character clipped off. Papers on the occupational exposure of personnel, and standards for control of such exposures, were not included in this book. A paper, such as one by Conover (Proc. IEEE 68(1), 1980) or other knowledge-able regulatory agency professionals should have been included in this section's summary/bibliography.

Section VII: INTERFERENCE EFFECTS: ELECTROMAGNETIC COMPATIBILITY OF CARDIAC PACEMAKERS by J. C. Mitchell

Electronic cardiac pacemakers are the only medical devices covered in this section on interference effects. Mr. Mitchell and his group at the U.S. Air Force School of Aerospace Medicine are world experts in the area of pacemaker interference. Although this paper represented the state of the art at the time of its publication, effects on the new generation of "programmable" pacemakers were not mentioned. These new devices actually contain radiofrequency receivers or other means to obtain instructions for their operational adjustment after implantation in the patient, and can be susceptible to certain kinds of RF interference. A shortcoming of this section on RF interference in biomedical systems is the lack of any attempt to cover any other medical-device EM-interference problems, such as interference with critical, life-support and monitoring devices. The FDA's Bureau of Medical Devices (now part of CDRH) published a proposed final draft standard on electromagnetic compatibility for medical devices several years ago. This document (Medical Device Standard MDS 201 0004, 1979) should be read by anyone who is concerned with RF interference effects on medical electronics.

CONCLUSIONS

This book and its collection of papers provides relatively good, but somewhat outdated, coverage of the engineering and physical aspects of RF fields and their interaction with biological systems, plus the biomedical applications of electromagnetic fields. The coverage of the "biological" areas of this subject (the biophysical, pathological, and behavioral/central nervous system effects of EM fields) lacks a discussion of some of the most important scientific information on this subject, including the important area of pulsed-magnetic and RF field biological effects, their biophysical basis, and medical application to bone and wound healing. An overall view of this book is that it provides an extensive but incomplete set of references for this complex, controversial, and rapidly-changing field. Due to the changes that have occurred since this book went to press, it does not provide a complete overview of the present state of knowledge in this area.

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Distingushed Achievement Award Announced

The Administrative Committee of the Antenna and Propagation Society has authorized a new award, the Distinguished Achievement Award. This award may be given to recognize an individual member of AP-S for outstanding technical achievement and meritorious service to our society.

The first award will be made in 1985 if a suitable candidate can be identified. Contact the AP-S Awards and Fellows Committee Chairwoman for nomination forms:

Professor I. C. Peden
Department of Electrical Engineering FT-10
University of Washington
Seattle, WA 98195
(206) 543-8025

The deadline data for receipt of completed nomination forms is October 1, 1984.

Winners of the IEEE Centennial Medal

The following members of the Antennas and Propagation Society have been awarded IEEE Centennial medals. Those marked with an asterisk were awarded medals by the Society, and were honored at the banquet of the International AP-S Symposium in Boston on June 28, 1984. The other members listed received their medals from other IEEE societies, or regional entities, such as Sections.

S P APPLEBAUM*
S L BAILEY
R BARTNIKAS
D M BOLLE
H G BOOKER*
R C BOOTON, JR.
E BROOKNER
KENNETH BULLINGTON
KEITH R. CARVER
J S CHATTERJEE
CLAYTON CLARK
ALVIN CLAVIN
A A COLLINS
M C CREUSERE
J B DAMONTE
G A DESCHAMPS*
THOMAS W DOEPPNER
ARWIN A DOUGAL
R S DUGGAN, JR.
JEROME ECKERMAN
ANTHONY ELLER
R M EMBERSON
W L EVERITT
L B FELSEN*
R J FREDRICKS
KAZYS B GABRIUNAS
WILLIAM E. GORDON*
H D GORAKHPURWALLA
HARRY E. GREEN
ROGER F. HARRINGTON*
H S HAYRE
HOWARD T. HEAD
R E HENNING
KARL H. HERING
ERIC HERZ
JAMES STEWART HILL
TIMOTHY A HOSTETLER
A. ISHIMARU*
VIJAY K. JAIN
E C JORDAN
J W JOYNER
GIDEON KANTOR
B E KEISER
RONALD W. P. KING*
R G KOUYOUMJIAN*
J D KRAUS*
H N KRITIKOS
M H LATOUR
DAVID C. LEWIS
RICHARD L. LEWIS
YUEN TZE LO*
ROBERT J. MARKS, II
R E MC INTOSH
FUMIO MINOZUMA
RAJ MITTRA
R K MOORE
PHILIP MORGAN
WILLIAM W. MUMFORD
J R NEUBAUER
KENNETH A. NORTON*
A A OLINER
D T PARIS
DON PARKER
IRENE C. PEDEN
JOHN P PERRY
O PRESTHOLDT
ALVIN REINER
JACK H. RICHMOND*
M RODRIGUEZ-VIDAL
L ROHDE

Continued on page 20

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Cell phone radiation poses a serious biological and health risk:

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7/5/01

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The Issue:

Thousands of people are using cell phones for hours each day. They are exposing a very sensitive organ, their brain, to higher mean intensities than military personnel are exposed to when repairing radar. The military personnel show significant increases in cancer and a wide range of illnesses. Even at the very low mean levels that people experience living within 10 km of radio and TV towers, significant increases in cancer has been observed.

Analogue cell phones emit an analogue modulated RF/MW signal similar to an FM radio or TV signal. The digital cell phones radiate a pulse RF/MW signal similar to radar. Biological and epidemiological effects from EMR exposure across the spectrum show the same or similar effects.

Many people continue to drive while talking on their cell phones. Attention deficit and neurological effects on the user's brain make accidents much more likely.

Very young children and teenagers are becoming regular to heavy users of cell phones while their brains and bodies are in a much more vulnerable state than elderly people. With cancer and neurodegenerative disease latencies of decades, the possible adverse effects will take some time to become evident. By which time it will be too late for thousands of people.

There is growing concern about cell phone interference with cardiac pacemakers. If cell phone signals can interfere with an electronic pacemaker, then it is likely to also interfere with human hearts that are arrhythmically unstable.

Biophysical Principles:

Radiant energy is absorbed into human bodies according to three main processes. The first is the Aerial Effect where bodies and body parts receive and absorb the RF/MW signal with resonant absorption that is a function of the size of the body parts and the wavelength of the RF/MW signal. For an adult male about 1.8 m tall the optimal absorption frequency is close to 70 MHz, Figure 1. This has a wavelength of 4.3m. The body acts like a half-wave dipole interacting strongly with a half wavelength close to the body size. A monkey interacts with a wavelength of 1m and a half wavelength of 0.5m. This is similar to the absorbency of a human child.

The Aerial effect also relates to body parts such as arms and heads. A typical adult head has a width of 15 cm. This is a half wavelength for a 1 GHz microwave signal, close to that used by most cell phones.

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Figure 1: Average SAR for 3 species exposed to 10 W/m^2 with E vector parallel to the long axis of the body, from Durney et al. (1978).

Cellphone-type radiation is in the 0.9 to 1.8 GHz range, i.e. 0.9×10^9 to 1.8×10^9 Hz. Hence according to Figure 1 neither children nor adults are close to the optimum absorption rate but babies and infants bodies, whose dimensions lie between "monkey" and "mouse", are close to the optimal absorption for cell phone-type radiation.

A person with a height h (m), acting as an aerial in an RF electric field E (V/m) at a carrier frequency f (MHz), has a current induced in them which flows to earth through their feet, given by, Gandhi et al. (1985):

$$I_h = 0.108\, h^2\, E\, f \quad (mA)$$

This induced current flows mainly through high water content organs. In flowing to ground the current passes through the ankles. These consist mainly of low conductivity bones and tendons and have an effective cross-sectional area of 9.5 cm^2 for an adult, despite the actual physical area is of the order of 40 cm^2. The formula for I_h also allows for the effective absorption area of the person, which is somewhat greater than their actual cross-sectional area, because of the attraction of the surrounding field to an earthed conductor. These aerial considerations are more pertinent to whole-body exposures to cell sites.

Cell phone aerials form digital phones typically occupy the length of the body of the phone and extend a few centimeters out of the top of the phone body. Cellphone radiation for the phone's aerial is quite close to the user's head and can be intense enough to cause a warming sensation.

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Figure 2: The dielectric constant and conductivity of typical biological tissue as a function of frequency, Schwan (1985).

The second mechanism involves the coupling of the signal to the tissue as the signal penetrates the tissue and interacts with the cells and layers of tissue. This process is related to the dielectric constant and conductivity of the tissue types, which vary significantly with the carrier frequency, Figure 2.

The third biophysical absorption process involves resonant absorption by biological systems in the brain and cells. Resonant absorption occurs when a system with a natural frequency is stimulated by an imposed signal of a similar frequency or harmonic frequency. Radio and TV receivers use both the aerial principle and the resonant absorption principle. The aerial resonantly absorbs the carrier frequency and carries it as an induced current to the receiver. Here a tuned circuit oscillating at the same frequency resonantly absorbs the carrier wave and uses decoding circuitry to extract the encoded message contained in the amplitude, frequency or digital modulation imprinted on the carrier wave.

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Figure 3: Comparison of the frequency spectra of the human EEG from 260 young males showing the 5%, 50% and 95%ile bands, adapted from Gibbs and Gibbs (1951), and Schumann Resonance peaks, from Polk (1982).

Figures 4 and 5 confirm the relationship shown in Figure 3, using independently derived spectra of the daytime human EEG, Figure 4 and the Schumann Resonance spectrum, Figure 5. The figures have been aligned to have a common horizontal frequency scale.

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Figure 4: A typical EEG spectrum, with the Schumann Resonance peaks superimposed.

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Figure 5: Daytime Schumann Resonance Spectrum, Polk (1982).

Figures 3-5 show that the frequency range of the primary peaks of the Schumann Resonances coincide with the frequency range of the human EEG. Upper Schumann peaks also associated with small peaks in the EEG. This shows a resonant interaction and supports the probability of an actual use by the brain or the Schumann Resonance signal. Figure 6 shows that this occurs in a study showing a significant dose-response correlation between the intensity of the 8-10 Hz Schumann Peak and human reaction times.

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Figure 6: Human reaction times as a function of Schumann Resonance 8-10 Hz Relative Intensity, for 49,500 subjects tested during 18 days in September 1953, at the German Traffic exhibition in Munich. Derived from data in Figure 3 of König (1974b). Trend: $t = 10.414$, 2-tailed $p<0.001$.

Cellphone radiation is shown to interact with human EEG patterns and to alter them and to change reaction times. The GSM signal has a pulse frequency of 217 Hz and a modulation at 8.34 Hz. This is in the Schumann Resonance and EEG spectral primary frequency range.

Effects shown for electromagnetic radiation, especially radio and radar signals, but also electrical occupations:

Such signals have been shown to:

Neurological Activity:

- • Alter brain activity, including EEG and reaction times, memory loss, headaches, fatigue and concentration problems, dizziness (the Microwave Syndrome), Gordon (1966), Deroche (1971), Moscovici et al. (1974), Lilienfeld et al. (1978), Shandala et al. (1979), Forman et al. (1982), Frey (1998).

- • Impair sleep and learning, Altpeter et al. (1995), Kolodynski and Kolodynska (1996)

- • Increase permeability of the blood brain barrier (a mechanism for headache), Frey et al. (1975), Alberts (1977, 1978) and Oscar and Hawkins (1977).

- • Alter GABA, Kolomytkin et al. (1994).

- • Increase neurodegenerative disease including Alzheimer's Disease, Sobel et al. (1995, 1996), Savitz et al. (1998a,b)

- • Highly significant Increased permeability of the blood brain barrier for 915 MHz radiation at SAR =0.016-0.1 (p=0.015) and SAR = 0.1-0.4 (p=0.002); Salford et al. (1994).

- • Increase the Suicide Risk, Baris and Armstrong (1990), Perry et al. (1991), Van Wijngaarden et al. (2000).

Cardiological Activity:

- • Alter blood pressure and heart rhythm (heart rate variability) Bortkiewicz et al. (1995, 1996, 1997) and Szmigielski at al (1998).

- • Increases Heart Disease and heart attack mortality, Forman et al. (1986), Hamburger, Logue and Silverman (1983), Savitz et al. (1999)

Immune System Activity:

- • Impairs the immune system Quan et al. (1992), Dmoch and Moszczynski (1998), Bruvere et al. (1998)

Reproductive Activity:

- • Reduces sperm counts in radar exposed military personnel, Weyandt et al. (1996)

- • Increases miscarriage and congenital abnormalities, Kallen et al. (1982), Larsen et al. (1991), Ouellet-Hellstrom and Stewart (1993).

- • Doubles the incidence of twins in the families of radar exposed personnel, Flaherty (1994).

- • Significantly alters the leaf structure of plants exposed to a radar, Magone (1996).

- • Significantly reduces the radial growth of pine trees, Balodis et al. (1996).

- • Reduced fertility of mice exposed to an RF field (27.12 MHz), Brown-Woodman et al. (1989).

- • Increased fetal/embryo lethality in mice exposed to 2.45 GHz microwaves, Nawrot, McRee and Galvin (1985).

- • Radio exposures completely cause complete infertility in mice over 3 to 5 generations at mean exposure levels of 1.05 and 0.17μW/cm^2, respectively, Magras and Xenos (1997).

Genotoxic Activity:

- • Reduce melatonin and alter calcium ions, Abelin (1999), Burch et al. (1997, 1999) Bawin and Adey (1976), Blackman et al. (1988, 1989, 1990).

- • Enhances heat shock proteins at extremely low exposure levels in a highly reproducible manner showing that they are not stimulated by heat but in reaction to a 'toxic' protein reaction, Daniells et al. (1998), and down to 0.001W/kg (0.34μW/cm^2) using 750MHz microwaves, de Pomerai (2000).

- • Damages chromosomes. Heller and Teixeira-Pinto (1959), Tonascia and Tonascia (1966), Yao (1982), Garaj-Vrhovac et al. (1990, 1991, 1992, 1993, 1999), Timchenko and Ianchevskaia (1995), Balode (1996), Haider et al. (1994) and Vijayalaxmi et al. (1997) have reported significant chromosome aberrations from RF/MW exposures. In the Mar/Apr 1999 edition of Microwave News it is reported that Drs Tice, Hook and McRee

- • Alters DNA, Ali and Behari (1994).

- • Breaks DNA strands, Lai and Singh (1995, 1996, 1997).

- • Alters gene transcription activity, Phillips et al. (1992, 1993).

- • Neoplastically transform cells, Balcer-Kubiczek and Harrison (1991).

- • Enhances cell death in a dose response manner for signal intensity and exposure time, Garaj-Vrhovac et al. (1991).

- • Enhances cell proliferation in a dose-response manner for exposure time, Mattei et al. (1999).

- • Enhances Ornithine Decarboxylase (ODC) activity, a measure of cell proliferation rate, Byus et al. (1988), Litovitz et al. (1997).

- • Enhances free radicals, Phelan et al. (1992).

- • Increased cancer in rats and mice, Prausnitz and Susskind (1962), Szmigielski et al. (1988) and Chou et al. (1992)

Cancer Epidemiology:

- • Increase the incidence of many types of cancer, including leukaemia, brain tumor, testicular cancer, genitourinary and breast cancer, Robinette et al. (1980), Milham (1985, 1988), Szmigielski (1996), Hocking et al. (1996), Dolk et al. (1997 a, b), Beall et al. (1996), Grayson (1996), Thomas et al. (1987), Lilienfeld et al. (1978), Zaret (1989), Davis and Mostofl (1993), Hayes et al. (1990), Tynes et al. (1996), Cantor et al. (1995), and many others.

These biological and health effects are consistent with the biological understanding that brains, hearts and cells are sensitive to electromagnetic signals because they use electromagnetic signals for their regulation, control and natural processes, including those processes monitored by the EEG and ECG. There is overwhelming evidence that EMR is genotoxic, alters cellular ions, neurotransmitters and neurohormones, and interferes with brain and heart signals, and increases cancer.

Cell Phone Radiation Research:

For years the cell phone companies and government authorities have assured us that cell phone are perfectly safe. For example, they claim that the particular set of radiation parameter associated with cell phones are not the same as any other radio signal and therefore earlier research does not apply. They also mount biased review teams who falsely dismiss any results that indicate adverse biological and health effects and the flawed pre-assumption that the only possible effect is tissue heating. There is a very large body of scientific research that challenges this view. Now we have published research, primarily funded by governments and industry that shows that cell phone radiation causes the following effects:

Neurological Activity:

- • Alters brain activity including EEG, Von Klitzing (1995), Mann and Roschkle (1996), Krause et al. (2000).

- • Disturbs sleep, Mann and Roschkle (1996), Bordely et al. (1999).

- • Alters sleep EEG after awake exposure, Huber et al. (2000).

- • Alters human reaction times, Preece et al. (1999), Induced potentials, Eulitz et al. (1998), slow brain potentials, Freude et al. (1998), Response and speed of switching attention (need for car driving) significantly worse, Hladky et al. (1999). Altered reaction times and working memory function (positive), Koivisto et al. (2000), Krause et al. (2000).

- • Brain cortex interaction as shown by significantly altered human EEG by cellphone radiation, during a 15 minute exposure, Lebedeva et al. (2000).

- • Weakens the blood brain barrier ($p<0.0001$): Persson, B.R.R., Salford, L.G. and Brun, A., 1997.

- • A Fifteen minute exposure, increased auditory brainstem response and hearing deficiency in 2 kHz to 10 kHz range, Kellenyi et al. (1999).

- • While driving, with 50 minutes per month with a cell phone, a highly significant 5.6-fold increase in accident risk, Violanti et al. (1996); a 2-fold increase in fatal accidents with cell phone in car, Violanti et al. (1998); impairs cognitive load and detection thresholds, Lamble et al. (1999). In a large Canadian study Redelmeier and Tibshirani (1997) the risk of collision when using a cellphone was 4 time higher, RR = 4.3, 95%CI 3.0-6.5. Calls close to the time of collision has RR =4.8 for 5 minutes and RR = 5.9, $p<0.001$, for 15 minutes.

- • Significant changes in local temperature, and in physiologic parameters of the CNS and cardiovascular system, Khdnisskii, Moshkarev and Fomenko (1999).

- • Causes memory loss, concentration difficulties, fatigue, and headache, in a dose response manner, (Mild et al. (1998)). Headache, discomfort, nausea, Hocking (1998).

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Figure 7: Prevalence of symptoms for Norwegian mobile phone users, mainly analogue, with various categories of length of calling time per day, Mild et al. (1998).

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Figure 8: Prevalence of symptoms for Swedish mobile phone users, mainly digital, with various categories of length of calling time per day, Mild et al. (1998).

These are the same symptoms that have frequently been reported as "Microwave Sickness Syndrome" or "Radiofrequency Sickness Syndrome", Baranski and Czerski (1976) and Johnson-Liakouris (1998).

Cardiac Activity:

- • Cardiac pacemaker interference: skipped three beats, Barbaro et al. (1996); showed interference, Hofgartner et al. (1996); significant interference, $p<0.05$ Chen et al. (1996); extremely highly significant interference, $p=0.0003$, Naegeli et al. (1996); $p<0.0001$, Altamura et al. (1997); reversible interference, Schlegal et al. (1998); significantly induced electronic noise, Occhetta et al. (1999); various disturbances observed and warnings recommended, Trigano et al. (1999)

- • Significantly increases blood pressure, Braune et al. (1998).

Hormone Activity:

- • Reduces the pituitary production of Thyrotropin (Thyroid Stimulating Hormone, TSH):

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Figure 9: A significant reduction in Thyrotropin (Thyroid Stimulating Hormone) during cell phone use, de Seze et al. (1998).

- • Reduces melatonin significantly, Burch et al. (1997, 1998). A GSM cellphone reduces melatonin, but not significantly in a very small sample (N=18) of subjects, de Seze et al. (1999).

- • A reported but yet to be published Australian Study, EMRAA News, June 2000, used a Clot Retention Test on blood samples to detect hormonal changes. A group of 30 volunteers used a Nokia 6150 cellphone for 10 minutes on each of two consecutive days. The CRT test showed significant changes in the thyroid, pancreas, ovaries, testes and hormonal balance.

Reproductive Activity:

- • Decreases in sperm counts and smaller tube development in rat testes, Dasdag et al. (1999).

- • Increases embryonic mortality of chickens, Youbicier-Simo, Lebecq and Bastide (1998).

Genotoxic Activity:

- • Breaks DNA strands, Verschaeve at al. (1994), Maes et al. (1997), which is still extremely significant $p<0.0001$, at 0.0024W/kg (1.2 $\mu W/cm^2$), Phillips et al. (1998).

- • Produces an up to three-fold increase in chromosome aberrations in a dose response manner from all cell phones tested, Tice, Hook and McRee, reported in Microwave News, March/April 1999. The findings were the same when the experiment was repeated and Dr Tice is quoted as stating: "There's no way you're going to get positive results twice over four different technologies as a chance result."

- • Doubles c-fos gene activity (a proto oncogene) for analogue phones and increases it by 41 % for digital phones, Goswami et al. (1999), altered c-jun gene, Ivaschuk et al. (1997), Increased hsp70 messenger RNA, Fritz et al. (1997).

- • Increases Tumour Necrosis Factor (TNK), Fesenko et al. (1999).

- • Increases ODC activity, Penafiel et al. (1997).

- • DNA synthesis and cell proliferation increased after 4 days of 20 min for 3 times/day exposure. Calcium ions were significantly altered, French, Donnellan and McKenzie (1997). Decreased cell proliferation, Kwee and Raskmark (1997), Velizarov, Raskmark and Kwee (1999)

- • Doubles the cancer in mice, Repacholi et al. (1997).

- • Increases the mortality of mobile phone users compared with portable phone users, RR = 1.38, 95%CI: 1.07-1.79, p=0.013, Rothman et al. (1996).

- • Increases human brain tumor rate by 2.5 times (Hardell et al. (1999)). Associated with an angiosarcoma (case study), Hardell (1999)

- • Hardell et al. (2000), for analogue phones OR = 2.62, 95%CI: 1.02-6.71, with higher tumour rates at points of highest exposure.

- • Significantly increases the incidence of eye cancer (Uveal Melanoma), by between OR = 4.2, 95%CI: 1.2-14.5, and OR = 10.1, 95%CI: 1.1-484.4, Stang et al. (2001).

- • United States, Motorola Study Morgan et al. (2000)

High Exposure	RR = 1.07 (0.32-2.66) n = 3
Moderate Exposure	RR = 1.18 (0.36-2.92) n = 3
High/Mod vs Low	RR = 1.13 (0.49-2.31) n = 6

  This project underestimated cancer rates by using a high cancer reference group.

- • Carlo and Schram (2001) report that in the industry funded WTR (Wireless Technology Research) programme Dr Joseph Roti Roti confirmed the Tice, Hook and McRee research showing that cellphone radiation significantly damaged DNA through observed micronuclei formation.

- • Muscat et al. (2000) report elevated brain cancer in cellphone users in the United States, with cerebral tumors occurring more frequently on the side of the head where the mobile phone had been used, (26 vs 15 cases, p=0.06) and for a rare brain cancer, neuroepitheliomatous, OR = 2.1, 95%CI: 0.9-4.7. Mean use of cell phones was 2.5 years for cases and 2.2 years for controls, showing that a small increase in cellphone use (0.3 years) produces a large increase in brain cancer risk.

- • Cell phone users in Denmark Johansen et al. (2001)

Duration of digital subscription		<1 yr	1-2yrs	≥3 yrs
Relative to reference group	SIR	0.7	0.9	1.2
Relative to <1 yr group	RR	1.0	1.29	1.71

Other cancers are set out in "Table 2" below. Over 67 % of phone users had used their phones for 2 years or less. The reference group had a higher than average cancer rate than the age range of cell phone users, underestimating the cancer rates. This is shown by Standard Incidence Ratios (SIR) of some groups being as little as 0.6. For example SIR for users for <1 year is 0.7.

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Table two shows that even with little cellphone use, and even with the use of a high cancer reference group, there are several elevated cancers approaching significance: Testicular cancer SIR = 1.12, 95%CI: 0.97-1.30, Cervical cancer, SIR = 1.34, 95%CI: 0.95-1.85, Female Pharynx cancer, SIR 2.43, 95%CI: 0.65-6.22, Esophagus cancer, SIR = 1.53, 95%CI: 0.31-4.46 and female breast cancer, SIR = 1.08, 95%CI: 0.91-1.26.

Conclusions:

To date over 50 studies have shown adverse biological or human health effects specifically from cell phone radiation. These research results to date clearly show that cell phones and cell phone radiation are a strong risk factor for all of the adverse health effects identified for EMR because they share the same biological mechanisms. The greatest risk is to cell phone users because of the high exposure to their heads and the great sensitivity of brain tissue and brain processes. DNA damage accelerates cell death in the brain, advancing neurodegenerative diseases and brain cancer. Brain tumour is already an identified risk factor. Cell phones are carried on people's belts and in breast pockets. Hence liver cancer, breast cancer and testicular cancer became probable risk factors.

Altered attention and cognition, as well as the diversion of talking on a phone while driving is a significant risk factor for accidents and fatal accidents.

Some cardiac pacemakers are susceptible to active cell phone signals, recommending keeping cell phones away from hearts and pacemakers.

Because the biological mechanisms are shown and EMR has been observed to significantly increase the following effects, there is extremely strong evidence to conclude that cell phones are a risk factor for breast, liver, testicular and brain cancer. It is also probable that we will observe a very wide range of other effects including cardiac, neurological and reproductive illness and death. Since cell phone radiation cause many cell damages including DNA and chromosome damage, all of these effects will also be caused by cell sites.

Dose-response studies of neurological, cardiac, reproductive and cancer effects in human populations all point to a near zero exposure level of no effect, Cherry (2000). Since cellphone radiation mimics RF/MW radiation effects which mimics ELF biological and health, the adverse effects occur across the spectrum and includes cellphone radiation, with a safe exposure level of zero.

Hence a risk reduction and public health protection based on keeping exposure below a level that doubles the risk, identifies 0.1 $\mu W/cm^2$ as the maximum acceptable exposure. This should allow a mean life-time exposure to be less than $0.01\mu W/cm^2$ which is necessary to reduce the risk of neurological effects. The lower level is necessary because of the exquisite sensitivity of the brain.

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The City of Vaughan
Telecommunications Protocol
Committee of the Whole Working Session

28 March 2011

Dear City of Vaughan Councilors and Citizens

Perhaps the most significant danger to your health, your family's health and the citizens you represent at Council, is exposure to wireless electro magnetic radiation. Although you may not yet be aware how significant the danger is, there is already considerable scientific evidence which indicates that long term harm is gradually being caused to the entire population. The scientific evidence shows that this harm is being caused at levels which are much lower than Health Canada safety levels. Health Canada guidelines only provide protection from heating effects and do not account for all the adverse biological harm that is caused by low exposure levels of wireless radiation.

I am presenting you with some of that information so that you can make informed decisions and keep your community as safe as possible. Much of the danger from wireless radiation is inside citizen's homes in the form of cell phones, cordless telephones, Wi Fi and other wireless devices. These devices all emit strong amounts of microwave radiation which endanger whole families. To combat this danger I recommend that the City commence an educational program to advise all your citizens about the dangers of wireless radiation from their own communications devices, and provide simple instructions about how they can be much safer by using wired alternatives. If people used safe wired communications, there would be much less need for additional communications masts and much lower levels of micro-wave radiation throughout the City and its environment.

The issue of cell phone antennas and communications masts is a more difficult issue, but is crucial to the long term safety of your community. Epidemiological studies of people living around cell phone masts have found significant increases of cancer, neurological illnesses, sleeping difficulties and other significant health effects. The research also shows that people living closest to the masts suffered much more harm than those situated further away. This suggests very clearly that communications masts should be located as far away from people as possible.

For people who live near to antennas and who are being exposed to high levels of micro-wave there is a need to provide shielding and protection from harmful radiation. This may entail installing anti radiation window foil over exposed windows or special curtain material to block radiation etc. This protection may be expensive and may need specialists to install it properly, but the costs should not be upon the householder, but should be on the corporations that are making huge profits from this technology.

Another concern is for the people who are developing severe sensitivity to electro magnetic radiation. As wireless technology becomes more widely used, more people are becoming disabled by this condition. You should plan ahead so that you have safe, low radiation areas, where you can provide protected housing, schooling and medical services.

The important thing for you to consider is that, the less radiation Vaughan citizens are exposed to, the safer they will be. There are many 'modern' illnesses that have only appeared since the use of wireless radiation has become wide-spread. The true harm of wireless radiation may not fully show itself for several more years, but by then action to reduce exposure may be too late to stop a health crisis. You have the opportunity to be leaders and a council that truly cares for its citizens. I urge you to take responsible action now to save the heart-ache later.

I have attached six important documents to help you understand the serious threat to health, which cell phone radiation poses. Of particular concern to you, should be the historical items that show that microwave radiation was a known threat to human heath many years ago. For a more detailed and up to date scientific report about the dangers, please refer to the Bio Initiative Report (www.bioinitiative.org) where over two thousand scientific reports are referenced.

If you would like any further help from me, I would be pleased to assist.

Yours sincerely

Martin Weatherall
Co Director WEEP
The Canadian initiative to stop Wireless Electrical and Electromagnetic Pollution
www.weepinitiative.org

CW (WS) C6
March 29/11 - submitted by Tina Catalano
Item 2

Five Studies

Five Studies Showing Ill-Health Effects From Masts

Document produced by Dr Grahame Blackwell 21 Feb 2005

1 Study of the health of people living in the vicinity of mobile phone base stations.
Santini et al.
Pathol Biol (Paris) [Pathologie Biologie (Paris)] 2002; 50: 369 – 73
Found significant health effects on people living within 300 metres of mobile phone base stations.
Conclusions include the recommendation:
"... it is advisable that mobile phone base stations not be sited closer than 300meters to populations"

2. Netherlands Organization for Applied Scientific Research (TNO)
Study for the Netherlands Ministries of Economic Affairs, Housing, Spatial Planning and the Environment,and Health, Welfare and Sport
" Effects of Global Communications System Radio-Frequency Fields On Well Being and Cognitive Function of Human Subjects With and Without Subjective Complaints"
(September 2003)
Found significant effects on wellbeing, according to a number of internationally-recognised criteria (including headaches, muscle fatigue/pain, dizziness etc) from 3G mast emissions well below accepted 'safety' levels (less than 1/25,000th of ICNIRP guidelines). Those who had previously been noted as 'electrosensitive' under a scheme in that country were shown to have more pronounced ill-effects, though others were also shown to experience significant effects.

3. THE MICROWAVE SYNDROME FURTHER ASPECTS OF A SPANISH STUDY
Oberfeld Gerd1, Navarro A. Enrique3, Portoles Manuel2, Maestu Ceferino4, Gomez Perretta Claudio2
   1. Public Health Department Salzburg, Austria
   2. University Hospital La Fe. Valencia, Spain
   3. Department of Applied Physics, University Valencia, Spain
   4. Foundation European Bioelectromagnetism (FEB) Madrid, Spain
   Presented at an International Conference in Kos (Greece), 2004

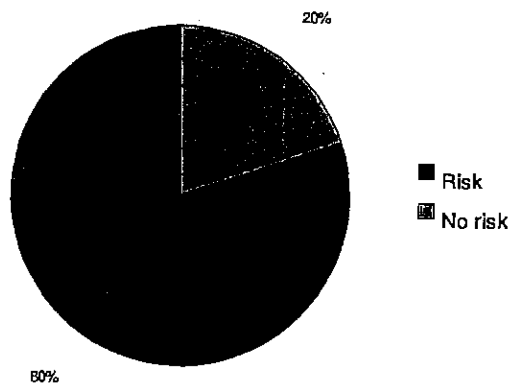
This study found significant ill-health effects in those living in the vicinity of two GSM mobile phone base stations. They observed that:
"The strongest five associations found are depressive tendency, fatigue, sleeping disorder, difficulty in concentration and cardiovascular problems."
As their conclusion the research team wrote:
"Based on the data of this study the advice would be to strive for levels not higher than 0.02 V/m for the sum total, which is equal to a power density of 0.0001 µW/cni2 or 1 µW/m2, which is the indoor exposure value for GSM base stations proposed on empirical evidence by the Public Health Office of the Government of Salzburg in 2002."

4. INCREASED INCIDENCE OF CANCER NEAR A CELL-PHONE TRANSMITTER STATION.
Ronni Wolf MD1, Danny Wolf MD2
   1. The Dermatology Unit, Kaplan Medical Center, Rechovot, and the Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, ISRAEL.
   2. The Pediatric Outpatient Clinic, Hasharon Region, Kupat Holim, ISRAEL.

Published in:
International Journal of Cancer Prevention Volume 1, No. 2, April 2004
This study, based on medical records of people living within 350 metres of a long-established phone mast, showed a fourfold increased incidence of cancer generally compared with the general population of Israel, and a tenfold increase specifically among women, compared with the surrounding locality further from the mast.

5. Naila Study, Germany (November 2004)

Report by researchers (five medical doctors)
Following the call by Wolfram König, President of the Bundesamt für Strahlenschutz (Federal Agency for radiation protection), to all doctors of medicine to collaborate actively in the assessment of the risk posed by cellular radiation, the aim of our study was to examine whether people living close to cellular transmitter antennas were exposed to a heightened risk of taking ill with malignant tumors.
The basis of the data used for the survey were PC files of the case histories of patients between the years 1994 and 2004. While adhering to data protection, the personal data of almost 1.000 patients were evaluated for this study, which was completed without any external financial support. It is intended to continue the project in the form of a register.
The result of the study shows that the proportion of newly developing cancer cases was significantly higher among those patients who had lived during the past ten years at a distance of up to 400 metres from the cellular transmitter site, which bas been in operation since 1993, compared to those patients living further away, and that the patients fell ill on average 8 years earlier.
In the years 1999-2004, i.e. after five years' operation of the transmitting installation, the relative risk of getting cancer had trebled for the residents of the area in the proximity of the installation compared to the inhabitants of Naila outside the area.
NOTE: These are the only studies known of that specifically consider the effects of masts on people. All five of these studies show clear and significant ill-health effects. There are no known studies relating to health effects of masts that do not show such ill-health effects.
In this respect, any statement by industry or official sources that claims (or suggests) that:
(a) There is no evidence of ill-health effects from masts;
or
(b) The overwhelming evidence is that masts do not cause ill-health effects;
is completely and blatantly untrue.
Dr Grahame Blackwell



80% of *(W.H.O acknowledged)* studies on people living in the vicinity of mobile phone base-stations, show a significantly increased risk of neurological diseases, impaired well-being and cancer.

Then *why* does the W.H.O claim that there is *no evidence* of health impact from mobile phone base-stations?

Researcher	Country	Type	Year	Tech.	WHO id	Subj.	Description	Risk
Oberfeld et al.	Austria	Epidem.	2008	GSM	1463	97	People living near mobile phone masts reported more symptoms of fatigue, irritability, headaches, nausea, loss of memory, visual disorder, dizziness and cardiovascular problems the higher their level of microwave exposure.	
Abdel-Rassoul et al.	Egypt	Epidem.	2007	GSM	1645	85	Residents living beneath and opposite a long-established mobile phone mast in Egypt reported significantly higher occurrences of headaches, memory changes, dizziness, tremors, depressive symptoms and sleep disturbance than a control group.	
Schüz et al.	Germany	Epidem.	2006	DECT	289	747	A follow-on study looked at glioma and menningioma cases and exposure to DECT cordless phone RF emissions. The authors suggest that, even though the study was limited by a small number of exposed subjects, it indicates that residental low-level exposure to cordless phones does not pose a health risk	No
Catney et al	Ireland	Epidem.	2006	?	1144	?	Cohort epidemiologic study surrounding a mobile phone base station tower. Standardised incidence and mortality rates were within, or lower than, the expected level.	No
Hutter et al.	Austria	Epidem.	2006	GSM	1626	365	365 people living near mobile phone masts reported higher incidences of headaches the closer they lived to the masts. Power density measurements in the bedrooms of 336 of these households were reported to be far below existing limits.	

Mobile phone base-station studies registered in World Health Organisation EMF database

Researcher	Country	Type	Year	Tech.	WHO id	Subj.	Description	Risk
Bortkiewicz et al.	Poland	Epidem.	2004	GSM	560	?	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.	
Wolf et al.	Israel	Epidem.	2004	GSM	970	622	A four-fold increase in the incidence of cancer among residents living within 300m radius of a mobile phone mast for between three and seven years was detected.	
Eger et al.	Germany	Epidem.	2004	GSM	1226	1000	A three-fold increase in the incidence of malignant tumours was found after five years exposure in people living within 400m radius of a mobile phone mast.	
Navarro E	Spain	Epidem.	2003	GSM	1122	?	The microwave power density was measured at the respondents' homes. Statistical analysis showed significant correlation between the declared severity of the symptoms and the measured power density. The separation of respondents into two different exposure groups also showed an increase of the declared severity in the group with the higher exposure.	
Santini et al.	France	Epidem.	2002	GSM	772	530	530 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 mast.	

Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays

B. Blake Levitt and Henry Lai

Abstract: The siting of cellular phone base stations and other cellular infrastructure such as roof-mounted antenna arrays, especially in residential neighborhoods, is a contentious subject in land-use regulation. Local resistance from nearby residents and landowners is often based on fears of adverse health effects despite reassurances from telecommunications service providers that international exposure standards will be followed. 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. The objective of this paper is to review the existing studies of people living or working near cellular infrastructure and other pertinent studies that could apply to long-term, low-level radiofrequency radiation (RFR) exposures. While specific epidemiological research in this area is sparse and contradictory, and such exposures are difficult to quantify given the increasing background levels of RFR from myriad personal consumer products, some research does exist to warrant caution in infrastructure siting. Further epidemiology research that takes total ambient RFR exposures into consideration is warranted. Symptoms reported today 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.

Key words: radiofrequency radiation (RFR), antenna arrays, cellular phone base stations, microwave sickness, nonionizing electromagnetic fields, environmental pollution.

Résumé : La localisation des stations de base pour téléphones cellulaires et autres infrastructures cellulaires, comme les installations d'antennes sur les toitures, surtout dans les quartiers résidentiels, constitue un sujet litigieux d'utilisation du territoire. La résistance locale de la part des résidents et propriétaires fonciers limitrophes repose souvent sur les craintes d'effets adverses pour la santé, en dépit des réassurances venant des fournisseurs de services de télécommunication, à l'effet qu'ils appliquent les standards internationaux d'exposition. En plus de rapports anecdotiques, certaines études épidémiologiques font état de maux de tête, d'éruption cutanée, de perturbation du sommeil, de dépression, de diminution de libido, d'augmentations du taux de suicide, de problèmes de concentration, de vertiges, d'altération de la mémoire, d'augmentation du risque de cancers, de trémulations et autres effets neurophysiologiques, dans les populations vivant au voisinage des stations de base. Les auteurs révisent ici les études existantes portant sur les gens, vivant ou travaillant près d'infrastructures cellulaires ou autres études pertinentes qui pourraient s'appliquer aux expositions à long terme à la radiation de radiofréquence de faible intensité « RFR ». Bien que la recherche épidémiologique spécifique dans ce domaine soit rare et contradictoire, et que de telles expositions soient difficiles à quantifier compte tenu des degrés croissants du bruit de fond des RFR provenant de produits de myriades de consommateurs personnels, il existe certaines recherches qui justifient la prudence dans l'installation des infrastructures. Les futures études épidémiologiques sont nécessaires afin de prendre en compte la totalité des expositions à la RFR ambiante. Les symptômes rapportés jusqu'ici pourraient correspondre à la maladie classique des micro-ondes, décrite pour la première fois en 1978. Les champs électromagnétiques non-ionisants constituent les formes de pollution environnementale croissant le plus rapidement. On peut effectuer certaines extrapolations à partir de recherches autres qu'épidémiologiques concernant les effets biologiques d'expositions à des degrés bien au-dessous des directives internationales.

Mots-clés : radiofréquence de faible intensité « RFR », les installations d'antennes, des stations de base pour téléphones cellulaires, la maladie classique des micro-ondes, les champs électromagnétiques non-ionisants, pollution environnementale.

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1. Introduction

Wireless technologies are ubiquitous today. According to the European Information Technology Observatory, an industry-funded organization in Germany, the threshold of 5.1 billion cell phone users worldwide will be reached by the end of 2010 — up from 3.3 billion in 2007. That number is expected to increase by another 10% to 5.6 billion in 2011, out of a total worldwide population of 6.5 billion.[2] In 2010, cell phone subscribers in the U.S. numbered 287 million, Russia 220 million, Germany 111 million, Italy 87 million, Great Britain 81 million, France 62 million, and Spain 57 million. Growth is strong throughout Asia and in South America but especially so in developing countries where landline systems were never fully established.

The investment firm Bank of America Merril-Lynch estimated that the worldwide penetration of mobile phone customers is twice that of landline customers today and that America has the highest minutes of use per month per user.[3] Today, 94% of Americans live in counties with four or more wireless service providers, plus 99% of Americans live in counties where next generation, 3G (third generation), 4G (fourth generation), and broadband services are available. All of this capacity requires an extensive infrastructure that the industry continues to build in the U.S., despite a 93% wireless penetration of the total U.S. population.[4]

Next generation services are continuing to drive the build-out of both new infrastructure as well as adaptation of pre-existing sites. According to the industry, there are an estimated 251 618 cell sites in the U.S. today, up from 19 844 in 1995.[4] There is no comprehensive data for antennas hidden inside of buildings but one industry-maintained Web site (www.antennasearch.com), allows people to type in an address and all antennas within a 3 mile (1 mile = 1.6 km) area will come up. There are hundreds of thousands in the U.S. alone.

People are increasingly abandoning landline systems in favor of wireless communications. One estimate in 2006 found that 42% of all wireless subscribers used their wireless phone as their primary phone. According to the National Center for Health Statistics of the U.S. Centers for Disease Control (CDC), by the second half of 2008, one in every five American households had no landlines but did have at least one wireless phone (Department of Health and Human Services 2008). The figures reflected a 2.7% increase over the first half of 2008 — the largest jump since the CDC began tracking such data in 2003, and represented a total of 20.2% of the U.S. population — a figure that coincides with industry estimates of 24.50% of completely wireless households in 2010.[5] The CDC also found that approximately 18.7% of all children, nearly 14 million, lived in households with only wireless phones. The CDC further found that one in every seven American homes, 14.5% of the population, received all or almost all of their calls via wireless phones, even when there was a landline in the home. They called these "wireless-mostly households."

The trend away from landline phones is obviously increasing as wireless providers market their services specifically toward a mobile customer, particularly younger adults who readily embrace new technologies. One study (Silke et al. 2010) in Germany found that children from lower socioeconomic backgrounds not only owned more cell phones than children from higher economic groups, but also used their cell phones more often — as determined by the test groups' wearing of personal dosimetry devices. This was the first study to track such data and it found an interesting contradiction to the assumption that higher socioeconomic groups were the largest users of cell services. At one time, cell phones were the status symbol of the wealthy. Today, it is also a status symbol of lower socioeconomic groups. The CDC found in their survey discussed above that 65.3% of adults living in poverty or living near poverty were more likely than higher income adults to be living in households with wireless only telephones. There may be multiple reasons for these findings, including a shift away from cell phone dialogues to texting in younger adults in higher socioeconomic categories.

In some developing countries where landline systems have never been fully developed outside of urban centers, cell phones are the only means of communication. Cellular technology, especially the new 3G, 4G, and broadband services that allow wireless communications for real-time voice communication, text messaging, photos, Internet connections, music and video downloads, and TV viewing, is the fastest growing segment of many economies that are in otherwise sharp decline due to the global economic downturn.

There is some indication that although the cellular phone markets for many European countries are more mature than in the U.S., people there may be maintaining their landline use while augmenting with mobile phone capability. This may be a consequence of the more robust media coverage regarding health and safety issues of wireless technology in the European press, particularly in the UK, as well as recommendations by European governments like France and Germany[6] that citizens not abandon their landline phones or wired computer systems because of safety concerns. According to OfCom's 2008 *Communications Market Interim Report* (OfCom 2008), which provided information up to December 2007, approximately 86% of UK adults use cell phones. While four out of five households have both cell phones and landlines, only 11% use cell phones exclusively, a total down from 28% noted by this group in 2005. In addition, 44% of UK adults use text messaging on a daily basis. Fixed landline services fell by 9% in 2007 but OfCom notes that landline services continue to be strong despite the fact that mobile services also continued to grow by 16%. This indicates that people are continuing to use both landlines and wireless technology rather than choosing one over the other in the UK. There were 51 300 UK base station sites in

[2] http://www.eito.com/pressinformation_20100811.htm. (Accessed October 2010.)
[3] http://www.ctia.org/advocacy/research/index.cfm/AID/10377. (Accessed October 2010.)
[4] http://www.ctia.org/advocacy/research/index.cfm/AID/10323. (Accessed October 2010.)
[5] http://www.ctia.org/advocacy/research/index.cfm/AID/10323. (Accessed October 2010.)
[6] http://www.icems.eu/docs/deutscher_bundestag.pdf and http://www.icems.eu/docs/resolutions/EP_EMF_resolution_2APR09.pdf. (Accessed October 2010.)

the beginning of 2009 (two-thirds installed on existing buildings or structures) with an estimated 52 900 needed to accommodate new 3G and 4G services by the end of 2009.

Clearly, this is an enormous global industry. Yet, no money has ever been appropriated by the industry in the U.S., or by any U.S. government agency, to study the potential health effects on people living near the infrastructure. The most recent research has all come from outside of the U.S. According to the CTIA – The Wireless Association, "If the wireless telecom industry were a country, its economy would be bigger than that of Egypt, and, if measured by GNP (gross national product), [it] would rank as the 46th largest country in the world." They further say, "It took more than 21 years for color televisions to reach 100 million consumers, more than 90 years for landline service to reach 100 million consumers, and less than 17 years for wireless to reach 100 million consumers."[7]

In lieu of building new cell towers, some municipalities are licensing public utility poles throughout urban areas for Wi-Fi antennas that allow wireless Internet access. These systems can require hundreds of antennas in close proximity to the population with some exposures at a lateral height where second- and third-storey windows face antennas. Most of these systems are categorically excluded from regulation by the U.S. Federal Communications Commission (FCC) or oversight by government agencies because they operate below a certain power density threshold. However, power density is not the only factor determining biological effects from radiofrequency radiation (RFR).

In addition, when the U.S. and other countries permanently changed from analog signals used for television transmission to newer digital formats, the old analog frequencies were reallocated for use by municipal services such as police, fire, and emergency medical dispatch, as well as to private telecommunications companies wanting to expand their networks and services. This creates another significant increase in ambient background exposures.

Wi-Max is another wireless service in the wings that will broaden wireless capabilities further and place additional towers and (or) transmitters in close proximity to the population in addition to what is already in existence. Wi-Max aims to make wireless Internet access universal without tying the user to a specific location or "hotspot." The rollout of Wi-Max in the U.S., which began in 2009, uses lower frequencies at high power densities than currently used by cellular phone transmission. Many in science and the activist communities are worried, especially those concerned about electromagnetic-hypersensitivity syndrome (EHS).

It remains to be seen what additional exposures "smart grid" or "smart meter" technology proposals to upgrade the electrical powerline transmission systems will entail regarding total ambient RFR increases, but it will add another ubiquitous low-level layer. Some of the largest corporations on earth, notably Siemens and General Electric, are involved. Smart grids are being built out in some areas of the U.S. and in Canada and throughout Europe. That technology plans to alter certain aspects of powerline utility metering from a wired system to a partially wireless one. The systems require a combination of wireless transmitters attached to homes and businesses that will send radio signals of approximately 1 W output in the 2.4000–2.4835 GHz range to local "access point" transceivers, which will then relay the signal to a further distant information center (Tell 2008). Access point antennas will require additional power density and will be capable of interfacing with frequencies between 900 MHz and 1.9 GHz. Most signals will be intermittent, operating between 2 to 33 seconds per hour. Access points will be mounted on utility poles as well as on free-standing towers. The systems will form wide area networks (WANs), capable of covering whole towns and counties through a combination of "mesh-like" networks from house to house. Some meters installed on private homes will also act as transmission relays, boosting signals from more distant buildings in a neighborhood. Eventually, WANs will be completely linked.

Smart grid technology also proposes to allow homeowners to attach additional RFR devices to existing indoor appliances, to track power use, with the intention of reducing usage during peak hours. Manufacturers like General Electric are already making appliances with transmitters embedded in them. Many new appliances will be incapable of having transmitters deactivated without disabling the appliance and the warranty. People will be able to access their home appliances remotely by cell phone. The WANs smart grids described earlier in the text differ significantly from the current upgrades that many utility companies have initiated within recent years that already use low-power RFR meters attached to homes and businesses. Those first generation RFR meters transmit to a mobile van that travels through an area and "collects" the information on a regular billing cycle. Smart grids do away with the van and the meter reader and work off of a centralized RFR antenna system capable of blanketing whole regions with RFR.

Another new technology in the wings is broadband over powerlines (BPL). It was approved by the U.S. FCC in 2007 and some systems have already been built out. Critics of the latter technology warned during the approval process that radiofrequency interference could occur in homes and businesses and those warnings have proven accurate. BPL technology couples radiofrequency bands with extremely low frequency (ELF) bands that travel over powerline infrastructure, thereby creating a multi-frequency field designed to extend some distance from the lines themselves. Such couplings follow the path of conductive material, including secondary distribution lines, into people's homes.

There is no doubt that wireless technologies are popular with consumers and businesses alike, but all of this requires an extensive infrastructure to function. Infrastructure typically consists of freestanding towers (either preexisting towers to which cell antennas can be mounted, or new towers specifically built for cellular service), and myriad methods of placing transceiving antennas near the service being called for by users. This includes attaching antenna panels to the sides of buildings as well as roof-mountings; antennas hidden inside church steeples, barn silos, elevator shafts, and any number of other "stealth sites." It also includes camouflaging towers to look like trees indigenous to areas where they are placed, e.g., pine trees in northern climates, cacti

[7] CTIA website: http://www.ctia.org/advocay/research/index.cfm/AID/10385. (Accessed 9 December 2008.)

in deserts, and palm trees in temperate zones, or as chimneys, flagpoles, silos, or other tall structures (Rinebold 2001). Often the rationale for stealth antenna placement or camouflaging of towers is based on the aesthetic concerns of host communities.

An aesthetic emphasis is often the only perceived control of a municipality, particularly in countries like America where there is an overriding federal preemption that precludes taking the "environmental effects" of RFR into consideration in cell tower siting as stipulated in Section 704 of *The Telecommunications Act of 1996* (USFCC 1996). Citizen resistance, however, is most often based on health concerns regarding the safety of RFR exposures to those who live near the infrastructure. Many citizens, especially those who claim to be hypersensitive to electromagnetic fields, state they would rather know where the antennas are and that hiding them greatly complicates society's ability to monitor for safety.[8]

Industry representatives try to reassure communities that facilities are many orders of magnitude below what is allowed for exposure by standards-setting boards and studies bear that out (Cooper et al. 2006; Henderson and Bangay 2006; Bornkessel et al. 2007). These include standards by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) used throughout Europe, Canada, and elsewhere (ICNIRP 1998). The standards currently adopted by the U.S. FCC, which uses a two-tiered system of recommendations put out by the National Council on Radiation Protection (NCRP) for civilian exposures (referred to as uncontrolled environments), and the International Electricians and Electronics Engineers (IEEE) for professional exposures (referred to as controlled environments) (U.S. FCC 1997). The U.S. may eventually adopt standards closer to ICNIRP. The current U.S. standards are more protective than ICNIRP's in some frequency ranges so any harmonization toward the ICNIRP standards will make the U.S. limits more lenient.

All of the standards currently in place are based on RFRs ability to heat tissue, called thermal effects. A longstanding criticism, going back to the 1950s (Levitt 1995), is that such acute heating effects do not take potentially more subtle non-thermal effects into consideration. And based on the number of citizens who have tried to stop cell towers from being installed in their neighborhoods, laypeople in many countries do not find adherence to exisitng standards valid in addressing health concerns. Therefore, infrastructure siting does not have the confidence of the public (Levitt 1998).

2. A changing industry

Cellular phone technology has changed significantly over the last two decades. The first wireless systems began in the mid-1980s and used analog signals in the 850–900 MHz range. Because those wavelengths were longer, infrastructure was needed on average every 8 to 10 miles apart. Then came the digital personal communications systems (PCS) in the late 1990s, which used higher frequencies, around 1900 GHz, and digitized signals. The PCS systems, using shorter wavelengths and with more stringent exposure guidelines, require infrastructure approximately every 1 to 3 miles apart. Digital signals work on a binary method, mimicking a wave that allows any frequency to be split in several ways, thereby carrying more information far beyond just voice messages.

Today's 3G network can send photos and download music and video directly onto a cell phone screen or iPod. The new 4G systems digitize and recycle some of the older frequencies in the 700 to 875 MHz bands to create another service for wireless Internet access. The 4G network does not require a customer who wants to log on wirelessly to locate a "hot spot" as is the case with private Wi-Fi systems. Today's Wi-Fi uses a network of small antennas, creating coverage of a small area of 100 ft (~30 m) or so at homes or businesses. Wi-fi can also create a small wireless computer system in a school where they are often called wireless local area networks (WLANs). Whole cities can make Wi-Fi available by mounting antennas to utility poles.

Large-scale Wi-Fi systems have come under increasing opposition from citizens concerned about health issues who have legally blocked such installations (Antenna Free Union[9]). Small-scale Wi-Fi has also come under more scrutiny as governments in France and throughout Europe have banned such installations in libraries and schools, based on precautionary principles (REFLEX Program 2004).

3. Cell towers in perspective: some definitions

Cell towers are considered low-power installations when compared to many other commercial uses of radiofrequency energy. Wireless transmission for radio, television (TV), satellite communications, police and military radar, federal homeland security systems, emergency response networks, and many other applications all emit RFR, sometimes at millions of watts of effective radiated power (ERP). Cellular facilities, by contrast, use a few hundred watts of ERP per channel, depending on the use being called for at any given time and the number of service providers co-located at any given tower.

No matter what the use, once emitted, RFR travels through space at the speed of light and oscillates during propagation. The number of times the wave oscillates in one second determines its frequency.

Radiofrequency radiation covers a large segment of the electromagnetic spectrum and falls within the nonionizing bands. Its frequency ranges between 10 kHz to 300 GHz; 1 Hz = 1 oscillation per second; 1 kHz = 1000 Hz; 1 MHz = 1 000 000 Hz; and 1 GHz = 1 000 000 000 Hz.

Different frequencies of RFR are used in different applications. Some examples include the frequency range of 540 to 1600 kHz used in AM radio transmission; and 76 to 108 MHz used for FM radio. Cell-phone technology uses frequencies between 800 MHz and 3 GHz. The RFR of 2450 MHz is used in some Wi-Fi applications and microwave cooking.

Any signal can be digitized. All of the new telecommunications technologies are digitized and in the U.S., all TV is

[8] See, for example, www.radiationresearch.org. (Accessed October 2010.)
[9] http://www.antennafreeunion.org/. (Accessed October 2010.)

broadcast in 100% digital formats — digital television (DTV) and high definition television (HDTV). The old analog TV signals, primarily in the 700 MHz ranges, will now be recycled and relicensed for other applications to additional users, creating additional layers of ambient exposures.

The intensity of RFR is generally measured and noted in scientific literature in watts per square meter (W/m^2); milliwatts per square centimetre (mW/cm^2), or microwatts per square centimetre ($\mu W/cm^2$). All are energy relationships that exist in space. However, biological effects depend on how much of the energy is absorbed in the body of a living organism, not just what exists in space.

4. Specific absorption rate (SAR)

Absorption of RFR depends on many factors including the transmission frequency and the power density, one's distance from the radiating source, and one's orientation toward the radiation of the system. Other factors include the size, shape, mineral and water content of an organism. Children absorb energy differently than adults because of differences in their anatomies and tissue composition. Children are not just "little adults". For this reason, and because their bodies are still developing, children may be more susceptible to damage from cell phone radiation. For instance, radiation from a cell phone penetrates deeper into the head of children (Gandhi et al. 1996; Wiart et al. 2008) and certain tissues of a child's head, e.g., the bone marrow and the eye, absorb significantly more energy than those in an adult head (Christ et al. 2010). The same can be presumed for proximity to towers, even though exposure will be lower from towers under most circumstances than from cell phones. This is because of the distance from the source. The transmitter is placed directly against the head during cell phone use whereas proximity to a cell tower will be an ambient exposure at a distance.

There is little difference between cell phones and the domestic cordless phones used today. Both use similar frequencies and involve a transmitter placed against the head. But the newer digitally enhanced cordless technology (DECT) cordless domestic phones transmit a constant signal even when the phone is not in use, unlike the older domestic cordless phones. But some DECT brands are available that stop transmission if the mobile units are placed in their docking station.

The term used to describe the absorption of RFR in the body is specific absorption rate (SAR), which is the rate of energy that is actually absorbed by a unit of tissue. Specific absorption rates (SARs) are generally expressed in watts per kilogram (W/kg) of tissue. The SAR measurements are averaged either over the whole body, or over a small volume of tissue, typically between 1 and 10 g of tissue. The SAR is used to quantify energy absorption to fields typically between 100 kHz and 10 GHz and encompasses RFR from devices such as cellular phones up through diagnostic MRI (magnetic resonance imaging).

Specific absorption rates are a more reliable determinant and index of RFR's biological effects than are power density, or the intensity of the field in space, because SARs reflect what is actually being absorbed rather than the energy in space. However, while SARs may be a more precise model, at least in theory, there were only a handful of animal studies that were used to determine the threshold values of SAR for the setting of human exposure guidelines (de Lorge and Ezell 1980; de Lorge 1984). (For further information see Section 8). Those values are still reflected in today's standards.

It is presumed that by controlling the field strength from the transmitting source that SARs will automatically be controlled too, but this may not be true in all cases, especially with far-field exposures such as near cell or broadcast towers. Actual measurement of SARs is very difficult in real life so measurements of electric and magnetic fields are used as surrogates because they are easier to assess. In fact, it is impossible to conduct SAR measurements in living organisms so all values are inferred from dead animal measurements (thermography, calorimetry, etc.), phantom models, or computer simulation (FDTD).

However, according to the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) *Health Effects of Exposure to EMF*, released in January of 2009:

> ... recent studies of whole body plane wave exposure of both adult and children phantoms demonstrated that when children and small persons are exposed to levels which are in compliance with reference levels, exceeding the basic restrictions cannot be excluded [Dimbylow and Bloch 2007; Wang et al. 2006; Kuhn et al., 2007; Hadjem et al., 2007]. While the whole frequency range has been investigated, such effects were found in the frequency bands around 100 MHz and also around 2 GHz. For a model of a 5-year-old child it has been shown that when the phantom is exposed to electromagnetic fields at reference levels, the basic restrictions were exceeded by 40% [Conil et al., 2008].... Moreover, a few studies demonstrated that multipath exposure can lead to higher exposure levels compared to plane wave exposure [Neubauer et al. 2006; Vermeeren et al. 2007]. It is important to realize that this issue refers to far field exposure only, for which the actual exposure levels are orders of magnitude below existing guidelines. (p. 34–35, SCENIHR 2009)

In addition to average SARs, there are indications that biological effects may also depend on how energy is actually deposited in the body. Different propagation characteristics such as modulation, or different wave-forms and shapes, may have different effects on living systems. For example, the same amount of energy can be delivered to tissue continuously or in short pulses. Different biological effects may result depending on the type and duration of the exposure.

5. Transmission facilities

The intensity of RFR decreases rapidly with the distance from the emitting source; therefore, exposure to RFR from transmission towers is often of low intensity depending on one's proximity. But intensity is not the only factor. Living near a facility will involve long-duration exposures, sometimes for years, at many hours per day. People working at home or the infirm can experience low-level 24 h exposures. Nighttimes alone will create 8 h continuous exposures. The current standards for both ICNIRP, IEEE and the NCRP (adopted by the U.S. FCC) are for whole-body exposures averaged over a short duration (minutes) and are based on results from short-term exposure studies, not for long-term, low-level exposures such as those experienced by people living or working near transmitting facilities. For such populations, these can be involuntary exposures, unlike cell phones where user choice is involved.

There have been some recent attempts to quantify human SARs in proximity to cell towers but these are primarily for occupational exposures in close proximity to the sources and questions raised were dosimetry-based regarding the accuracy of antenna modeling (van Wyk et al. 2005). In one study by Martínez-Búrdalo et al. (2005) however, the researchers used high-resolution human body models placed at different distances to assess SARs in worst-case exposures to three different frequencies — 900, 1800, and 2170 MHz. Their focus was to compute whole-body averaged SARs at a maximum 10 g averaged SAR inside the exposed model. They concluded that for

> … antenna–body distances in the near zone of the antenna, the fact that averaged field values are below reference levels, could, at certain frequencies, not guarantee guidelines compliance based on basic restrictions.
> (p. 4125, Martínez-Búrdalo et al. 2005)

This raises questions about the basic validity of predicting SARs in real-life exposure situations or compliance to guidelines according to standard modeling methods, at least when one is very close to an antenna.

Thus, the relevant questions for the general population living or working near transmitting facilities are: Do biological and (or) health effects occur after exposure to low-intensity RFR? Do effects accumulate over time, since the exposure is of a long duration and may be intermittent? What precisely is the definition of low-intensity RFR? What might its biological effects be and what does the science tell us about such exposures?

6. Government radiofrequency radiation (RFR) guidelines: how spatial energy translates to the body's absorption

The U.S. FCC has issued guidelines for both power density and SARs. For power density, the U.S. guidelines are between 0.2–1.0 mW/cm^2. For cell phones, SAR levels require hand-held devices to be at or below 1.6 W/kg measured over 1.0 g of tissue. For whole body exposures, the limit is 0.08 W/kg.

In most European countries, the SAR limit for hand-held devices is 2.0 W/kg averaged over 10 g of tissue. Whole body exposure limits are 0.08 W/kg.

At 100–200 ft (~30–60 m) from a cell phone base station, a person can be exposed to a power density of 0.001 mW/cm^2 (i.e., 1.0 µW/cm^2). The SAR at such a distance can be 0.001 W/kg (i.e., 1.0 mW/kg). The U.S. guidelines for SARs are between 0.08–0.40 W/kg.

For the purposes of this paper, we will define low-intensity exposure to RFR of power density of 0.001 mW/cm^2 or a SAR of 0.001 W/kg.

7. Biological effects at low intensities

Many biological effects have been documented at very low intensities comparable to what the population experiences within 200 to 500 ft (~60–150 m) of a cell tower, including effects that occurred in studies of cell cultures and animals after exposures to low-intensity RFR. Effects reported include: genetic, growth, and reproductive; increases in permeability of the blood–brain barrier; behavioral; molecular, cellular, and metabolic; and increases in cancer risk. Some examples are as follows:

- Dutta et al. (1989) reported an increase in calcium efflux in human neuroblastoma cells after exposure to RFR at 0.005 W/kg. Calcium is an important component in normal cellular functions.
- Fesenko et al. (1999) reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm^2.
- Magras and Xenos (1997) reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168–0.001053 mW/cm^2.
- Forgacs et al. (2006) reported an increase in serum testosterone levels in rats exposed to GSM (global system for mobile communication)-like RFR at SAR of 0.018–0.025 W/kg.
- Persson et al. (1997) reported an increase in the permeability of the blood–brain barrier in mice exposed to RFR at 0.0004–0.008 W/kg. The blood–brain barrier is a physiological mechanism that protects the brain from toxic substances, bacteria, and viruses.
- Phillips et al. (1998) reported DNA damage in cells exposed to RFR at SAR of 0.0024–0.024 W/kg.
- Kesari and Behari (2009) also reported an increase in DNA strand breaks in brain cells of rats after exposure to RFR at SAR of 0.0008 W/kg.
- Belyaev et al. (2009) reported changes in DNA repair mechanisms after RFR exposure at a SAR of 0.0037 W/kg. A list of publications reporting biological and (or) health effects of low-intensity RFR exposure is in Table 1.

Out of the 56 papers in the list, 37 provided the SAR of exposure. The average SAR of these studies at which biological effects occurred is 0.022 W/kg — a finding below the current standards.

Ten years ago, there were only about a dozen studies reporting such low-intensity effects; currently, there are more than 60. This body of work cannot be ignored. These are important findings with implications for anyone living or working near a transmitting facility. However, again, most of the studies in the list are on short-term (minutes to hours) exposure to low-intensity RFR. Long-term exposure studies are sparse. In addition, we do not know if all of these reported effects occur in humans exposed to low-intensity RFR, or whether the reported effects are health hazards. Biological effects do not automatically mean adverse health effects, plus many biological effects are reversible. However, it is clear that low-intensity RFR is not biologically inert. Clearly, more needs to be learned before a presumption of safety can continue to be made regarding placement of antenna arrays near the population, as is the case today.

Table 1. List of studies reporting biological effects at low intensities of radiofrequency radiation (RFR).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Balmori (2010) (in vivo) (eggs and tadpoles of frog)	88.5–1873.6 MHz	Cell phone base station emission	2 months		3.25	Retarded development
Belyaev et al. (2005) (in vitro)	915 MHz	GSM	24, 48 h	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz	GSM, UMTS	24, 72 h	0.037		DNA repair mechanism in human white blood cells
Blackman et al. (1980) (in vitro)	50 MHz	AM at 16 Hz		0.0014		Calcium in forebrain of chickens
Boscol et al. (2001) (in vivo) (human whole body)	500 KHz–3 GHz	TV broadcast			0.5	Immunological system in women
Campisi et al. (2010) (in vitro)	900 MHz	CW (CW– no effect observed) AM at 50 Hz	14 days, 5, 10, 20 min per day		26	DNA damage in human glial cells
Capri et al. (2004) (in vitro)	900 MHz	GSM	1 h/day, 3 days	0.07		A slight decrease in cell proliferation when human immune cells were stimulated with mitogen and a slight increase in the number of cells with altered distribution of phosphatidylserine across the membrane
Chiang et al. (1989) (in vivo) (human whole body)	Lived and worked close to AM radio and radar installations for more than 1 year				10	People lived and worked near AM radio antennas and radar installations showed deficits in psychological and short-term memory tests
de Pomerai et al. (2003) (in vitro)	1 GHz		24, 48 h	0.015		Protein damages
D'Inzeo et al. (1988) (in vitro)	10.75 GHz	CW	30–120 s	0.008		Operation of acetylcholine-related ion-channels in cells. These channels play important roles in physiological and behavioral functions
Dutta et al. (1984) (in vitro)	915 MHz	Sinusoidal AM at 16 Hz	30 min	0.05		Increase in calcium efflux in brain cancer cells
Dutta et al. (1989) (in vitro)	147 MHz	Sinusoidal AM at 16 Hz	30 min	0.005		Increase in calcium efflux in brain cancer cells
Fesenko et al. (1999) (in vivo) (mouse- wavelength in mm range)	From 8.15–18 GHz		5 h to 7 days direction of response depended on exposure duration		1	Change in immunological functions
Forgacs et al. (2006) (in vivo) (mouse whole body)	1800 MHz	GSM, 217 Hz pulses, 576 µs pulse width	2 h/day, 10 days	0.018		Increase in serum testosterone
Guler et al. (2010) (In vivo) (rabbit whole body)	1800 MHz	AM at 217 Hz	15 min/day, 7 days		52	Oxidative lipid and DNA damages in the brain of pregnant rabbits

Table 1 (*continued*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Hjollund et al. (1997) (in vivo) (human partial or whole body)	Military radars				10	Sperm counts of Danish military personnel, who operated mobile ground-to-air missile units that use several RFR emitting radar systems, were significantly lower compared to references
Ivaschuk et al. (1997) (in vitro)	836.55 MHz	TDMA	20 min	0.026		A gene related to cancer
Jecb et al. (2001) (in vivo) (human partial body exposure-narcoleptic patients)	900 MHz	GSM— 217 Hz pulses, 577 μs pulse width	45 min	0.06		Improved cognitive functions
Kesari and Behari (2009) (in vivo) (rat whole body)	50 GHz		2 h/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2010) (in vivo) (rat whole body)	50 GHz		2 h/day, 45 days	0.0008		Reproductive system of male rats
Kesari et al. (2010) (in vivo) (rat whole body)	2450 MHz	50 Hz modulation	2 h/day, 35 days	0.11		DNA double strand breaks in brain cells
Kwee et al. (2001) (in vitro)	960 MHz	GSM	20 min	0.0021		Increased stress protein in human epithelial amnion cells
Lebedeva et al. (2000) (in vivo) (human partial body)	902.4 MHz	GSM	20 min		60	Brain wave activation
Lerchl et al. (2008) (in vivo) (hamster whole body)	383 MHz 900 and 1800 MHz	TETRA GSM	24 h/day, 60 days	0.08		Metabolic changes
Magras and Xenos (1997) (in vivo) (mouse whole body)	"Antenna park"	TV and FM-radio	Exposure over several generations		0.168	Decrease in reproductive function
Mann et al. (1998) (in vivo) (human whole body)	900 MHz	GSM pulse-modulated at 217 Hz, 577 μs width	8 h		20	A transient increase in blood cortisol
Marinelli et al. (2004) (in vitro)	900 MHz	CW	2–48 h	0.0035		Cell's self-defense responses triggered by DNA damage
Markovà et al. (2005) (in vitro)	915 and 905 MHz	GSM	1 b	0.037		Chromatin conformation in human white blood cells
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz 3000 MHz	CW (no effect observed) Pulse-modulated 2 μs pulses at 400 Hz	Single (0.5–12hr) or repeated (15–60 days, 7–12 h/day) exposure, CW–no effect	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin
Nittby et al. (2008) (in vivo) (rat whole body)	900 MHz,	GSM	2 h/week, 55 weeks	0.0006		Reduced memory functions
Novoselova et al. (1999) (in vivo) (mouse whole body – wavelength in mm range)	From 8.15–18 GHz		1 s sweep time – 16 ms reverse, 5 h		1	Functions of the immune system
Novoselova et al. (2004) (in vivo) (mouse whole body – wavelength in mm range)	From 8.15–18 GHz		1 s sweep time16 ms reverse, 1.5 h/day, 30 days		1	Decreased tumor growth rate and enhanced survival

Table 1 (*continued*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Panagopoulos et al. (2010) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	6 min/day, 5 days		1–10	Reproductive capacity and induced cell death
Panagopoulos and Margaritis (2010*a*) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death
Panagopoulos and Margaritis (2010*b*) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	1–21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure
Pavicic and Trosic (2008) (in vitro)	864 and 935 MHz	CW	1–3 h	0.08		Growth affected in Chinese hamster V79 cells
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz	90% AM	24 h	0.0004		Increased proliferation rate in human astrocytoma cancer cells
Persson et al. (1997) (in vivo) (mouse whole body)	915 MHz	CW and pulse-modulated (217 Hz, 0.57 ms; 50 Hz, 6.6 ms)	2–960 min; CW more potent	0.0004		Increase in permeability of the blood–brain barrier
Phillips et al. (1998) (in vitro)	813.5625 MHz 836.55 MHz	iDEN TDMA	2, 21 h 2, 21 h	0.0024		DNA damage in human leukemia cells
Pologea-Moraru et al. (2002) (in vitro)	2.45 GHz		1 h		15	Change in membrane of cells in the retina
Pyrpasopoulou et al. (2004) (in vivo) (rat whole body)	9.4 GHz	GSM (50 Hz pulses, 20 μs pulse length)	1–7 days postcoitum	0.0005		Exposure during early gestation affected kidney development
Roux et al. (2008*a*) (in vivo) (tomato whole body)	900 MHz				7	Gene expression and energy metabolism
Roux et al. (2008*b*) (in vivo) (plant whole body)	900 MHz				7	Energy metabolism
Salford et al. (2003) (in vivo) (rat whole body)	915 MHz	GSM	2 h	0.02		Nerve cell damage in brain
Sarimov et al. (2004) (in vitro)	895–915 MHz	GSM	30 min	0.0054		Human lymphocyte chromatin affected similar to stress response
Schwartz et al. (1990) (in vitro)	240 MHz	CW and sinusoidal modulation at 0.5 and 16 Hz, effect only observed at 16 Hz modulation	30 min	0.00015		Calcium movement in the heart
Schwarz et al. (2008) (in vitro)	1950 MHz	UMTS	24 h	0.05		Genes in human fibroblasts
Somosy et al. (1991) (in vitro)	2.45 GHz	CW and 16 Hz square-modulation, modulated field more potent than CW		0.024		Molecular and structural changes in cells of mouse embryos

Table 1 (*concluded*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density (μW/cm²)	Effects reported
Stagg et al. (1997) (in vitro)	836.55 MHz	TDMA duty cycle 33%	24 h	0.0059		Glioma cells showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division
Stankiewicz et al. (2006) (in vitro)	900 MHz	GSM 217 Hz pulses, 577 ms width		0.024		Immune activities of human white blood cells
Tattersall et al. (2001) (in vitro)	700 MHz	CW	5–15 min	0.0016		Function of the hippocampus
Velizarov et al. (1999) (in vitro)	960 MHz	GSM 217 Hz square-pulse, duty cycle 12%	30 min	0.000021		Decrease in proliferation of human epithelial amnion cells
Veyret et al. (1991) (in vivo) (mouse whole body)	9.4 GHz	1 μs pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM, direction of response depended on AM frequency		0.015		Functions of the immune system
Vian et al. (2006) (in vivo) plant	900 MHz				7	Stress gene expression
Wolke et al. (1996) (in vitro)	900, 1300, 1800 MHz 900 MHz	Square-wave modulated at 217 Hz CW, 16 Hz, 50 Hz, and 30 KHz modulations		0.001		Calcium concentration in heart muscle cells of guinea pig
Yurekli et al. (2006) (in vivo) (rat whole body)	945 MHz	GSM, 217 Hz pulse-modulation	7 h/day, 8 days	0.0113		Free radical chemistry

Note: These papers gave either specific absorption rate, SAR, (W/kg) or power density (μW/cm²) of exposure. (Studies that did not contain these values were excluded). AM, amplitude-modulated or amplitude-modulation; CW, continuous wave; GSM, global system for mobile communication; iDEN, integrated digital enhanced network; TDMA, time division multiple access, TETRA, terrestrial trunked radio; UMTS, universal mobile telecommunications system.

8. Long-term exposures and cumulative effects

There are many important gaps in the RFR research. The majority of the studies on RFR have been conducted with short-term exposures, i.e., a few minutes to several hours. Little is known about the effects of long-term exposure such as would be experienced by people living near telecommunications installations, especially with exposures spanning months or years. The important questions then are: What are the effects of long-term exposure? Does long-term exposure produce different effects from short-term exposure? Do effects accumulate over time?

There is some evidence of cumulative effects. Phillips et al. (1998) reported DNA damage in cells after 24 h exposure to low-intensity RFR. DNA damage can lead to gene mutation that accumulates over time. Magras and Xenos (1997) reported that mice exposed to low-intensity RFR became less reproductive. After five generations of exposure the mice were not able to produce offspring. This shows that the effects of RFR can pass from one generation to another. Persson et al. (1997) reported an increase in permeability of the blood–brain barrier in mice when the energy deposited in the body exceeded 1.5 J/kg (joule per kilogram) — a measurement of the total amount of energy deposited. This suggests that a short-term, high-intensity exposure can produce the same effect as a long-term, low-intensity exposure, and is another indication that RFR effects can accumulate over time.

In addition, there is some indication that test animals become more sensitive to radiation after long-term exposure as seen in two of the critical experiments that contributed to the present SAR standards, called the "behavior–disruption experiments" carried out in the 1980s.

In the first experiment, de Lorge and Ezell (1980) trained rats on an auditory observing-response task. In the task, an animal was presented with two bars. Pressing the right bar would produce either a low-pitch or a high-pitch tone for half a second. The low-pitch tone signaled an unrewarded situation and the animal was expected to do nothing. However, when the high-pitch tone was on, pressing the left bar would produce a food reward. Thus, the task required continuous vigilance in which an animal had to coordinate its motor responses according to the stimulus presented to get a reward by choosing between a high-pitch or low-pitch tone. After learning the task, rats were then irradiated with 1280 MHz or 5620 MHz RFR during performance. Disruption of behavior (i.e., the rats could not perform very well) was observed within 30–60 min of exposure at a SAR of 3.75 W/kg for 1280 MHz, and 4.9 W/kg for 5620 MHz.

In another experiment, de Lorge (1984) trained monkeys on a similar auditory observing response task. Monkeys were exposed to RFR at 225, 1300, and 5800 MHz. Disruption of performance was observed at 8.1 mW/cm^2 (SAR 3.2 W/kg) for 225 MHz; at 57 mW/cm^2 (SAR 7.4 W/kg) for 1300 MHz; and at 140 mW/cm^2 (SAR 4.3 W/kg) for 5800 MHz. The disruption occurred when body temperature was increased by 1°C.

The conclusion from these experiments was that "... disruption of behavior occurred when an animal was exposed at an SAR of approximately 4 W/kg, and disruption occurred after 30–60 minutes of exposure and when body temperature increased by 1°C" (de Lorge 1984). Based on just these two experiments, 4 W/kg has been used in the setting of the present RFR exposure guidelines for humans. With theoretical safety margins added, the limit for occupational exposure was then set at 0.4 W/kg (i.e., 1/10 of the SAR where effects were observed) and for public exposure 0.08 W/kg for whole body exposures (i.e., 1/5 of that of occupational exposure).

But the relevant question for establishing a human SAR remains: Is this standard adequate, based on so little data, primarily extrapolated from a handful of animal studies from the same investigators? The de Lorge (1984) animal studies noted previously describe effects of short-term exposures, defined as less than one hour. But are they comparable to long-term exposures like what whole populations experience when living or working near transmitting facilities?

Two series of experiments were conducted in 1986 on the effects of long-term exposure. D'Andrea et al. (1986*a*) exposed rats to 2450 MHz RFR for 7 h a day, 7 days per week for 14 weeks. They reported a disruption of behavior at an SAR of 0.7 W/kg. And D'Andrea et al. (1986*b*) also exposed rats to 2450 MHz RFR for 7 h a day, 7 days per week, for 90 days at an SAR of 0.14 W/kg and found a small but significant disruption in behavior. The experimenters concluded, "... the threshold for behavioral and physiological effects of chronic (long-term) RFR exposure in the rat occurs between 0.5 mW/cm^2 (0.14 W/kg) and 2.5 mW/cm^2 (0.7 W/kg)" (p. 55, D'Andrea et al. 1986*b*).

The previously mentioned studies show that RFR can produce effects at much lower intensities after test animals are repeatedly exposed. This may have implications for people exposed to RFR from transmission towers for long periods of time.

Other biological outcomes have also been reported after long-term exposure to RFR. Effects were observed by Baranski (1972) and Takashima et al. (1979) after prolonged, repeated exposure but not after short-term exposure. Conversely, in other work by Johnson et al. (1983), and Lai et al. (1987, 1992) effects that were observed after short-term exposure disappeared after prolonged, repeated exposure, i.e., habituation occurred. Different effects were observed by Dumansky and Shandala (1974) and Lai et al. (1989) after different exposure durations. The conclusion from this body of work is that effects of long-term exposure can be quite different from those of short-term exposure.

Since most studies with RFR are short-term exposure studies, it is not valid to use their results to set guidelines for long-term exposures, such as in populations living or working near cell phone base stations.

9. Effects below 4 W/kg: thermal versus nonthermal

As described previously, current international RFR exposure standards are based mainly on the acute exposure experiments that showed disruption of behavior at 4 W/kg. However, such a basis is not scientifically valid. There are many studies that show biological effects at SARs less than 4 W/kg after short-term exposures to RFR. For example, since the 4 W/kg originated from psychological and (or) behavioral experiments, when one surveys the EMF literature on behavioral effects, one can find many reports on behavioral effects observed at SARs less than 4 W/kg, e.g., D'Andrea et al. (1986*a*) at 0.14 to 0.7 W/kg; DeWitt et al. (1987) at 0.14 W/kg; Gage (1979) at 3 W/kg ; King et al. (1971) at 2.4 W/kg; Kumlin et al. (2007) at 3 W/kg; Lai et al. (1989) at 0.6 W/kg; Mitchell et al. (1977) at 2.3 W/kg (1977); Navakatikian and Tomashevskaya (1994) at 0.027 W/kg; Nittby et al. (2008) at 0.06 W/kg; Schrot et al. (1980) at 0.7 W/kg; Thomas et al. (1975) at 1.5 to 2.7 W/kg; and Wang and Lai (2000) at 1.2 W/kg.

The obvious mechanism of effects of RFR is thermal (i.e., tissue heating). However, for decades, there have been questions about whether nonthermal (i.e., not dependent on a change in temperature) effects exist. This is a well-discussed area in the scientific literature and not the focus of this paper but we would like to mention it briefly because it has implications for public safety near transmission facilities.

Practically, we do not actually need to know whether RFR effects are thermal or nonthermal to set exposure guidelines. Most of the biological-effects studies of RFR that have been conducted since the 1980s were under nonthermal conditions. In studies using isolated cells, the ambient temperature during exposure was generally well controlled. In most animal studies, the RFR intensity used usually did not cause a significant increase in body temperature in the test animals. Most scientists consider nonthermal effects as established, even though the implications are not fully understood.

Scientifically, there are three rationales for the existence of nonthermal effects:

1. Effects can occur at low intensities when a significant increase in temperature is not likely.
2. Heating does not produce the same effects as RFR exposure.
3. RFR with different modulations and characteristics produce different effects even though they may produce the same pattern of SAR distribution and tissue heating.

Low-intensityeffects have been discussed previously (see Section 7.). There are reports that RFR triggers effects that are different from an increase in temperature, e.g., Wachtel et al. (1975); Seaman and Wachtel (1978); D'Inzeo et al. (1988). And studies showing that RFR of the same frequency and intensity, but with different modulations and waveforms, can produce different effects as seen in the work of Baranski (1972); Arber and Lin (1985); Campisi et al. (2010); d'Ambrosio et al. (2002); Frey et al. (1975); Oscar and Hawkins (1977); Sanders et al. (1985); Huber et al. (2002); Markkanen et al. (2004); Hung et al. (2007); and Luukkonen et al. (2009).

A counter-argument for point 1 is that RFR can cause micro-heating at a small location even though there is no measurement change in temperature over the whole sample. This implies that an effect observed at low intensities could be due to localized micro-heating, and, therefore, is still considered thermal. However, the micro-heating theory could not apply to test subjects that are not stationary, such as in the case of Magras and Xenos (1997) who reported that mice exposed to low-intensity RFR became less reproductive over several generations. "Hot spots" of heating move within the body when the subject moves in the field and, thus, cannot maintain sustained heating of certain tissue.

The counter argument for point 2 is that heating by other means does not produce the same pattern of energy distribution as RFR. Thus, different effects would result. Again, this counter argument does not work on moving objects. Thus, results supporting the third point are the most compelling.

10. Studies on exposure to cell tower transmissions

From the early genesis of cell phone technology in the early 1980s, cell towers were presumed safe when located near populated areas because they are low-power installations in comparison with broadcast towers. This thinking already depended on the assumption that broadcast towers were safe if kept below certain limits. Therefore, the reasoning went, cell towers would be safer still. The thinking also assumed that exposures between cell and broadcast towers were comparable. In certain cities, cell and broadcast tower transmissions both contributed significantly to the ambient levels of RFR (Sirav and Seyhan 2009; Joseph et al. 2010).

There are several fallacies in this thinking, including the fact that broadcast exposures have been found unsafe even at regulated thresholds. Adverse effects have been noted for significant increases for all cancers in both men and women living near broadcast towers (Henderson and Anderson 1986); childhood leukemia clusters (Maskarinec et al. 1994; Ha et al. 2003; Park et al. 2004); adult leukemia and lymphoma clusters, and elevated rates of mental illness (Hocking et al. 1996; Michelozzi et al. 2002; Ha et al. 2007); elevated brain tumor incidence (Dolk et al. 1997*a*, 1997*b*); sleep disorders, decreased concentration, anxiety, elevated blood pressure, headaches, memory impairment, increased white cell counts, and decreased lung function in children (Altpeter et al. 2000); motor, memory, and learning impairment in children (Kolodynski and Kolodynski 1996), nonlinear increases in brain tumor incidence (Colorado Department of Public Health 2004); increases in malignant melanoma (Hallberg and Johansson 2002); and nonlinear immune system changes in women (Boscol et al. 2001). (The term "nonlinear" is used in scientific literature to mean that an effect was not directly proportional to the intensity of exposure. In the case of the two studies mentioned previously, adverse effects were found at significant distances from the towers, not in closer proximity where the power density exposures were higher and therefore presumed to have a greater chance of causing effects. This is something that often comes up in low-level energy studies and adds credence to the argument that low-level exposures could cause qualitatively different effects than higher level exposures.)

There is also anecdotal evidence in Europe that some communities have experienced adverse physical reactions after the switch from analog TV broadcast signals to the new digital formats, which can be more biologically complex

Three doctors in Germany, Cornelia Waldmann-Selsam, MD, Christine Aschermann, MD, and Markus Kern, MD, wrote (in a letter to the U.S. President, entitled *Warning — Adverse Health Effects From Digital Broadcast Television*)[10], that on 20 May 2006, two digital broadcast television stations went on the air in the Hessian Rhoen area. Prior to that time that area had low radiation levels, which included that from cell phone towers of which there were few. However, coinciding with the introduction of the digital signals, within a radius of more than 20 km, there was an abrupt onset of symptoms for constant headaches, pressure in the head, drowsiness, sleep problems, inability to think clearly, forgetfulness, nervousness, irritability, tightness in the chest, rapid heartbeat, shortness of breath, depression, apathy, loss of empathy, burning skin, sense of inner burning, leg weakness, pain in the limbs, stabbing pain in various organs, and weight gain. They also noted that birds fled the area. The same symptoms gradually appeared in other locations after digital signals were introduced. Some physicians accompanied affected people to areas where there was no TV reception from terrestrial sources, such as in valleys or behind mountain ranges, and observed that many people became symptom free after only a short time. The digital systems also require more transmitters than the older analog systems and, therefore, somewhat higher exposure levels to the general population are expected, according to the 2009 SCENIHR Report (SCENIHR 2009).

Whether digital or analog, the frequencies differ between broadcast and cell antennas and do not couple with the human anatomy in whole-body or organ-specific models in the same ways (NCRP 1986; ICNIRP 1998). This difference in how the body absorbs energy is the reason that all standards-setting organizations have the strictest limitations between 30–300 MHz — ranges that encompass FM broadcast where whole body resonance occurs (Cleveland 2001). Exposure allowances are more lenient for cell technology in frequency ranges between 300 MHz and 3 GHz, which encompass cellular phone technology. This is based on the assumption that the cell frequencies do not penetrate the body as deeply and no whole-body resonance can occur.

There are some studies on the health effects on people living near cell phone towers. Though cell technology has been in existence since the late 1980s, the first study of populations near cell tower base stations was only conducted by Santini et al. (2002). It was prompted in part by complaints of adverse effects experienced by residents living near cell base stations throughout the world and increased activism by citizens. As well, increasing concerns by physicians to understand those complaints was reflected in professional organizations like the ICEMS (International Committee on Electromagnetic Safety) Catania Resolution[11], the Irish Doctors Environmental Association (IDEA)[12], and the Freiburger Appeal[13].

Santini conducted a survey study of 530 people (270 men, 260 women) on 18 nonspecific health symptoms (NSHS) in relation to self-reported distance from towers of <10 m, 10 to 50 m, 50 to 100 m, 100 to 200 m, 200 to 300 m, and >300 m. The control group compared people living more than 300 m (approximately 1000 ft) or not exposed to base stations. They controlled for age, presence of electrical transformers (<10 m), high tension lines (<100 m), and radio/TV broadcast transmitters (<4 km), the frequency of cell phone use (>20 min per day), and computer use (>2 h per day). Questions also included residents' location in relation to antennas, taking into account orientations that were facing, beside, behind, or beneath antennas in cases of roof-mounted antenna arrays. Exposure conditions were defined by the length of time living in the neighborhood (<1 year through >5 years); the number of days per week and hours per day (<1 h to >16 h) that were spent in the residence.

Results indicated increased symptoms and complaints the closer a person lived to a tower. At <10 m, symptoms included nausea, loss of appetite, visual disruptions, and difficulty in moving. Significant differences were observed up through 100 m for irritability, depressive tendencies, concentration difficulties, memory loss, dizziness, and lower libido. Between 100 and 200 m, symptoms included headaches, sleep disruption, feelings of discomfort, and skin problems. Beyond 200 m, fatigue was significantly reported more often than in controls. Women significantly reported symptoms more often than men, except for libido loss. There was no increase in premature menopause in women in relation to distance from towers. The authors concluded that there were different sex-dependent sensitivities to electromagnetic fields. They also called for infrastructure not to be sited <300 m (~1000 ft) from populations for precautionary purposes, and noted that the information their survey captured might not apply to all circumstances since actual exposures depend on the volume of calls being generated from any particular tower, as well as on how radiowaves are reflected by environmental factors.

Similar results were found in Egypt by Abdel-Rassoul et al. (2007) looking to identify neurobehavioral deficits in people living near cell phone base stations. Researchers conducted a cross-sectional study of 85 subjects: 37 living inside a building where antennas were mounted on the rooftop and 48 agricultural directorate employees who worked in a building (~10 m) opposite the station. A control group of 80 who did not live near base stations were matched for age, sex, occupation, smoking, cell phone use, and educational level. All participants completed a questionnaire containing personal, educational, and medical histories; general and neurological examinations; a neurobehavioral test battery (NBTB) involving tests for visuomotor speed, problem solving, attention, and memory, in addition to a Eysenck personality questionnaire (EPQ).

Their results found a prevalence of neuropsychiatric complaints: headaches, memory changes, dizziness, tremors, depressive symptoms, and sleep disturbance were significantly higher among exposed inhabitants than controls. The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory (paced auditory

[10] http://www.notanotherconspiracy.com/2009/02/warning-adverse-health-effects-from.html. (Accessed October 2010.)
[11] http://www.icems.eu/resolution.htm
[12] http://www.ideeaireland.org/emr.htm
[13] http://www.laleva.cc/environment/freiburger_appeal.html

serial addition test (PASAT)). Also, the inhabitants opposite the station exhibited a lower performance in the problem-solving test (block design) than those who lived under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls.

Environmental power-density data were taken from measurements of that building done by the National Telecommunications Institute in 2000. Measurements were collected from the rooftop where the antennas were positioned, the shelter that enclosed the electrical equipment and cables for the antennas, other sites on the roof, and within an apartment below one of the antennas. Power-density measurements ranged from 0.1–6.7 $\mu W/cm^2$. No measurements were taken in the building across the street. The researchers noted that the last available measurements of RFR in 2002 in that area were less than the allowable standards but also noted that exposures depended on the number of calls being made at any given time, and that the number of cell phone users had increased approximately four times within the 2 years just before the beginning of their study in 2003. They concluded that inhabitants living near mobile phone base stations are at risk for developing neuropsychiatric problems, as well as some changes in the performance of neurobehavioral functions, either by facilitation (over-stimulation) or inhibition (suppression). They recommended the standards be revised for public exposure to RFR, and called for using the NBTB for regular assessment and early detection of biological effects among inhabitants near base stations (Abdel-Rassoul et al. 2007).

Hutter et al. (2006) sought to determine cognitive changes, sleep quality, and overall well-being in 365 rural and urban inhabitants who had lived for more than a year near 10 selected cell phone base stations. Distance from antennas was 24 to 600 m in rural areas, and 20 to 250 m in the urban areas. Field strength measurements were taken in bedrooms and cognitive tests were performed. Exposure to high-frequency EMFs was lower than guidelines and ranged from 0.000002 to 0.14 $\mu W/cm^2$ for all frequencies between 80 MHz and 2 GHz with the greater exposure coming from mobile telecommunications facilities, which was between 0.000001 and 0.14 $\mu W/cm^2$. Maximum levels were between 0.000002 and 0.41 $\mu W/cm^2$ with an overall 5% of the estimated maximum above 0.1 $\mu W/cm^2$. Average levels were slightly higher in rural areas (0.005 $\mu W/cm^2$) than in urban areas (0.002 $\mu W/cm^2$). The researchers tried to ascertain if the subjective rating of negative health consequences from base stations acted as a covariable but found that most subjects expressed no strong concerns about adverse effects from the stations, with 65% and 61% in urban and rural areas, respectively, stating no concerns at all. But symptoms were generally higher for subjects who expressed health concerns regarding the towers. The researchers speculated that this was due to the subjects with health complaints seeking answers and consequently blaming the base station; or that subjects with concerns were more anxious in general and tended to give more negative appraisals of their body functions; and the fact that some people simply give very negative answers.

Hutter's results were similar to those of Santini et al. (2002) and Abdel-Rassoul et al. (2007). Hutter found a significant relationship between symptoms and power densities. Adverse effects were highest for headaches, cold hands and feet, cardiovascular symptoms, and concentration difficulties. Perceptual speed increased while accuracy decreased insignificantly with increasing exposure levels. Unlike the others, however, Hutter found no significant effects on sleep quality and attributed such problems more to fear of adverse effects than actual exposure. They concluded that effects on well-being and performance cannot be ruled out even as mechanisms of action remain unknown. They further recommended that antenna siting should be done to minimize exposure to the population.

Navarro et al. (2003) measured the broadband electric field (E-field) in the bedrooms of 97 participants in La Nora, Murcia, Spain and found a significantly higher symptom score in 9 out of 16 symptoms in the groups with an exposure of 0.65 V/m (0.1121 $\mu W/cm^2$) compared with the control group with an exposure below 0.2 V/m (0.01061 $\mu W/cm^2$), both as an average. The highest contributor to the exposure was GSM 900/1800 MHz signals from mobile telecommunications. The same researchers also reported significant correlation coefficients between the measured E-field and 14 out of 16 health-related symptoms with the five highest associations found for depressive tendencies, fatigue, sleeping disorders, concentration difficulties, and cardiovascular problems. In a follow up work, Oberfeld et al. (2004) conducted a health survey in Spain in the vicinity of two GSM 900/1800 MHz cell phone base stations, measuring the E-field in six bedrooms, and found similar results. They concluded that the symptoms are in line with "microwave syndrome" reported in the literature (Johnson-Liakouris 1998). They recommended that the sum total for ambient exposures should not be higher than 0.02 V/m — the equivalent of a power density of 0.00011 $\mu W/cm^2$, which is the indoor exposure value for GSM base stations proposed by the Public Health Office of the Government of Salzburg, Austria in 2002[14].

Eger et al. (2004) took up a challenge to medical professionals by Germany's radiation protection board to determine if there was an increased cancer incidence in populations living near cell towers. Their study evaluated data for approximately 1000 patients between the years of 1994 and 2004 who lived close to cell antennas. The results showed that the incidence of cancer was significantly higher among those patients who had lived for 5 to 10 years at a distance of up to 400 m from a cell installation that had been in operation since 1993, compared with those patients living further away, and that the patients fell ill on an average of 8 years earlier than would be expected. In the years between 1999 and 2004, after 5 years operation of the transmitting installation, the relative risk of getting cancer had tripled for residents in proximity of the installation compared with inhabitants outside of the area.

Wolf and Wolf (2004) investigated increased cancer incidence in populations living in a small area in Israel exposed

[14] http://www.salzburg.gv.at/umweltmedizin. (Accessed October 2010.)

to RFR from a cell tower. The antennas were mounted 10 m high, transmitting at 850 MHz and 1500 W at full-power output. People lived within a 350 m half circle of the antennas. An epidemiologic assessment was done to determine whether the incidence of cancer cases among individuals exposed to the base station in the south section of the city of Netanya called Irus (designated area A) differed from expected cancer rates throughout Israel, and in the town of Netanya in general, as compared with people who lived in a nearby area without a cell tower (designated area B). There were 622 participants in area A who had lived near the cell tower for 3 to 7 years and were patients at one health clinic. The exposure began 1 year before the start of the study when the station first came into service. A second cohort of individuals in area B, with 1222 participants who received medical services at a different clinic located nearby, was used as a control. Area B was closely matched for environment, workplace, and occupational characteristics. In exposure area A, eight cases of different types of cancer were diagnosed in a period of 1 year, including cancers of the ovary (1), breast (3), Hodgkins lymphoma (1), lung (1), osteoid osteoma (1), and hypernephroma (1). The RFR field measurements were also taken per house and matched to the cancer incidents. The rate of cancers in area A was compared with the annual rate of the general population (31 cases per 10 000) and to incidence for the entire town of Netanya. There were two cancers in area B, compared to eight in area A. They also examined the history of the exposed cohort (area A) for malignancies in the 5 years before exposure began and found only two cases in comparison to eight cases 1 year after the tower went into service. The researchers concluded that relative cancer rates for females were 10.5 for area A, 0.6 for area B, and 1.0 for the whole town of Netanya. Cancer incidence in women in area A was thus significantly higher ($p < 0.0001$) compared with that of area B and the whole city. A comparison of the relative risk revealed that there were 4.15 times more cases in area A than in the entire population. The study indicated an association between increased incidence of cancer and living in proximity to a cell phone base station. The measured level of RFR, between 0.3 to 0.5 $\mu W/cm^2$, was far below the thermal guidelines.

11. Risk perception, electrohypersensitivity, and psychological factors

Others have followed up on what role risk perception might play in populations near cell base stations to see if it is associated with health complaints.

Blettner et al. (2008) conducted a cross-sectional, multiphase study in Germany. In the initial phase, 30 047 people out of a total of 51 444, who took part in a nationwide survey, were also asked about their health and attitudes towards mobile phone base stations. A list of 38 potential health complaints were used. With a response rate of 58.6%, 18.0% were concerned about adverse health effects from base stations, 10.3% directly attributed personal adverse effects to them. It was found that people living within 500 m, or those concerned about personal exposures, reported more health complaints than others. The authors concluded that even though a substantial proportion of the German population is concerned about such exposures, the observed higher health complaints cannot be attributed to those concerns alone.

Kristiansen et al. (2009) also explored the prevalence and nature of concerns about mobile phone radiation, especially since the introduction of new 3G–UMTS (universal mobile telecommunications system) networks that require many more towers and antennas have sparked debate throughout Europe. Some local governments have prohibited mobile antennas on public buildings due to concerns about cancer, especially brain cancer in children and impaired psychomotor functions. One aim of the researchers was risk assessment — to compare people's perceptions of risk from cell phones and masts to other fears, such as being struck by lightening. In Denmark, they used data from a 2006 telephone survey of 1004 people aged 15+ years. They found that 28% of the respondents were concerned about exposure to mobile phone radiation and 15% about radiation from masts. In contrast, 82% of respondents were concerned about other forms of environmental pollution. Nearly half of the respondents considered the mortality risk of 3G phones and masts to be of the same order of magnitude as being struck by lightning (0.1 fatalities per million people per year), while 7% thought it was equivalent to tobacco-induced lung cancer (approximately 500 fatalities per million per year). Among women, concerns about mobile phone radiation, perceived mobile phone mortality risk, and concerns about unknown consequences of new technologies, increased with educational levels. More than two thirds of the respondents felt that they had not received adequate public information about the 3G system. The results of the study indicated that the majority of the survey population had little concern about mobile phone radiation, while a minority is very concerned.

Augner et al. (2009) examined the effects of short-term GSM base station exposure on psychological symptoms including good mood, alertness, and calmness as measured by a standardized well-being questionnaire. Fifty-seven participants were randomly assigned to one of three different exposure scenarios. Each of those scenarios subjected participants to five 50 min exposure sessions, with only the first four relevant for the study of psychological symptoms. Three exposure levels were created by shielding devices, which could be installed or removed between sessions to create double-blinded conditions. The overall median power densities were 0.00052 $\mu W/cm^2$ during low exposures, 0.0154 $\mu W/cm^2$ during medium exposures, and 0.2127 $\mu W/cm^2$ during high-exposure sessions. Participants in high- and medium-exposure scenarios were significantly calmer during those sessions than participants in low-exposure scenarios throughout. However, no significant differences between exposure scenarios in the "good mood" or "alertness" factors were found. The researchers concluded that short-term exposure to GSM base station signals may have an impact on well-being by reducing psychological arousal.

Eltiti et al. (2007) looked into exposures to the GSM and UMTS exposures from base stations and the effects to 56 participants who were self-reported as sensitive to electromagnetic fields. Some call it electro-hypersensitivity (EHS) or just electrosensitivity. People with EHS report that they suffer negative health effects when exposed to electromagnetic fields from everyday objects such as cell phones, mobile phone base stations, and many other common things in modern societies. EHS is a recognized functional impairment in Sweden. This study used both open provocation and double-blind tests to determine if electrosensitive and control individuals experienced more negative health effects when exposed to base-station-like signals compared with sham exposures. Fifty-six electrosensitive and 120 control participants were tested first in an open provocation test. Of these, 12 electrosensitive and six controls withdrew after the first session. Some of the electrosensitive subjects later issued a statement saying that the initial exposures made them too uncomfortable to continue participating in the study. This means that the study may have lost its most vulnerable test subjects right at the beginning, possibly skewing later outcomes. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms, as well as physiological measures of blood-volume pulse, heart rate, and skin conductance were obtained. They found that during the open provocation, electrosensitive individuals reported lower levels of well-being to both GSM and UMTS signals compared with sham exposure, whereas controls reported more symptoms during the UMTS exposure. During double-blind tests the GSM signal did not have any effect on either group. Electrosensitive participants did report elevated levels of arousal during the UMTS condition, but the number or severity of symptoms experienced did not increase. Physiological measures did not differ across the three exposure conditions for either group. The researchers concluded that short-term exposure to a typical GSM base-station-like signal did not affect well-being or physiological functions in electrosensitive or control individuals even though the electrosensitive individuals reported elevated levels of arousal when exposed to a UMTS signal. The researchers stated that this difference was likely due to the effect of the order of the exposures throughout the series rather than to the exposure itself. The researchers do not speculate about possible data bias when one quarter of the most sensitive test subjects dropped out at the beginning.

In follow-up work, Eltiti et al. (2009) attempted to clarify some of the inconsistencies in the research with people who report sensitivity to electromagnetic fields. Such individuals, they noted, often report cognitive impairments that they believe are due to exposure to mobile phone technology. They further said that previous research in this area has revealed mixed results, with the majority of research only testing control individuals. Their aim was to clarify whether short-term (50 min) exposure at 1 $\mu W/cm^2$ to typical GSM and UMTS base station signals affects attention, memory, and physiological endpoints in electrosensitive and control participants. Data from 44 electrosensitive and 44 matched-control participants who performed the digit symbol substitution task (DSST), digit span task (DS), and a mental arithmetic task (MA), while being exposed to GSM, UMTS, and sham signals under double-blind conditions were analyzed. Overall, the researchers concluded that cognitive functioning was not affected by short-term exposure to either GSM or UMTS signals. Nor did exposure affect the physiological measurements of blood-volume pulse, heart rate, and skin conductance that were taken while participants performed the cognitive tasks. The GSM signal was a combined signal of 900 and 1800 MHz frequencies, each with a power flux density of 0.5 $\mu W/cm^2$, which resulted in combined power flux density of 1 $\mu W/cm^2$ over the area where test subjects were seated. Previous measurements in 2002 by the National Radiological Protection Board in the UK, measuring power density from base stations at 17 sites and 118 locations (Mann et al. 2002), found that in general, the power flux density was between 0.001 $\mu W/cm^2$ to 0.1 $\mu W/cm^2$, with the highest power density being 0.83 $\mu W/cm^2$. The higher exposure used by the researchers in this study was deemed comparable by them to the maximum exposure a person would encounter in the real world. But many electrosensitive individuals report that they react to much lower exposures too. Overall, the electrosensitive participants had a significantly higher level of mean skin conductance than control subjects while performing cognitive tasks. The researchers noted that this was consistent with other studies that hypothesize sensitive individuals may have a general imbalance in autonomic nervous system regulation. Generally, cognitive functioning was not affected in either electrosensitives or controls. When Bonferroni corrections were applied to the data, the effects on mean skin conductance disappeared. A criticism is that this averaging of test results hides more subtle effects.

Wallace et al. (2010) also tried to determine if short-term exposure to RFR had an impact on well-being and what role, if any, psychological factors play. Their study focused on "Airwave", a new communication system being rolled out across the UK for police and emergency services. Some police officers have complained about skin rashes, nausea, headaches, and depression as a consequence of using Airwave two-way radio handsets. The researchers used a small group of self-reported electrosensitive people to determine if they reacted to the exposures, and to determine if exposures to specific signals affect a selection of the adult population who do not report sensitivity to electromagnetic fields. A randomized double-blind provocation study was conducted to establish whether short-term exposure to a terrestrial trunked radio (TETRA) base station signal has an impact on health and well-being in individuals with electrosensitivity and controls. Fifty-one individuals with electrosensitivity and 132 age- and gender-matched controls participated first in an open provocation test, while 48 electrosensitive and 132 control participants went on to complete double-blind tests in a fully screened semi-anechoic chamber. Heart rate, skin conductance, and blood pressure readings provided objective indices of short-term physiological response. Visual analogue scales and symptom scales provided subjective indices of well-being. Their results found no differences on any measure between TETRA and sham (no signal) under double-blind conditions for either control or electrosensitive participants and neither group could detect the presence of a TETRA signal above chance (50%). The researchers noted, however, that when conditions were not double-blinded, the electrosensitive individuals did report feeling worse and experienced more severe symptoms during TETRA compared with sham exposure. They concluded that the adverse symptoms experienced by electrosensitive individuals are caused by the belief of harm from TETRA base stations rather than because of the low-level EMF exposure itself.

It is interesting to note that the three previously mentioned studies were all conducted at the same Electromagnetics and Health Laboratory at the University of Essex, Essex, UK, by the same relative group of investigators. Those claiming to be electrosensitive are a small subgroup in the population, often in touch through Internet support groups. In the first test, many electrosensitives dropped out because they found the exposures used in the study too uncomfortable. The drop-out rate decreased with the subsequent studies, which raises the question of whether the electrosensitive participants in the latter studies were truly electrosensitive. There is a possibility that a true subgroup of electrosensitives cannot tolerate such study conditions, or that potential test subjects are networking in a way that preclude their participation in the first place. In fact, researchers were not able to recruit their target numbers for electrosensitive participants in any of the studies. The researchers also do not state if there were any of the same electrosensitive participants used in the three studies. Nor do they offer comment regarding the order of the test methods possibly skewing results.

Because of uncertainty regarding whether EMF exposures are actually causing the symptoms that electrosensitives report, and since many electrosensitives also report sensitivities to myriad chemicals and other environmental factors, it has been recommended (Hansson Mild et al. 2006) that a new term be used to describe such individuals — idiopathic environmental intolerance with attribution to electromagnetic fields (IEI-EMF).

Furubayashi et al. (2009) also tried to determine if people who reported symptoms to mobile phones are more susceptible than control subjects to the effect of EMF emitted from base stations. They conducted a double-blind, cross-over provocation study, sent questionnaires to 5000 women and obtained 2472 valid responses from possible candidates. From those, they were only able to recruit 11 subjects with mobile phone related symptoms (MPRS) and 43 controls. The assumption was that individuals with MPRS matched the description of electrosensitivity by the World Health Organization (WHO). There were four EMF exposure conditions, each of which lasted 30 min: (*i*) continuous, (*ii*) intermittent, (*iii*) sham exposure with noise, and (*iv*) sham exposure without noise. Subjects were exposed to EMF of 2.14 GHz, 10 V/m (26.53 $\mu W/cm^2$) wideband code division multiple access (W-CDMA), in a shielded room to simulate whole-body exposure to EMF from base stations, although the exposure strength they used was higher than that commonly received from base stations. The researchers measured several psychological and cognitive parameters immediately before and after exposure, and monitored autonomic functions. Subjects were asked to report on their perception of EMF and level of discomfort during the experiment. The MPRS group did not differ from the controls in their ability to detect exposure to EMF. They did, however, consistently experience more discomfort in general, regardless of whether or not they were actually exposed to EMF, and despite the lack of significant changes in their autonomic functions. The researchers noted that others had found electrosensitive subjects to be more susceptible to stress imposed by task performance, although they did not differ from normal controls in their personality traits. The researchers concluded that the two groups did not differ in their responses to real or sham EMF exposure according to any psychological, cognitive or autonomic assessment. They said they found no evidence of any causal link between hypersensitivity symptoms and exposure to EMF from base stations. However, this study, had few MPRS participants.

Regel et al. (2006) also investigated the effects of the influence of UMTS base-station-like signals on well-being and cognitive performance in subjects with and without self-reported sensitivity to RFR. The researchers performed a controlled exposure experiment in a randomized, double-blind crossover study, with 45 min at an electric field strength of 0 V/m, 1.0 V/m (0.2653 $\mu W/cm^2$), or 10.0 V/m (26.53 $\mu W/cm^2$), incident with a polarization of 45° from the left-rear side of the subject, at weekly intervals. A total of 117 healthy subjects that included 33 self-reported sensitive subjects and 84 nonsensitive subjects, participated in the study. The team assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain-tissue-specific dosimetry, including uncertainty and variation analysis, was performed. Their results found that in both groups, well-being and perceived field strength were not associated with actual exposure levels. They observed no consistent condition-induced changes in cognitive performance except for two marginal effects. At 10 V/m (26.53 $\mu W/cm^2$) they observed a slight effect on speed in one of six tasks in the sensitive subjects and an effect on accuracy in another task in nonsensitive subjects. Both effects disappeared after multiple endpoint adjustments. They concluded that they could not confirm a short-term effect of UMTS base-station-like exposure on well-being. The reported effects on brain functioning were marginal, which they attributed to chance. Peak spatial absorption in brain tissue was considerably smaller than during use of a mobile phone. They concluded that no conclusions could be drawn regarding short-term effects of cell phone exposure or the effects of long-term base-station-like exposures on human health.

Siegrist et al. (2005) investigated risk perceptions associated with mobile phones, base stations, and other sources of EMFs through a telephone survey conducted in Switzerland. Participants assessed both risks and benefits associated with nine different sources of EMF. Trust in the authorities regulating these hazards was also assessed. Participants answered a set of questions related to attitudes toward EMF and toward mobile phone base stations. Their results were: high-voltage transmission lines are perceived as the most risky source of EMF; and mobile phones and base stations received lower risk ratings. Trust in authorities was positively associated with perceived benefits and negatively associated with perceived risks. Also, people who use their mobile phones frequently perceived lower risks and higher benefits than people who use their mobile phones infrequently. People who believed they lived close to a base station did not significantly differ in their perceived level of risks associated with mobile phone base stations from people who did not believe they lived close to a base station. A majority of participants favored limits to exposures based on worst-case scenarios. The researchers also correlated perceived risks with other beliefs and found that belief in paranormal phenomena is related to level of perceived risks associated with

EMF. In addition, people who believed that most chemical substances cause cancer also worried more about EMF than people who did not believe that chemical substances are harmful. This study found the obvious — that some people worry more about environmental factors than others across a range of concerns.

Wilen et al. (2006) investigated the effects of exposure to mobile phone RFR on people who experience subjective symptoms when using mobile phones. Twenty subjects with MPRS were matched with 20 controls without MPRS. Each subject participated in two experimental sessions, one with true exposure and one with sham exposure, in random order. In the true exposure condition, the test subjects were exposed for 30 min to an RFR field generating a maximum SAR (1 g) in the head of 1 W/kg through an indoor base station antenna attached to signals from a 900 MHz GSM mobile phone. Physiological and cognitive parameters were measured during the experiment for heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time. No significant differences related to RFR exposure conditions and no differences in baseline data were found between subject groups with the exception for reaction time, which was significantly longer among the test subjects than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the test subjects differed significantly from the controls with respect to HRV as measured in the frequency domain. The test subjects displayed a shift in the low/high frequency ratio towards a sympathetic dominance in the autonomous nervous system during the CFFT and memory tests, regardless of exposure condition. They interpreted this as a sign of differences in the autonomous nervous system regulation among persons with MPRS and persons with no such symptoms.

12. Assessing exposures

Quantifying, qualifying, and measuring radiofrequency (RF) energy both indoors and outdoors has frustrated scientists, researchers, regulators, and citizens alike. The questions involve how best to capture actual exposure data — through epidemiology, computer estimates, self-reporting, or actual dosimetry measurements. Determining how best to do this is more important than ever, given the increasing background levels of RFR. Distance from a generating source has traditionally been used as a surrogate for probable power density but that is imperfect at best, given how RF energy behaves once it is transmitted. Complicated factors and numerous variables come into play. The wearing of personal dosimetry devices appears to be a promising area for capturing cumulative exposure data.

Neubauer et al. (2007) asked the question if epidemiology studies are even possible now, given the increasing deployment of wireless technologies. They examined the methodological challenges and used experts in engineering, dosimetry, and epidemiology to critically evaluate dosimetric concepts and specific aspects of exposure assessment regarding epidemiological study outcomes. They concluded that, at least in theory, epidemiology studies near base stations are feasible but that all relevant RF sources have to be taken into account. They called for pilot studies to validate exposure assessments and recommended that short-to-medium term effects on health and well-being are best investigated by cohort studies. They also said that for long-term effects, groups with high exposures need to be identified first, and that for immediate effects, human laboratory studies are the preferred approach. In other words, multiple approaches are required. They did not make specific recommendations on how to quantify long-term, low-level effects on health and well-being.

Radon et al. (2006) compared personal RF dosimetry measurements against recall to ascertain the reliability of self-reporting near base stations. Their aim was to test the feasibility and reliability of personal dosimetry devices. They used a 24 h assessment on 42 children, 57 adolescents, and 64 adults who wore a Maschek dosimeter prototype, then compared the self-reported exposures with the measurements. They also compared the readings of Maschek prototype with those of the Antennessa DSP-090 in 40 test subjects. They found that self-reported exposures did not correlate with actual readings. The two dosimeters were in moderate agreement. Their conclusion was that personal dosimetry, or the wearing of measuring devices, was a feasible method in epidemiology studies.

A study by Frei et al. (2009) also used personal dosimetry devices to examine the total exposure levels of RFR in the Swiss urban population. What they found was startling — nearly a third of the test subjects' cumulative exposures were from cell base stations. Prior to this study, exposure from base stations was thought to be insignificant due to their low-power densities and to affect only those living or working in close proximity to the infrastructure. This study showed that the general population moves in and out of these particular fields with more regularity than previously expected. In a sample of 166 volunteers from Basel, Switzerland, who agreed to wear personal exposure meters (called exposimeters), the researchers found that nearly one third of total exposures came from base stations. Participants carried an exposimeter for 1 week (2 separate weeks in 32 participants) and also completed an activity diary. Mean values were calculated using the robust regression on order statistics (ROS) method. Results found a mean weekly exposure to all RFR and (or) EMF sources was 0.013 μW/cm^2 (range of individual means 0.0014–0.0881 μW/cm^2). Exposure was mainly from mobile phone base stations (32.0%), mobile phone handsets (29.1%), and digital enhanced cordless telecommunications (DECT) phones (22.7%). People owning a DECT phone (total mean 0.015 μW/cm^2) or mobile phone (0.014 μW/cm^2) were exposed more than those not owning a DECT or mobile phone (0.010 μW/cm^2). Mean values were highest in trains (0.116 μW/cm^2), airports (0.074 μW/cm^2), and tramways or buses (0.036 μW/cm^2) and were higher during daytime (0.016 μW/cm^2) than nighttime (0.008 μW/cm^2). The Spearman correlation coefficient between mean exposure in the first and second week was 0.61. Another surprising finding of this study contradicted Neubauer et al. (2008) who found that a rough dosimetric estimate of a 24 h exposure from a base station (1–2 V/m) (i.e., 0.2653–1.061 μW/cm^2) corresponded to approximately 30 min of mobile phone use. But Frei et al. (2009) found, using the exposimeter, that cell phone use was 200 times higher than the average base station exposure contribution in self-selected volunteers (0.487 versus 0.002 μW/cm²). This implied that at the belt, backpack, or in close vicinity to the body, the mean base station contribution corresponds to about 7 min of mobile phone use (24 h divided by 200), not 30 min. They concluded that exposure to RFR varied considerably between persons and locations but was fairly consistent for individuals. They noted that cell phones, base stations, and cordless phones were important sources of exposure in urban Switzerland but that people could reduce their exposures by replacing their cordless domestic phones with conventional landlines at home. They determined that it was feasible to combine diary data with personal exposure measurements and that such data was useful in evaluating RFR exposure during daily living, as well as helpful in reducing exposure misclassification in future epidemiology studies.

Viel et al. (2009) also used personal exposure meters (EME SPY 120 made by Satimo and ESM 140 made by Maschek) to characterize actual residential exposure from antennas. Their primary aim was to assess personal exposures, not ambient field strengths. Two hundred randomly selected people were enrolled to wear measurement meters for 24 h and asked to keep a time–location–activity diary. Two exposure metrics for each radiofrequency were then calculated: the proportion of measurements above the detection limit of 0.05 V/m (0.0006631 μW/cm²) and the maximum electric field strength. Residential addresses were geocoded and distances from each antenna were calculated. They found that much of the time-recorded field strength was below the detection level of 0.05 V/m, with the exception of the FM radio bands, which had a detection threshold of 12.3%. The maximum electric field was always lower than 1.5 V/m (0.5968 μW/cm²). Exposure to GSM and digital cellular system (DCS) frequencies peaked around 280 m in urban areas and 1000 m from antennas in more suburban/rural areas. A downward trend in exposures was found within a 10 km distance for FM exposures. Conversely, UMTS, TV3, and TV 4 and 5 signals did not vary with distance. The difference in peak exposures for cell frequencies were attributed to microcell antennas being more numerous in urban areas, often mounted a few meters above ground level, whereas macrocell base stations in less urban areas are placed higher (between 15 and 50 m above ground level) to cover distances of several kilometres. They concluded that despite the limiting factors and high variability of RF exposure assessments, in using sound statistical technique they were able to determine that exposures from GSM and DCS cellular base stations actually increase with distance in the near source zone, with a maximum exposure where the main beam intersects the ground. They noted that such information should be available to local authorities and the public regarding the siting of base stations. Their findings coincide with Abdel-Rassoul et al. (2007) who found field strengths to be less in the building directly underneath antennas, with reported health complaints higher in inhabitants of the building across the street.

Amoako et al. (2009) conducted a survey of RFR at public access points close to schools, hospitals, and highly populated areas in Ghana near 50 cell phone base stations. Their primary objective was to measure and analyze field strength levels. Measurements were made using an Anritsu model MS 2601A spectrum analyzer to determine the electric field level in the 900 and 1800 MHz frequency bands. Using a GPS (global positioning system), various base stations were mapped. Measurements were taken at 1.5 m above ground to maintain line of sight with the RF source. Signals were measured during the day over a 3 h period, at a distance of approximately 300 m. The results indicated that power densities for 900 MHz at public access points varied from as low as 0.000001 μW/cm² to as high as 0.001 μW/cm². At 1800 MHz, the variation of power densities was from 0.000001 to 0.01 μW/cm². There are no specific RFR standards in Ghana. These researchers determined that while their results in most cites were compliant with the ICNIRP standards, levels were still 20 times higher than values typically found in the UK, Australia, and the U.S., especially for Ghana base stations in rural areas with higher power output. They determined that there is a need to reduce RFR levels since an increase in mobile phone usage is foreseen.

Clearly, predicting actual exposures based on simple distance from antennas using standardized computer formulas is inadequate. Although power density undoubtedly decreases with distance from a generating source, actual exposure metrics can be far more complex, especially in urban areas. Contributing to the complexity is the fact that the narrow vertical spread of the beam creates a low RF field strength at the ground directly below the antenna. As a person moves away or within a particular field, exposures can become complicated, creating peaks and valleys in field strength. Scattering and attenuation alter field strength in relation to building placement and architecture, and local perturbation factors can come into play. Power density levels can be 1 to 100 times lower inside a building, depending on construction materials, and exposures can differ greatly within a building, depending on numerous factors such as orientation toward the generating source and the presence of conductive materials. Exposures can be twice as high in upper floors than in lower floors, as found by Anglesio et al. (2001).

However, although distance from a transmitting source has been shown to be an unreliable determinant for accurate exposure predictions, it is nevertheless useful in some general ways. For instance, it has been shown that radiation levels from a tower with 15 nonbroadcast radio systems will fall off to hypothetical natural background levels at approximately 1500 ft (~500 m) (Rinebold 2001). This would be in general agreement with the lessening of symptoms in people living near cell towers at a distance over 1000 ft (~300 m) found by Santini et al. (2002) .

The previously mentioned studies indicate that accuracy in both test design and personal dosimetry measurements are possible in spite of the complexities and that a general safer distance from a cell tower for residences, schools, daycare centers, hospitals, and nursing homes might be ascertained.

13. Discussion

Numerous biological effects do occur after short-term exposures to low-intensity RFR but potential hazardous health effects from such exposures on humans are still not well established, despite increasing evidence as demonstrated throughout this paper. Unfortunately, not enough is known about biological effects from long-term exposures, especially as the effects of long-term exposure can be quite different from those of short-term exposure. It is the long-term, low-intensity exposures that are most common today and increasing significantly from myriad wireless products and services.

People are reporting symptoms near cell towers and in proximity to other RFR-generating sources including consumer products such as wireless computer routers and Wi-Fi systems that appear to be classic "microwave sickness syndrome," also known as "radiofrequency radiation sickness." First identified in the 1950s by Soviet medical researchers, symptoms included headache, fatigue, ocular dysfunction, dizziness, and sleep disorders. In Soviet medicine, clinical manifestations include dermographism, tumors, blood changes, reproductive and cardiovascular abnormalities, depression, irritability, and memory impairment, among others. The Soviet researchers noted that the syndrome is reversible in early stages but is considered lethal over time (Tolgskaya et al. 1973).

Johnson-Liakouris (1998) noted there are both occupational studies conducted between 1953 and 1991 and clinical cases of acute exposure between 1975 and 1993 that offer substantive verification for the syndrome. Yet, U.S. regulatory agencies and standards-setting groups continue to quibble about the existence of microwave sickness because it does not fit neatly into engineering models for power density, even as studies are finding that cell towers are creating the same health complaints in the population. It should be noted that before cellular telecommunications technology, no such infrastructure exposures between 800 MHz and 2 GHz existed this close to so many people. Microwave ovens are the primary consumer product utilizing a high RF intensity, but their use is for very brief periods of time and ovens are shielded to prevent leakage above 1000 $\mu W/cm^2$ — the current FDA standard. In some cases, following the U.S. Telecommunications Act of 1996 preemption of local health considerations in infrastructure siting, antennas have been mounted within mere feet of dwellings. And, on buildings with roof-mounted arrays, exposures can be lateral with top floors of adjacent buildings at close range.

It makes little sense to keep denying health symptoms that are being reported in good faith. Though the prevalence of such exposures is relatively new to a widespread population, we, nevertheless, have a 50 year observation period to draw from. The primary questions now involve specific exposure parameters, not the reality of the complaints or attempts to attribute such complaints to psychosomatic causes, malingering, or beliefs in paranormal phenomenon. That line of argument is insulting to regulators, citizens, and their physicians. Serious mitigation efforts are overdue.

There is early Russian and U.S. documentation of long-term, very low-level exposures causing microwave sickness as contained in *The Johns Hopkins Foreign Service Health Status Study* done in 1978 (Lilienfield et al. 1978; United States Senate 1979). This study contains both clinical information, and clear exposure parameters. Called the Lilienfield study, it was conducted between 1953 and 1976 to determine what, if any, effects there had been to personnel in the U.S. Embassy in Moscow after it was discovered that the Soviet government had been systematically irradiating the U.S. government compound there.

The symptoms reported were not due to any known tissue heating properties. The power densities were not only very low but the propagation characteristics were remarkably similar to what we have today with cell phone base stations. Lilienfield recorded exposures for continuous-wave, broadband, modulated RFR in the frequency ranges between 0.6 and 9.5 GHz. The exposures were long-term and low-level at 6 to 8 h per day, 5 days per week, with the average length of exposure time per individual between 2 to 4 years. Modulation information contained phase, amplitude, and pulse variations with modulated signals being transmitted for 48 h or less at a time. Radiofrequency power density was between 2 and 28 $\mu W/cm^2$ — levels comparable to recent studies cited in this paper.

The symptoms that Lilienfield found included four that fit the Soviet description for dermographism — eczema, psoriasis, allergic, and inflammatory reactions. Also found were neurological problems with diseases of peripheral nerves and ganglia in males; reproductive problems in females during pregnancy, childbearing, and the period immediately after delivery (puerperium); tumor increases (malignant in females, benign in males); hematological alterations; and effects on mood and well-being including irritability, depression, loss of appetite, concentration, and eye problems. This description of symptoms in the early literature is nearly identical to the Santini, Abdel-Rassoul, and Narvarro studies cited earlier, as well as the current (though still anecdotal) reports in communities where broadcast facilities have switched from analog to digital signals at power intensities that are remarkably similar. In addition, the symptoms in the older literature are also quite similar to complaints in people with EHS.

Such reports of adverse effects on well-being are occurring worldwide near cell infrastructure and this does not appear to be related to emotional perceptions of risk. Similar symptoms have also been recorded at varying distances from broadcast towers. It is clear that something else is going on in populations exposed to low-level RFR that computer-generated RFR propagation models and obsolete exposure standards, which only protect against acute exposures, do not encompass or understand. With the increase in so many RFR-emitting devices today, as well as the many in the wings that will dramatically increase total exposures to the population from infrastructure alone, it may be time to approach this from a completely different perspective.

It might be more realistic to consider ambient outdoor and indoor RFR exposures in the same way we consider other environmental hazards such as chemicals from building materials that cause sick building syndrome. In considering public health, we should concentrate on aggregate exposures from multiple sources, rather than continuing to focus on individual source points like cell and broadcast base stations. In addition, whole categorically excluded technologies must be included for systems like Wi-Fi, Wi-Max, smart grids, and smart metering as these can greatly increase ambient radiation levels. Only in that way will low-level electromagnetic energy exposures be understood as the broad environmental factor it is. Radiofrequency radiation is a form of energetic air pollution and it should be controlled as such. Our current predilection to take this one product or service at a time does not encompass what we already know beyond reasonable doubt. Only when aggregate exposures are better understood by consumers will disproportionate resistance to base station siting bring more intelligent debate into the public arena and help create safer infrastructure. That can also benefit the industries trying to satisfy customers who want such services.

Safety to populations living or working near communications infrastructure has not been given the kind of attention it deserves. Aggregate ambient outdoor and indoor exposures should be emphasized by summing up levels from different generating source points in the vicinity. Radiofrequency radiation should be treated and regulated like radon and toxic chemicals, as aggregate exposures, with appropriate recommendations made to the public including for consumer products that may produce significant RFR levels indoors. When indoor consumer products such as wireless routers, cordless/DECT phones, leaking microwave ovens, wireless speakers, and (or) security systems, etc. are factored in with nearby outdoor transmission infrastructure, indoor levels may rise to exposures that are unsafe. The contradictions in the studies should not be used to paralyze movement toward safer regulation of consumer products, new infrastructure creation, or better tower siting. Enough good science exists regarding long-term low-level exposures — the most prevalent today — to warrant caution.

The present U.S. guidelines for RFR exposure are not up to date. The most recent IEEE and NCRP guidelines used by the U.S. FCC have not taken many pertinent recent studies into consideration because, they argue, the results of many of those studies have not been replicated and thus are not valid for standards setting. That is a specious argument. It implies that someone tried to replicate certain works but failed to do so, indicating the studies in question are unreliable. However, in most cases, no one has tried to exactly replicate the works at all. It must be pointed out that the 4 W/kg SAR threshold based on the de Lorge studies have also not been replicated independently. In addition, effects of long-term exposure, modulation, and other propagation characteristics are not considered. Therefore, the current guidelines are questionable in protecting the public from possible harmful effects of RFR exposure and the U.S. FCC should take steps to update their regulations by taking all recent research into consideration without waiting for replication that may never come because of the scarcity of research funding. The ICNIRP standards are more lenient in key exposures to the population than current U.S. FCC regulations. The U.S. standards should not be "harmonized" toward more lenient allowances. The ICNIRP should become more protective instead. All standards should be biologically based, not dosimetry based as is the case today.

Exposure of the general population to RFR from wireless communication devices and transmission towers should be kept to a minimum and should follow the "As Low As Reasonably Achievable" (ALARA) principle. Some scientists, organizations, and local governments recommend very low exposure levels — so low, in fact, that many wireless industries claim they cannot function without many more antennas in a given area. However, a denser infrastructure may be impossible to attain because of citizen unwillingness to live in proximity to so many antennas. In general, the lowest regulatory standards currently in place aim to accomplish a maximum exposure of 0.02 V/m, equal to a power density of 0.0001 $\mu W/cm^2$, which is in line with Salzburg, Austria's indoor exposure value for GSM cell base stations. Other precautionary target levels aim for an outdoor cumulative exposure of 0.1 $\mu W/cm^2$ for pulsed RF exposures where they affect the general population and an indoor exposure as low as 0.01 $\mu W/cm^2$ (Sage and Carpenter 2009). In 2007, *The BioInitiative Report, A rationale for a biologically based public exposure standard for electromagnetic fields (ELF and RF)*, also made this recommendation, based on the precautionary principle (Bioinitiative Report 2007).

Citizens and municipalities often ask for firm setbacks from towers to guarantee safety. There are many variables involved with safer tower siting — such as how many providers are co-located, at what frequencies they operate, the tower's height, surrounding topographical characteristics, the presence of metal objects, and others. Hard and fast setbacks are difficult to recommend in all circumstances. Deployment of base stations should be kept as efficient as possible to avoid exposure of the public to unnecessary high levels of RFR. As a general guideline, cell base stations should not be located less than 1500 ft (~500 m) from the population, and at a height of about 150 ft (~50 m). Several of the papers previously cited indicate that symptoms lessen at that distance, despite the many variables involved. However, with new technologies now being added to cell towers such as Wi-Max networks, which add significantly more power density to the environment, setback recommendations can be a very unpredictable reassurance at best. New technology should be developed to reduce the energy required for effective wireless communication.

In addition, regular RFR monitoring of base stations should be considered. Some communities require that ambient background levels be measured at specific distances from proposed tower sites before, and after, towers go online to establish baseline data in case adverse effects in the population are later reported. The establishment of such baselines would help epidemiologists determine what changed in the environment at a specific point in time and help better assess if RFR played a role in health effects. Unfortunately, with so much background RFR today, it is almost impossible to find a clean RFR environment. Pretesting may have become impossible in many places. This will certainly be the case when smart grid technologies create a whole new blanket of low-level RFR, with millions of new transceivers attached to people's homes and appliances, working off of centralized RFR hubs in every neighborhood. That one technology alone has the ability to permanently negate certain baseline data points.

The increasing popularity of wireless technologies makes understanding actual environmental exposures more critical with each passing day. This also includes any potential effects on wildlife. There is a new environmental concept taking form — that of "air as habitat" (Manville 2007) for species such as birds, bats, and insects, in the same way that water is considered habitat for marine life. Until now, air has been considered something "used" but not necessarily "lived in" or critical to the survival of species. However, when air is considered habitat, RFR is among the potential pollutants with an ability to adversely affect other species. It is a new area of inquiry deserving of immediate funding and research.

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CHAPTER 10

Biological Effects of Low Frequency Electromagnetic Fields[1]

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10.1 INTRODUCTION

The biological effects of low frequency electric and magnetic fields[2] (EMF) have become a topic of considerable scientific scrutiny during the past two decades. The flurry of research in this area has contributed greatly to our understanding of the complex electromagnetic environment to which we are exposed but it has not abated the controversy associated with the harmful effects of electromagnetic fields. If anything it has polarized scientists into two camps, those who think exposure to low frequency electromagnetic fields causes health effects and those who do not. Those who believe there is a causal association are trying to find the mechanism responsible and those who question the concept of causality think this research is a waste of time and money.

Controversy is the norm when complex environmental issues with substantial economic and health consequences are scientifically scrutinized. Asbestos, lead, acid rain, tobacco smoke, DDT, PCBs (and more recently estrogen mimics) were all contentious issues and were debated for decades in scientific publications and in the popular press before their health effects and the mechanisms responsible were understood. In some cases the debate was scientifically legitimate, while in others interested parties deliberately confuse the issue to delay legislation (Havas et al 1984).

The public, uncomfortable with scientific controversy and unable to determine the legitimacy of a scientific debate, wants a clear answer to the question, "Are low frequency electric and magnetic fields harmful?"

As a direct response to public concern three major reports, with multiple contributors with diverse expertise, have been published recently on the health effects of low frequency electric and magnetic fields: one by the U.S. National Research Council (1997), another by the National Institute of Environmental Health Sciences (Portier and Wolfe, 1998), and the most recent, still in draft form, by the California

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1 Note: An expanded version of this paper can be found in Environmental Reviews 8: 173-253 (2000). Research published since 2000 has been incorporated in the present paper.

2 Magnetic field and magnetic flux density are used interchangeably in this document although the correct term is the later.

EMF Program (2001). These influential reports attempt to make sense of the many, and sometimes contradictory, documents from different fields of study, related to the health effects of power-line frequency fields.

The purpose of the present paper is three-fold:

(1) To characterize human exposure to low frequency electromagnetic fields;

(2) To identify key biological markers and possible mechanisms linked to EMF exposure;

(3) To comment on the concept of scientific consistency and bias.

The question "Are low frequency electric and magnetic fields harmful?" is valid and timely. The answer is likely to have far reaching consequences, considering our growing dependence on electric power, computer technology, and wireless communication, and it is likely to be of interest to a large population using, manufacturing, selling, and regulating this technology.

10.2 BACKGROUND INFORMATION

In the broadest sense, electromagnetic research involves three major sources of electromagnetic energy: those generated by the earth, sun and the rest of the cosmos (geofields); those generated by living organisms (biofields); and those generated by technology (technofields).

These fields interact and it is these interactions that most interest us. Solar flares sufficiently powerful to knock out satellites or to disrupt power distribution and the reflection of radio signals by the ionosphere are examples of geofield and technofield interactions. Photosynthesis, tanning, weather sensitivity are examples of geofield and biofield interactions.

The areas of current scientific debate are the interactions between living organisms (biofields) and technologically generated fields (technofields) at power line frequencies (60 Hz in North America and 50 Hz elsewhere) and at frequencies generated by computers and cell phones in the kilo (10^3), Mega (10^6) and Giga (10^9) Hertz range.

Until recently, frequencies below the microwave band were assumed to be "biologically safe". This began to change in the 1960s and early 1970s. Several months after the first 500 kV substations became operable in the Soviet Union high voltage switchyard workers began to complain of general ill health (Korobkova *et al.* 1971). The electric field, with maximum intensities between 15 and 25 kV/m, was assumed to be responsible for the health complaints. Personnel working with 500 and 750 kV lines were compared with workers at 110 and 220 kV substations. Biological effects were reported above 5 kV/m. The harmful effects of high voltage power lines on substation workers and their families have since been document elsewhere (Nordstrom *et al.* 1983, Nordenson *et al.* 1994).

Nancy Wertheimer and Ed Leeper were the first to report the potential harmful effects of power lines associated with residential rather than occupational exposure. An increased incidence of childhood leukemia, lymphoma, and nervous system tumors was associated with residential exposure to power line-frequency fields in Denver Colorado (Wertheimer and Leeper 1979). Paul Brodeur did much to publicized this type of information in *The New York Times* and elsewhere (Brodeur 1993), alerting the public and enraging members of the scientific community who were unwilling to accept the Wertheimer and Leeper results.

The Wertheimer and Leeper study was repeated in various locations and by the early 1990s, more than a dozen studies were published on childhood cancer. While some studies found no effects others confirmed the Wertheimer and Leeper results.

Studies of childhood cancers were followed by studies of adult cancers in occupational as well as residential settings and by effects of electromagnetic fields on reproduction. Residential exposure was associated with miscarriages (Wertheimer and Leeper 1986, 1989) while occupational exposure was linked to various reproductive problems as well as adult cancers including primary brain tumors, leukemia, and breast cancer. Similarities between childhood and adult cancers raised concern.

One problem with the early epidemiological studies was that information on exposure was scarce. Wire codes provided a surrogate metric for the magnetic field. In residential settings the magnetic field, which penetrates through walls, was assumed to be more important biologically than the electric field, which does not. Once portable gauss meters sensitive to power line frequencies became available, the spot measurement and 24-hour monitoring supplemented the wire codes. Of these three methods, the wire codes are highly associated (as measured by odds ratios or relative risk) and the spot measurements are poorly associated with magnetic field exposure and health effects in epidemiological studies (London *et al.* 1991, Feychting and Ahlbom 1993, Savitz et al 1988), although a reassessment of earlier studies points to a stronger association between wire codes and magnetic field measurements (Savitz and Poole 2001).

The odds ratio (OR) and relative risk (RR) are two metrics epidemiologists use to compare a test population (observed) with a control population (expected) for a specific endpoint (cancer for example). The higher the OR (ratio of observed to expected), the greater the association between an agent and an end point.

In the past decade appliances, rooms, and houses have been monitored and we have a much better understanding of the magnetic flux density to which we are exposed. Whether magnetic flux density is the only biologically important metric, or, indeed, the one we should be measuring remains to be determined.

Epidemiological studies were complemented by *in vivo* and *in vitro* studies attempting to explore the mechanisms underlying the EMF effect. Because of the novelty of this type of research there were (and still are) no standardized protocols for testing. Experimental intensities for magnetic flux density range from less than 0.1 μT to greater than 300,000 μT (300 mT); daily exposure varies from 30 minutes to 24 hours; and duration of exposure extends from days to years. Some of the tests involve continuous, homogeneous fields, others involved gradients, and still others used intermittent fields with on:off cycles ranging from seconds to hours. Interpreting such a wide array of exposure conditions is not an easy task and thus conflicting conclusions are to be expected depending on the scientific weight placed on individual studies.

10.3 EXPOSURE

10.3.1 Residential Exposure

In a residential setting there are three major sources of technologically generated magnetic fields: appliances, the indoor distribution system consisting of indoor wiring and grounding, and the outdoor distribution system consisting of either below or above ground wires and transformers. The early studies assumed that power lines provided the major source of magnetic field inside the home and both indoor wiring and appliances were ignored, although some studies attempted to minimize indoor sources by turning appliances and lights off. More recent studies recognize the importance of these additional sources and enable us to calculate cumulative and time-weighted average (TWA) magnetic flux densities for a given environment.

10.3.1.1 Outdoor Distribution System

Wire codes, used to estimate exposure to magnetic fields (based on distance and wire configuration) may provide a good relative surrogate for the magnetic flux density within a community; however, they become less reliable when different communities are compared. The magnetic flux density associated with outdoor wiring in a residential setting can range from less than 0.03 to greater than 8 μT, although the values are generally below 1 μT for most homes (Havas 2000, Table 7).

The electric field was not considered to be important in the residential epidemiological studies because they cannot penetrate building material. Electric fields immediately beneath overhead neighborhood distribution lines are likely to be less than 30 V/m (Havas 2002, in press). However, there is a trend among electric utilities to increase the voltage of power distribution lines to minimize resistance and thus energy loss. As voltage increases so does the intensity of the electric field, and studies report that the harmful effects associated with magnetic field exposure may be worse in the presence of a strong electric field (Miller *et al.* 1996, see paper by Henshaw in these proceedings on particulate density near power lines).

10.3.1.2 Indoor Distribution System

Indoor wiring is another important source of magnetic fields in the home. Within a properly wired building far from a power line normal fields should not exceed 0.03 μT (Riley 1995). In a building with faulty wiring or with older knob-and-tube wiring, fields may be 0.2 to 3 μT, and even higher near walls, ceilings, and floors (Bennett 1994, Riley 1995).

EPRI (1993, as cited in NIEHS 1998) conducted a survey of 1000 homes and took both 24-h and spot measurements in different rooms. The median magnetic flux densities for 24-h measurements vary more than 10 fold with 50% of the homes exceeding 0.05 μT (and 1% of the homes exceeding 0.55 μT). The highest wire code category (VH, very high current configuration) in the Wertheimer and Leeper (1982) study was 0.25 μT and according to the EPRI study, 5% of the homes exceeded this value.

The spot measurements for magnetic flux density in the EPRI (1993) study differed in rooms and some were sufficiently high to suggest faulty wiring. Rooms with the highest average spot measurements ranged from 0.11 μT(50th percentile, 50% of homes exceeded this value) to 1.22 μT(99th percentile, 1% of homes exceeded this value).

Improperly installed indoor wiring can account for very high fields. In a survey of 150 buildings, Riley (1995) reported that the majority (66%) of the high fields above 3 mG (0.3 μT) were due to wiring and grounding problems, 18% were due to the proximity to power lines, and 3% were due to appliances. Of the wiring problems, 12% were due to knob-and-tube wiring used in older buildings, 22% were due to improper grounding to the plumbing system, and 65% were due to wiring violations. Knob-and-tube is a system of wiring used until the 1940s. The hot and neutral conductors are separated by several inches to several feet. The greater the separation the higher the magnetic field that is produced and the less it decreases with distance ($1*r^{-1}$ for a single line conductor rather than $1*r^{-2}$ for close parallel line conductors). Changes from knob-and-tube to twisted cables have reduced magnetic fields in modern homes.

Common wiring faults that lead to large magnetic fields include: neutral to ground connections, separation of conductors (as with knob-and-tube wiring), grounding to water pipes, and parallel neutrals (i.e. neutrals from different circuits connected together on the load side of the breaker box) (Riley 1995). Rerouting or adding ground return wires can produce background magnetic fields in the order of 1 μT in the home (Bennett 1994), a value that exceeds exposure in many occupations.

10.3.1.3 Appliances

EPA (1992) measured the magnetic fields produced by a variety of household and office appliances. According to this study, the magnetic fields generated by appliances differ enormously and drop off rapidly (generally $1*r^{-3}$) with distance. Magnetic flux densities, range from 150 μTfor can openers to less than 0.1 μTfor tape players. There are considerable model differences as well. For example, hair dryers can range from 70 μT to 0.1 μT depending on make and model.

The appliances of greatest concern are those with high magnetic flux densities and long exposure times. Electric blankets, for example, generate a field of 2 to 4 μT and are in contact with the body for several hours each night. New models, known as the positive temperature coefficient electric blankets, now generate magnetic fields that are one tenth or lower than those generated by the older models. Hair dryers and electric shavers generate a high magnetic field near the head. Power saws generate high magnetic fields and they may be of concern for the professional carpenter. Among household appliances electric can openers generate some of the highest fields recorded (50 to 150 μT at 15 cm).

10.3.1.4 Components of Residential Exposure

Maximum daily cumulative exposure can be attributed to appliances, indoor wiring, or outdoor power lines depending on the circumstances. Individuals living in the same building may be exposed to different magnetic fields based on the amount of time they spent in various rooms and the type of appliances they use. These differences, not considered in the early epidemiological studies, may account for some of the discrepancy in the results. Future epidemiological studies need to take them into consideration.

10.3.2 OCCUPATIONAL EXPOSURE

Just as the early residential epidemiological studies used wire codes as surrogates for magnetic fields, the occupational studies initially based their result on job titles. As interest in occupational exposure increased, more measurements of magnetic fields in various occupational settings associated with individual exposure began to be documented. Because of the variability within and among occupations as well as between types of measurements (spot measurement vs. time weight averages), comparisons of occupations are difficult and can only be considered tentative at this time. Personal monitoring of workers provides the most information and, in the long term, may prove to be the most useful measurement.

Portier and Wolfe (1998) summarized a vast amount of data for time-weighted-average (TWA) magnetic field exposures according to industry type. The original data were ranked and classified into percentile groupings. The 95th percentile was at 0.66 μT and can be considered very high exposure with only 5% of the work force exposed to higher TWA magnetic fields. The 75th percentile was at 0.27 μT and is close to the values associated with very high current configuration (VH) for power lines (Wertheimer and Leeper 1982). The median (50th %) TWA magnetic flux density was at 0.17 μT and the 25th percentile was at 0.12 μT.

Despite the variability of occupational exposure, some general conclusions can be drawn. For instance, some of the highest exposures occur in the textile, utility, transportation and metallurgical industries. Among textile works, dressmakers and tailors who use industrial sewing machines are exposed to some of the highest fields (mean 3 uT, Havas 2000). In the utility industry, linemen, electricians, cable splicers, as well as power plant and substation operators are among those with the highest magnetic field exposure (mean 1.4 to 3.6 μT). In transportation, railway workers have high exposures (mean 4 μT) Among metal workers, welders and those who do electrogalvanizing or aluminum refining tend to have high magnetic field exposure (mean 2 μT).

Another industry with notable exposure is telecommunications, especially telephone linemen, technicians, and engineers (mean 0.35 to 0.43 μT). Individuals repairing electrical and electronic equipment (0.16 to 0.25 μT) can also be exposed to above average magnetic fields, as can dental hygienists (mean 0.64 μT) and motion picture projectionists (mean 0.8 μT). Those involved in forestry and logging have a high average exposure of 2.48 μT (Havas 2000)..

In an office environment, magnetic fields are generally at or below the 50th percentile ($\leq$0.17 μT) except near computers, photocopiers, or other electronic equipment. People in sales, in computer services and in the construction industry are generally exposed to lower magnetic fields. Teachers have below average exposure with a TWA magnetic flux density of 0.15 uT.

Normally we think of high EMF exposure only or primarily in electrical occupations and perhaps in an office setting with computers and copy machines. However, a number of occupations not normally classified "electrical" can be exposed to high EMFs. These include airplane pilots, streetcar and trains conductors, hairdressers (hand-held hairdryers), carpenters (power tools), tailors and seamstresses (sewing machine), metal workers, loggers, and medical technicians.

10.3.3 TRANSPORTATION

The few studies that document magnetic field exposure associated with transportation suggest that exposure can be quite high depending on the mode of travel.

Typical magnetic fields for commuter trains are much higher than for most occupational exposure. According to Bennett (1994), magnetic flux densities of 24 μT have been recorded 1 meter above the floor and 4 meters from the line of an electric commuter train. In the Amtrak train from Washington to New York, the average magnetic field at 25 Hz was 12.6 μT and the maximum field was 64 uT.

Passengers may not be on these commuter trains for long but workers are exposed to them all day. The MAGLEV (magnetic levitation) electric train generates varying frequencies and magnetic flux densities. Alternating currents in a set of magnets in the guide way change polarity to push/pull the train. The train is accelerated as the ac frequency is increased. Magnetic flux densities of 50,000 μT (50 mT) in the passenger compartment where people work have been reported (Bennett 1994).

Airplanes generate a 400 Hz electromagnetic field. The highest fields are in the cockpit with values greater than 10 μT near the conduits behind the pilot and co-pilot and near the windshield (heating element). In the passenger part of the airplane, values between 3 and 0.3 μT are more common (Havas, unpublished data). Since flights generally last several hours, cumulative exposure can be considerable. Employees and passengers are also exposed to higher than average cosmic radiation at these altitudes.

Extensive monitoring of automobiles has not been done, to my knowledge. Preliminary monitoring of a few vehicles suggests much lower magnetic fields than those associated with either commuter trains or airplanes (Havas, unpublished data). Drivers are exposed to higher magnetic fields in luxury vehicles with electronic equipment and in smaller than larger vehicles, presumably due to proximity to the alternator. The fan, air conditioning, heating, as well as the driving style (acceleration) all contribute to the ambient magnetic field. Motorbike riders are exposed to high magnetic fields in excess of 3 μT on the seat of the motorbike (Havas, unpublished data).

10.3.4 COMPLICATIONS WITH EXPOSURE

Although we are beginning to get a sense of the magnetic environment we have created and can now estimate cumulative exposures, there is much we still do not know. It is not clear what attributes of the field are important biologically. Are values above a certain threshold critical, if so, what is that threshold? Are the rapid changes between high and low intensities biologically significant or should we focus on time-weighted cumulative exposure? We have yet to determine the metric of biological significance.

To complicate matters, the electromagnetic environment consists of an electric field as well as a magnetic field. Although the previous section and much of the literature have focused primarily on magnetic fields, conditions exist where both fields are present (a person standing directly under a power line or someone in contact with an electrical appliance). Also, external magnetic fields can generate internal electric fields, so a distinction between the two is not simple. The biological response is likely to be a function of the fields within our bodies rather than the external fields to which we are exposed and this is difficult to measure and equally difficult to calculate.

More than one frequency can be generated by the power distribution system. While the dominant frequency is 50/60 Hz, harmonics (multiples of the original frequency) and subharmonics (fractions of the original frequency) as well as transients (spikes generated by random on and off switching) are produced. Some of the studies suggest that biological effects are frequency and intensity specific (Blackman *et al.* 1979, Liboff 1985, Dutta *et al.* 1989). A slightly higher or lower frequency (or intensity) may not necessarily produce the same biological response. A good model for biological response may be one based on the radio tuned to a specific modulation (Frey 1994).

Biological response may also be influenced by the local magnetic field produced by the earth and this field may be spatially and temporally heterogeneous (Liboff 1985). What is becoming obvious is that this area of research, concerned with EMF exposure is complex and of utmost importance if we are to understand biological interactions with electromagnetic fields.

10.4 BIOLOGICAL RESPONSE TO EMFS

10.4.1 CANCER

Epidemiological studies of cancer have focused on two primary populations: children in residential settings and adults in occupational settings. The main cancers associated with EMF exposure are leukemia, nervous system tumors and, to a lesser extent, lymphoma among children; and leukemia, nervous system tumors, and breast cancer among adults.

10.4.1.1 Cancer in Children

Irrespective of which metric is used (wire codes, distance, measurements, or calculations of exposure), when viewed as a whole, many of the studies on childhood leukemia suggest an odds ratio (OR) above 1. Critical distances appear to be approximately 50 m from a power line and critical magnetic flux densities are above 0.2 uT. Daytime spot measurements give the lowest ORs while median nighttime measurements give the highest.

Several studies suggest a dose/response relationship. Feychting *et al.* (1993, 1995) reported a significant OR of 2.7 above 0.2 μT and 3.8 above 0.3 uT. Schuz *et al.* (2001) reported a non-significant 1.33 OR between 0.1 and 0.2 uT, a significant 2.4 OR between 0.2 and 0.4 μTand 4.28 OR above 0.4 uT, based on nighttime exposure. These values are low compared with other known carcinogens like cigarettes and asbestos but are certainly well above background.

Two recent meta-analyses of childhood cancer conclude that exposure to magnetic flux densities in excess of 0.4 μTare associated with an increase risk of childhood leukemia. The first of these meta-analyses (Ahlbom *et al.* 2000) includes data from 9 countries and is based on 3,203 cases and 10,338 controls. Above 0.4 μT the relative risk is 2.0, with a range of 1.27 to 3.13, which is statistically significant (P=0.002). This means there is a 2-fold increased risk for children developing leukemia. Fortunately, a very small percentage (0.8%) of the children in this study were exposed to fields above 0.4 uT.

In the second meta-analysis based on 19 studies Wartenberg (2001) concludes that with widespread exposure to magnetic fields there may be a 15 to 25% increase in the rate of childhood leukemia, which is "a large and important public health impact." In the United States as many as 175 to 240 cases of childhood leukemia may be due to EMF exposure.

One point that must be kept in mind is that exposure to EMF is so "universal and unavoidable that even a very small proven adverse effect of exposure to electric and magnetic fields would need to be considered from a public health perspective: a very small adverse effect on virtually the entire population would mean that many people are affected." (NRC 1997).

10.4.1.2 Cancer in Adults

For adults, the link between EMF exposure and leukemia, brain tumors, and breast cancer, is also convincing when viewed as a whole. Two forms of leukemia seem to predominate: acute myeloid leukemia (AML) and chronic lymphocytic leukemia (CLL). As with childhood cancers there is some evidence for a dose/response relationship although it is very difficult to accurately estimate dose in an occupational setting. For this reason it is difficult to provide a threshold value, if indeed one exists, based on the information available. Studies suggest that cumulative exposure is important (Miller *et al.* 1996)

Among the cancers, the one with the highest odds ratio is breast cancer in men. Several studies indicate a relative risk above 4 for men (Demers *et al.* 1991, Tynes *et al.* 1992, Floderus *et al.* 1994), while the highest value for women is 2.17 (Loomis *et al.* 1994). This form of cancer is rare among men and the presence of one or two cases is likely to result in a high risk estimate. The lower OR of 2 for women should not be taken lightly since as many as 5000 women in Canada and as many as 44,000 in the United States die from breast cancer each year (WHO 1998).

Laboratory studies report an increase growth rate for estrogen-responsive breast cancer cells above 12 mG (1.2 μT) (Liburdy *et al.* 1993). These studies have been independently replicated by at least two other labs and show a causal relationship between magnetic fields and breast cancer growth.

Astrocytoma is the most common type of brain cancer associated with EMF exposure (Floederus *et al.* 1993, Theriault *et al.* 1994, Lin *et al.* 1985). Floederus *et al.* (1993) reported a dose-response relationship for astrocytoma with a non-significant increased OR of 1.3 below 0.19 uT; a statistically significant OR of 1.7 between 0.2 and 0.28 μT and a significant OR of 5.0 above 0.29 uT.

10.4.2 REPRODUCTION

Adverse pregnancy outcomes, including miscarriages, still births, congenital deformities, and illness at birth have been associated with maternal occupational exposure to electromagnetic fields (Goldhaber *et al.* 1988) as well as residential use of electric blankets, heated waterbeds, conductive heating elements in bedroom ceilings (Wertheimer and Leeper 1986, 1989, Hatch *et al.* 1998). The development of childhood cancers (particularly brain tumors) and congenital deformities have been linked with paternal EMF exposure in occupational settings (Nordstrom *et al.* 1983, Wilkins and Koutras 1988, Johnson and Spitz 1989, Tornqvist 1998).

10.4.2.1 Residential Exposure

Two studies by Wertheimer and Leeper, one examining the use of electric blankets and heated waterbeds (1986) and the other examining ceiling cable electric heat (1989), showed that fetal loss increased when conception occurred during the months of increasing cold (October to January) for parents exposed to an EMF source during the night. Homes in which electric blankets and ceiling cables were not used did not show a seasonal pattern of fetal loss. Electric blankets can generate magnetic fields as high as 4 μTat a distance of 5 cm, and ceiling cable heating produces ambient magnetic fields of approximately 10 μTand electric fields of 10-50 V/m. Ambient fields in most homes, even those with baseboard heaters, tend to be less than 0.1 μT and 10 V/m (Wertheimer and Leeper 1989).

Timing of exposure may be of particular significance. Liburdy *et al.* (1993) reported that women sleeping under electric blankets had disrupted melatonin production. The threshold for effect was between 0.2 and 2 uT, well within the range of the Wertheimer and Leeper (1986, 1989) studies. Melatonin has many functions one of which is the regulation of sex hormones, estrogen and progesterone, which are critical for full term pregnancies.

Li *et al.* (2002) reported an increased risk of miscarriage for women exposed for any length of time during a normal 24-hour period to a magnetic field above 16 mG (1.6 μT). The California EMF Program draft report (2001) calculates that as many as 40% of the miscarriages (24,000 miscarriages) each year in California may be attributed to magnetic field exposure.

10.4.2.2 Maternal VDT Use

Clusters of abnormal pregnancies associated with maternal use of video display terminals (VDT) during pregnancy have been reported in Canada, the United States, Britain, and Denmark (DeMatteo, 1986). A study of 803 pregnancies among data processors in the British Department of Employment indicated that abnormal pregnancies were 36% among VDT users but only 16% among non-VDT users (DeMatteo 1986).

Goldhaber *et al.* (1988) conducted a case-control study of 1583 pregnant women who attended one of three gynecology clinics in Northern California during 1981 and 1982. They found a significantly elevated risk of miscarriages for the working-women who reported using VDTs for more than 20 hr each week during the first trimester of pregnancy compared to other working women who reported not using VDTs (OR 1.8, 95% CI: 1.2-2.8). The elevated risk could not be explained by age, education, smoking, or alcohol consumption. No significantly elevated risk for birth defects was found for moderate and high VDT exposure (OR 1.4, 95% CI: 0.7-2.7).

10.4.2.3 Paternal Exposure

Paternal occupational exposure to electromagnetic fields has also been linked to reduced fertility, lower male to female sex ratio in offspring, congenital malformations and teratogenic effects expressed in the form of childhood cancer (Nordstrom *et al.* 1983, Spitz and Johnson 1985, Wilkins and Koutras 1988, Tornqvist 1998, Feychting *et al.* 2000).

Nordstrom and colleagues (1983) did a retrospective study of pregnancy outcomes for 542 Swedish power plant employees working in high voltage (130 to 400 kV) substations. Employees who worked on lines no higher than 380/220 V served as the reference group. There was no significant difference in spontaneous abortions or perinatal deaths among the high voltage switchyard workers but there was an increase of congenital malformations for this group, especially for those with wives aged 30 plus, compared with the reference group (OR approximately 2.5). Two additional differences are worth noting. One is that the male to female sex ratio of offspring was slightly lower (0.92) for high-voltage switch yard workers compared with the reference group (1.16). The second is that couples experienced some difficulty conceiving when the husband worked in a high-voltage switch yard (OR approximately 2.5). *In vivo* studies with rats showed that exposure to high electric fields reduced plasma testosterone concentrations and reduced sperm viability (Andrienko *et al.* 1977; Free *et al.* 1981).

Feychting *et al.* (2000) reported a statistically significant association between paternal exposure to magnetic fields at or above 0.3 μT with a two-fold increase in childhood leukemia but no risk with childhood brain tumors.

Wilkins and Koutras (1988) conducted a case-control study of Ohio-born children who had died of brain cancer during 1959 and 1978. Case fathers were more likely than control-fathers to be electrical assemblers, installers, and repairers (OR=2.7, 95% CI=1.2-6.1); welders and cutters (OR=2.7, 95% CI=0.9-8.1); or farmers (OR=2.0, 95% CI=1.0-4.1). Although chemicals cannot be ruled out as potential confounders, these industries (except perhaps farming) tend to have higher than average EMF exposure. A paternal occupational study that can differentiate between EMF and chemical exposure and the risk of childhood cancers is needed.

10.4.3 DEPRESSION

Several lines of evidence suggest that depression is associated with and may be induced by exposure to electromagnetic fields. Epidemiological studies have found higher ratios of depression-like symptoms (Poole *et al.* 1993) and higher rates of suicide (Reichmanis *et al.* 1979) among people living near transmission lines.

Poole *et al.* (1993) conducted a telephone survey of people living adjacent to a transmission line and a control population selected randomly from telephone directories. Questions related to depression were based on the Center for

Epidemiological Studies-Depression scale. A higher percentage of depressive symptoms were recorded among people living near the line compared with the control population. The odds ratio was 2.1 (1.3-3.4, 95% confidence interval). Demographic characteristics, environmental attitudes, and reporting bias do not appear to influence the OR. The association between proximity to the transmission line and headaches (migraine and other) was much weaker (OR 1.2 and 1.4 respectively).

Depressive symptoms as well as fatigue, irritability, and headaches have also be reported for occupational exposures (DeMatteo 1986, Wilson 1988).

Another line of evidence comes from *in vivo* studies that report desynchronization in pineal melatonin synthesis in rats exposed to electromagnetic fields (Wilson 1988). The association between depression and disrupted melatonin secretion is well documented (see Breck-Friis *et al.* 1985, Lewy *et al.* 1982). Exposure to artificial light (a different part of the electromagnetic spectrum) in the evening also disturbs night-time melatonin synthesis (Lewy *et al.* 1987), which suggests that timing of EMF exposure may be critical and that nighttime exposure may be more biologically critical than daytime exposure.

10.4.4 ALZHEIMER'S DISEASE

In contrast to cancers, very few studies have examined the association between occupational EMF exposure and Alzheimer's disease. One case-control study by Sobel *et al.* (1995) included 3 independent clinical series of non-familial Alzheimer's disease in Finland (2 series) and California, USA (1 series). Non-familial Alzheimer's was selected to minimize the genetic influences in the etiology of this disease. A total of 387 cases and 475 control were included in the combined series and were classified into two EMF categories (medium/high and low exposure in primary occupations). Significantly elevated odds ratios (OR 3.9, 1.7-8.9 95% CI) were observed for the combined data sets for females working primarily as seamstresses and dress makers. The OR for males was also above 1 (OR 1.9) but was not statistically significant.

Sewing machines generate very high magnetic fields, much higher than most electrical occupations. More studies focused on Alzheimer's disease and EMF exposure with a much broader occupation base are needed before any definitive statements can be made. The highly significant OR in this study is disturbing if the results can be generalized to a broader population.

10.4.5 AMYOTROPHIC LATERAL SCLEROSIS (ALS)

Several studies link EMF exposure to amyotrophic lateral sclerosis (ALS). Three studies have reported a statistically significant increase in ALS, with a relative risk from 1.3 to 3.8, for electric utility workers (Deapen and Hendersen 1986, Savitz *et al.* 1998a,b, Johansen and Olsen 1998). The California EMF Program classifies EMFs as possibly causal agents in ALS. Both Alzheimer's disease and ALS are neurodegenerative diseases.

10.4.6 ELECTROMAGNETIC SENSITIVITY

One of the most detailed and carefully controlled experiments to determine the existence of electromagnetic field sensitivity was conducted by Rea and co-workers (1991). A four-phased approach was used that involved establishing a chemically and electromagnetically "clean" environment; screening 100 self-proclaimed EMF-sensitive patients for frequencies between 0 and 5 MHz; retesting positive cases (25 patients) and comparing them with controls; and finally retesting the most reactive patients (16 patients) with frequencies to which they were most sensitive during the previous challenge.

Sensitive individuals responded to several frequencies between 0.1 Hz and 5 MHz but not to blank challenges. The controls subjects did not respond to any of the frequencies tested.

Most of the reactions were neurological (such as tingling, sleepiness, headache, dizziness and in severe cases unconsciousness) although a variety of other symptoms were also observed including pain of various sorts, muscle tightness particularly in the chest, spasm, palpitation, flushing, tachycardia, edema, nausea, belching, pressure in ears, burning and itching of eyes and skin.

In addition to the clinical symptoms, instrument recordings of pupil dilation, respiration and heart activity were also included in the study using a douhle-blind approach. Results indicate a 20% decrease in pulmonary function and a 40% increase in heart rate. Patients sometimes had delayed or prolonged responses. These objective instrumental recordings, in combination with the clinical symptoms, demonstrate that EMF sensitive individuals respond physiologically to certain frequencies.

People who claim to be electrically sensitive can't use computers and develop headaches and "brain fog", which they describe as an inability to think clearly, when they are exposed to fluorescent lighting for any length of time. The symptoms can be quite debilitating but often the medical profession's response is that the symptoms are probably psychosomatic. Hence the diagnosis creates more stress for the patient and does not correct the underlying cause of the problem.

10.4.7 THE ELUSIVE MECHANISM

The effect of an environmental pollutant, such as DDT, lead, asbestos, is often observed long before the mechanism of action is understood. This delay does not negate the original observation. With respect to electric and magnetic fields, several promising mechanisms related to the biological responses are currently being considered. For low frequency, low intensity fields these include but are not limited to (1) melatonin production; (2) mitosis and DNA synthesis; and (3) ion fluxes particularly that of calcium.

10.4.7.1 Melatonin Production

Melatonin is a neurohormone that regulates sleep cycles, sex hormones, and reproduction. It is produced by the pineal gland, a light-sensitive pea-shaped gland located in the middle of the brain. In animals the pineal gland serves as a compass (it detects changes in the geomagnetic field), a clock (it sense changes in visible light, a part of the EMF spectrum, and induces sleep), and a calendar (it senses changes in photoperiod and induces hibernation as well as ovulation and thus controls reproductive cycles in seasonal breeding animals).

Melatonin follows several natural cycles. It is higher at night than during the day and is associated with restful sleep. It is higher in young people, particularly infants who spend a lot of time sleeping, as opposed to the elderly who have difficulty sleeping. It is higher in winter than in summer and has been linked with changes in serotonin levels and seasonal affective disorder (SAD), a form of depression that is accompanied by prolonged periods of fatigue. Melatonin has been used to treat sleep disturbances associated with jet lag.

The evidence linking changes in the melatonin cycle to EMF exposure is growing. We now know that the pineal gland can senses changes in electromagnetic frequencies other than those associated with visible light including static and power frequencies fields (Liburdy *et al.* 1993). Timing of exposure is critical for melatonin production. If EMF exposure occurs in the evening it can interfere with night-time concentrations of melatonin and affect sleep but if it occurs earlier in the day it has no effect on melatonin production (Reiter and Robinson 1995).

Melatonin also controls the concentrations of sex hormones. High levels of melatonin are associated with lower levels of estrogen. Some types of breast cancer are estrogen-responsive which means their growth is promoted by estrogen. Post-menopausal women have an increased risk of developing breast cancer if they take estrogen supplements. High levels of melatonin (which suppress estrogen levels) may have a protective effect on this form of cancer. Conversely, if normal night-time peaks of melatonin are reduced and estrogen levels remain high, this form of breast cancer is likely to be more aggressive.

Women sleeping under electric blankets have lower night-time melatonin levels (Wilson *et al.* 1990), which shows that melatonin regulation in influenced by power line frequency at intensities commonly found in the home.

Since melatonin controls reproductive cycles it may also explain some of the miscarriages experienced by women who either sleep in a high EMF environment (electric blankets, waterbeds, or ceiling-cable heating systems) or work with video display terminals that generate power frequency and higher frequency fields (Wertheimer and Leeper 1986, 1989; Goldhaber *et al.* 1988).

Melatonin has also been heralded as a natural anti-cancer chemical (Reiter and Robinson 1995). If endogenous melatonin concentrations are reduced, the natural ability of the body to fight cancerous cells may be compromised, resulting in a more aggressive spread of the cancer.

Melatonin is synthesized from serotonin, a neurotransmitter associated with depression (Reiter and Robinson 1995). Imbalances in the serotonin/melatonin cycle may account for depressive symptoms experienced by people living near power lines or working in high electromagnetic environments.

Melatonin is linked with some of the key responses to electromagnetic fields, namely breast cancer as well as other forms of cancer, miscarriages, and depression, and for this reason is one of the more likely candidates for explaining the mechanism responsible for some of the bioeffects of electromagnetic fields.

10.4.7.2 Mitosis and DNA Synthesis and Chromosomal Aberrations

The dynamics of cell proliferation is complex but changes in mitosis associated with fluctuations with the earth's magnetic field and with various ac frequencies has been reported. Liboff *et al.* (1984) examined the effect of electromagnetic fields on DNA synthesis in human fibroblasts. They exposed the cells to frequencies between 15 and 4 kHz and intensities from 2.3 to 560 μT and measured the incorporation of tritiated thymidine. DNA synthesis was enhanced during the 24-hour incubation. The threshold for this effect is estimated to be between 5 and 25 uT/sec (product of magnetic flux density (rms) and frequency) and is within the range associated with abnormal chick embryo development (10 uT/sec).

10.4.7.3 Ion Fluxes and Molecular Resonance

If resonance occurs in atoms or molecules (as has been suggested for some physiologically important monovalent and divalent ions, including lithium, potassium, sodium, and calcium) then these frequencies may very well have biological consequences (Blackman *et al.* 1994). The model that has received empirical support (but has also been criticized) is that of cyclotron resonance. The frequencies at which ions resonate depends on their mass, charge, and the strength of the static (geofield) magnetic field. Alternating current at the resonant frequency can transfer more energy to these ions and thus disturb their internal movement. The effects are location specific which may explain the discrepancy in some epidemiological and laboratory based studies.

Calcium has received the most attention in this regard. Brain tissue of newly hatched chicks released calcium ions when exposed to a radio frequency modulated at specific frequencies (15, 45, 75, 105 and 135 Hz, for example), which suggested that specific frequencies windows were important for biological effects (Adey 1980, Blackman 1985). Calcium is critical for many cell processes and changes in its flux could have significant and diverse effects on biota.

10.5 COMMENTS ON BIAS AND CONSISTENCY

10.5.1 Executive Summary of Three Major Reviews

Since 1997, three major reports have reviewed the literature on the biological effects of low frequency electromagnetic fields. Of interest is the shift in conclusions of these three reports during a 5-year period.

10.5.1.1 US National Research Council Expert Committee (1997)

The overall conclusions of the NRC Expert Committee, as stated in the Executive Summary, are as follows (NRC 1997, page 2):

" . . . the current body of evidence does not show that exposure to these fields presents a human health hazard. Specifically, no conclusive and consistent evidence shows that exposures to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects or reproductive and developmental effects."

"An association between residential wiring configuration (called wire codes, defined below) and childhood leukemia persists in multiple studies, although the causative factor responsible for that statistical association has not been identified. No evidence links contemporary measurements of magnetic-field levels to childhood leukemia."

10.5.1.2 National Institute of Environmental Health Science Executive Summary (1998)

The evaluation of the majority of the Working Group is that extremely low frequency (ELF) EMF can be classified as "*possibly carcinogenic*" and that this "*is a conservative, public-health decision based on limited evidence of an increased risk for childhood leukemias with residential exposure and an increased occurrence of CLL (chronic lymphocytic leukemia) associated with occupational exposure. For these particular cancers, the results of in vivo, in vitro, and mechanistic studies do not confirm or refute the findings of the epidemiological studies.*" (Portier and Wolfe 1998, page 402).

They go on to state that "*Because of the complexity of the electromagnetic environment, the review of the epidemiological and other biological studies did not allow precise determination of the specific, critical conditions of exposure to ELF EMF associated with the disease endpoints studied.*" (Portier and Wolfe 1998, page 400).

10.5.1.3 California EMF Program, Executive Summary (Draft 3, 2001)

The California Department of Health Services initiated the California EMF Program on behalf of the California Public Utilities Commission. Three reviewers examined epidemiological studies linking EMFs to 13 health conditions to determine whether these links might be causal in nature. These assessments were based on previously developed Risk Evaluation Guidelines and criteria developed by the International Agency of Research on Cancer (IARC).

Based on IARC Guidelines, the reviewers state that electromagnetic fields are:

- *Possible Human Carcinogens to Human Carcinogen:* based on childhood and adult leukemia
- *Possibly Causal*: based on adult brain cancer, miscarriage, and Lou Gehrig's disease, and that there is
- *Inadequate evidence* for male breast cancer, female breast cancer, childhood brain cancer, suicide, Alzheimer's disease, acute myocardial infarction, general cancer risk, birth defects, low birth weight or neonatal deaths, depression and electrical sensitivity.

The reviewers calculate that 1150 deaths per year with an additional 24,000 miscarriages annually may be attributed to EMFs. These estimates are much higher than the sum of annual non-fatal cancers associated with chloroform in chlorinated drinking water (49 cases), benzene in ambient air (100 cases); formaldehyde in indoor air (124 cases); or naturally occurring indoor radon (570 cases), all of which are currently regulated environmental agents. Over 1000 deaths with a much larger number of non-fatal cancers in California is a serious environmental hazard that requires serious regulatory attention.

During a relatively short period of 5 years we have moved from "no evidence links contemporary measurements of magnetic-field levels to childhood leukemia" (NRC 1997); to electromagnetic fields being classified as a *possible carcinogen* based on childhood and adult leukemia (Portier and Wolfe 1998); to electromagnetic fields classified as *possibly causal* for 5 health conditions, those identified by NIEHS as well as adult brain cancer, miscarriage, and Lou Gehrig's disease (California EMF Program 2001). If this trend continues, with better designed studies, more of the health conditions listed above are likely to be linked in a causal way with electromagnetic field exposure. The increasing connection between EMF exposure and estrogen-responsive breast cancer among younger woman rather than all forms of breast cancer among women of all ages is one case in point.

10.5.2 THE QUESTION OF BIAS

Prejudicial bias is something that scientists try to avoid since their credibility depends on an open unbiased approach to scientific hypothesis testing. By prejudicial bias I refer to someone with a firmly held opinion whose mind is not open to evidence that might contradict that opinion. Cultural bias, a type of bias associated with different scientific disciplines (and indeed different cultures), refers to the amount of proof needed before an opinion is considered valid. This type of bias, or level of acceptance, is considered the norm within a scientific subculture and is taught to young scientists as part of their training. Since variability among data sets and within scientific subdisciplines differs, the standards for acceptance are culturally defined. Physical scientists are accustomed to precise measurements while biological scientists, particularly those who work in the field, are accustomed to considerable variability in their data sets and have developed techniques to detect low signal to noise ratios. For this reason, two scientists with different expertise will often interpret the same data differently. One sees the noise while the other sees the signal. Differentiating between prejudicial and cultural bias is difficult.

Two strong cultural biases are presented in the literature: One represented the views of epidemiologists and the other that of physiologists. These conflicting perspectives are both well presented in the NIEHS and California reviews.

The NRC (1997) document is culturally biased towards the physical sciences and is highly critical of positive associations between EMF exposure and effects to the point that it raises questions of prejudicial bias. Scientific studies that suggested detectable biological responses to electromagnetic fields in the section on cellular and molecular effects and in the section on animal and tissue effects were down played so frequently that I began to think, "Methinks, thou doth protest too much!" For a detailed assessment of this refer to Havas (2000). Positive studies (those finding an association between exposure and effects) were criticized, while negative studies (those finding no association) were accepted at face value.

Another example of bias is the absence of studies dealing with occupational exposure in the executive summary despite the fact that they were included in the body of the text. The following are quotes from this summary that indicate increased risk of cancer associated with occupational exposure to electromagnetic fields, none of which appears in the executive summary.

Across a wide range of geographic settings . . . and diverse study designs . . . workers engaged in electrical occupations have often been found to have slightly increased risks of leukemia and brain cancer (Savitz and Ahlbom 1994). (pg. 179).

. . . a large well-designed study of utility workers in Canada and France provided evidence of a 2- to 3- fold increased risk of acute myeloid leukemia among men with increased magnetic field exposure (Theriault et al. 1994). Brain cancer showed much more modest increases (relative risk of 1.5-2.8) with increased magnetic field exposure. (pg. 180).

A series of three studies reported an association between electrical occupations and male breast cancer (Tynes and Andersen 1990; Matanoski et al. 1991; Demers et al 1991) . . . (pg. 181).

Female breast cancer in relation to electrical occupations was evaluated by Loomis et al. 1994 . . . a modest increase in risk was found for women in electrical occupations, particularly telephone workers . . . (pg 181).

The relative risks in the upper categories of 2-3 reported in the high quality studies of Floderus et al. 1993 and Theriault et al 1994 cannot be ignored (pg 181). Yet this is exactly what the NRC report did, it ignored some vital pieces of information in its executive summary.

10.5.3 THE QUESTION OF CONSISTENCY

The issue of "consistency" vs. "inconsistency" is an interesting one. For example, water boils at 100 C but it can also boil at higher and lower temperatures depending on atmospheric pressure. Without understanding the importance atmospheric pressure we may claim that two studies, each of which report a different temperature for the boiling point of water, are inconsistent. It's not until we understand the role atmospheric pressure plays that we recognize the consistency.

Similarly in EMF research, we can state that a study showing the link between cancer and residential or occupational EMF exposure and that showing a link between bone healing and medical EMF exposure are inconsistent because one is linked with a harmful cancerous growth and the other with a beneficial bone growth. However, if the underlying mechanism is similar, namely that electromagnetic fields enhance the rate of cell division (and/or cell differentiation) then we again recognize the consistency.

Not all studies found an increased relative risk (odds ratio) between residential EMF exposure and one specific type of childhood cancer. Some found an increase in acute myeloid leukemia, others in lymphomas, and still others in central nervous system tumors. Once again, tbis can be viewed as an inconsistency. Alternatively, if EMFs are involved in cancer promotion rather than cancer initiation (which is what the *in vitro* studies show), then the tumor type is not necessarily an inconsistency. The higher relative risk for different types of cancer may be viewed as a consistency if EMF promotes tumor growth that was initiated by a different agent. The type of tumor would be agent (or initiator) specific. Furthermore, an underlying mechanism that supports tumor promotion (of several types of tumors) is the melatonin hypothesis.

10.5.4 CLASSICAL CHEMICAL TOXICOLOGY AND EMF EXPOSURE

Some of the apparently contradictory results may be due to the fact that the chemical toxicology model, with its emphasis on dose/response, may be the wrong model for electromagnetic bioeffects. We may be getting a distorted picture by viewing the results through this lens. Frey (1994) suggests that the radio with its frequency modulated carrier waves may provide a much better model for understanding electromagnetic bioeffects. The radio picks up a very weak electromagnetic signal and converts it into sound. The electromagnetic energies that interfere with the radio signal are not necessarily those that are the strongest but rather those that are tuned to the same frequencies or modulations. Similarly "if we impose a weak electromagnetic signal on a living being, it may interfere with normal function if it is properly tuned" (Frey 1994, page 4). This makes sense once we recognize that living organisms generate and use low frequency electromagnetic fields in everything from regeneration through cellular communication to nervous system function. Frey goes on to suggest that high frequency EM waves may carry low frequency EM signals to the cell.

10.6 CONCLUSIONS

After a decade of trying to make sense of data from diverse fields I have become increasingly convinced that electric and magnetic fields do affect living systems; that these effects vary with individual sensitivities, with geography as influenced by the earth's magnetic field, and with daily and seasonal cycles; that they can occur at low frequencies and low intensities; and that we are very close to understanding several of the mechanisms involved.

If we wish to manage the risk of EMF we need to understand the parameters of exposure that are biologically important (this has yet to be done), and to identify biological end points and the mechanisms responsible for those endpoints. The scientific work is unfinished but this should not delay policy makers who are now in a position to introduce cost-effective, technologically feasible measures to limit EMF exposure.

The entire realm of EMF interactions is complex, but I am convinced that studies in this area will provide us with a novel view of how living systems work and, in the process, will open a new dimension into scientific exploration dealing with living energy systems. I am also convinced that this information will have many beneficial outcomes. We will better understand certain disorders and will learn to treat these and other ailments, for which we currently lack the tools.

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CW(WS) - March 29/11
- Item 2
C7

MCNE Marsden Centre of Naturopathic Excellence

City of Vaughan Committee of the Whole – March 29, 2011
Presented by: Von Chaleunsouk-Marsden BSc. ND

Background
While electromagnetic and radiofrequency fields are not visible, the effects are real, and may pose significant risks to the health and well-being of our community.

We are all electrical beings – from our heartbeat to brainwaves to muscle contraction. All communication in the body takes place via electromagnetic signaling between cells. Man-made RF from cell antennas, and wireless technology of unusual intensities, waveforms and signaling characteristics – meaning fields that are not normally found in nature, affects this cell-to-cell communication.

Various laboratory studies of RF radiation as well as epidemiological research of people who live near cell towers/antennas or use wireless technology have shown clear biological effects. These effects include:

- Breaks in DNA – which are the molecules responsible for the function of our cells
- Increase in cancers
- Reduced immunity
- Changes in behavior
- Nervous system effects
- Increased permeability of the BBB – important for the prevention of toxins entering the brain and central nervous system
- Heart arrhythmias
- Reduction in fertility
- Induction of a protective chemical response mounted by the body - This means that the cell recognizes that EMF/RF radiation as being harmful

A detailed summary of this information is clearly outlined in the 2007 BioInitiative Report – which has been provided to you

Acute Thermal vs. Chronic Non-Thermal Effects
Industry Canada's exposure standards are based on the assumption that there are no harmful effects at intensities that do not cause thermal effects or a rise in body temperature. It is clear that our safety standards are not adequate to protect our community – as they are designed for short term (6 min) acute exposure causing heating of tissues, and are not reflective of our low level, cumulative exposure in which the public now lives.

Differences in physiology of children

Our most vulnerable population is our children. Children are more susceptible to these low frequency fields for several reasons:

1. Physiologically and neurologically immature:
   a. Their nervous system is developing – the synapses (connections) between neurons are forming,
   b. The process of Myelination (production of fatty sheath around nerve cells) that supports the transmission of information within the nervous system occur rapidly in children, takes up to the second decade of life to form
2. Their skulls are thinner, brain tissue is more conductive (more fat and water – increases the absorption of RF radiation)
3. They will have a longer lifetime exposure than adults. When they reach adulthood, today's children will have much higher cumulative exposure to RF radiation than today's adults.

The adverse effects of non-ionizing, RF radiation may take decades to be revealed.

Precautionary Principle

History has taught us many lessons. Many things that were once thought to be safe have been confirmed to be dangerous many years later –

- 1964 US Surgeon General's Report on Smoking and Health was released, however government only began to implement protective legislation 20 years later
- Or with asbestos and mesothelioma – in which industry officials knew of the dangers from the 1930s, but did not act upon them for decades later

Although there are over 2000 research papers showing health effects at levels of radiation much lower than our federal guidelines, there seems to be confusion, and a lack of consensus.

We ask that council consider that in the absence of scientific consensus, that the City of Vaughan follow the PRECAUTIONARY APPROACH and take the responsibility to protect our community, our children from the potential harm of RF radiation by:

1. Limiting background levels of RF radiation (number and location of other towers and antennas)
2. Creating by-laws to hold responsibility over land owners renting their property for cell tower installations within 500m of schools, residential areas, public buildings
3. Create policy to not allow cell phone antennas and towers on city property

Marsden Centre of Naturopathic Excellence, 2338 Major Mackenzie Drive, Maple, ON L6A 3Y7
Phone: 905-508-4498 Fax: 905-508-4827 Email: info@mcne.ca Website: www.mcne.ca

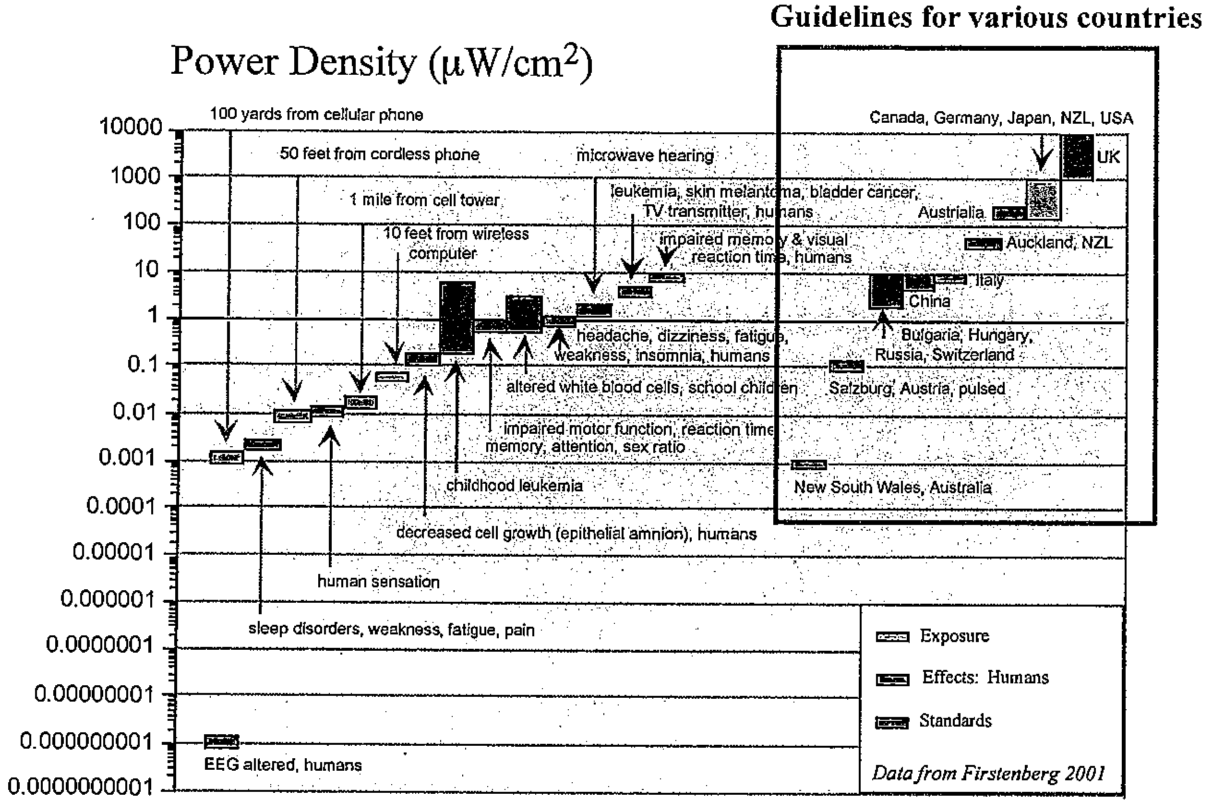


Figure 1. Guidelines, exposures and effects of radio frequency radiation at various power densities. Data from Firstenberg (6).

Firstenberg, A. 2001. Radio Wave Packet. President, Cellular Phone Taskforce. http://www.goodhealthinfo.net/radiation/radio_wave_packet.pdf

Graphed by Madga Havas PhD

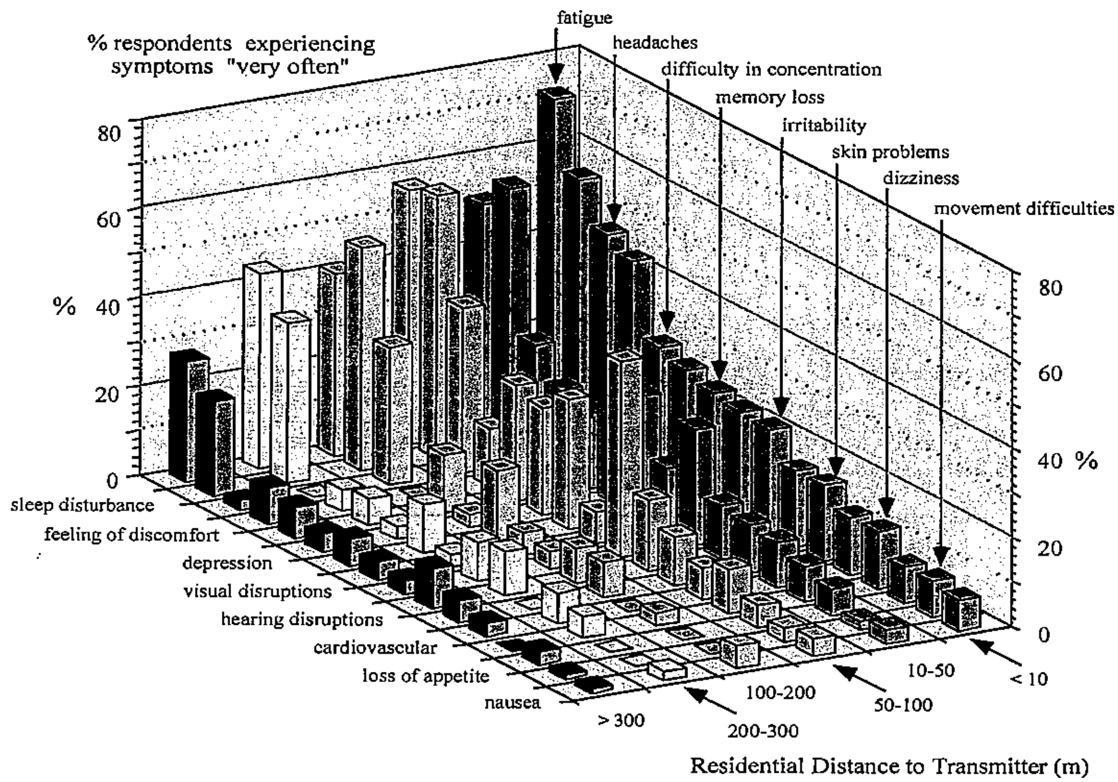


Figure 2. Response of residents living in the vicinity of a cellular phone base station in Spain Santini, 2001. Symptoms experienced by people in the vicinity of cellular phone base station in La Presse Medicale.

CW(WS) March 29/11
Item 1

C8

York Region

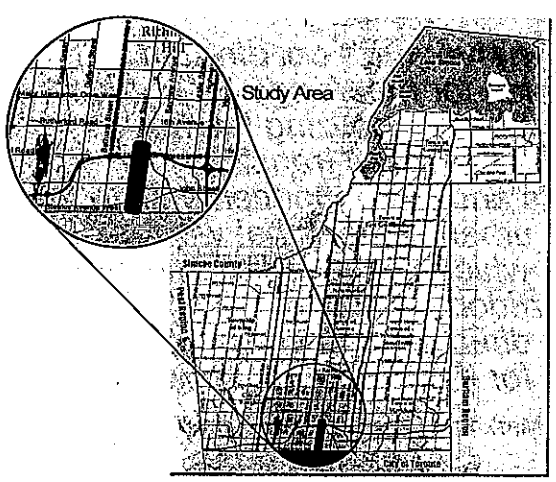
South Yonge Street Corridor Streetscape Master Plan

Presentation to
City of Vaughan
Committee of the Whole

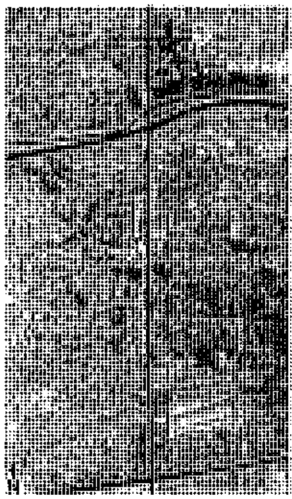
Angela Gibson
Head, Policy and Planning

March 29, 2011

Regional Context



Policy Context



- 3 Municipalities
- 6 Planning Policy and Infrastructure plans
- 17 Urban Design and Special Studies
- 7 Transportation Studies

Collaborative Approach

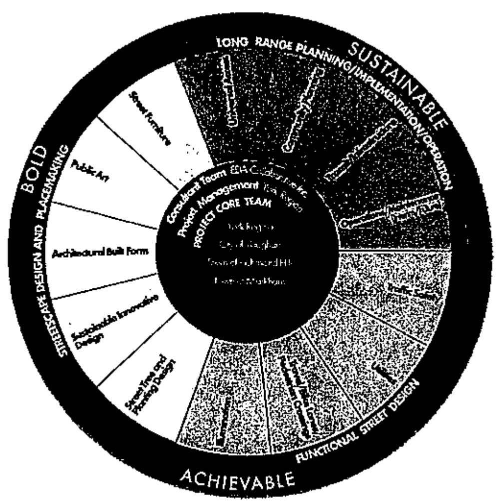
*"A **comprehensive** and **coordinated** streetscape plan for the Yonge St. corridor will play a key role in realizing the full potential of the proposed transit improvements and the enhancements to the quality of the urban context that will result. York Region, which has jurisdiction over the Yonge St. corridor... will play a key role in coordinating, directing and implementing a future **vision** for the Yonge St. streetscape."*

– Markham Council Resolution, Feb 2009

Key Study Objectives

- Establish a bold **Vision** for a pedestrian-friendly streetscape master plan to complement planned transit initiatives and inform future development along Yonge Street.
- Develop **Detailed Design Guidelines and Standards** that are sustainable and achievable.
- Develop an **Implementation and Phasing Strategy.**
- Provide a framework and **design direction** for Regional and local planning staff, and the development community.

Study Components



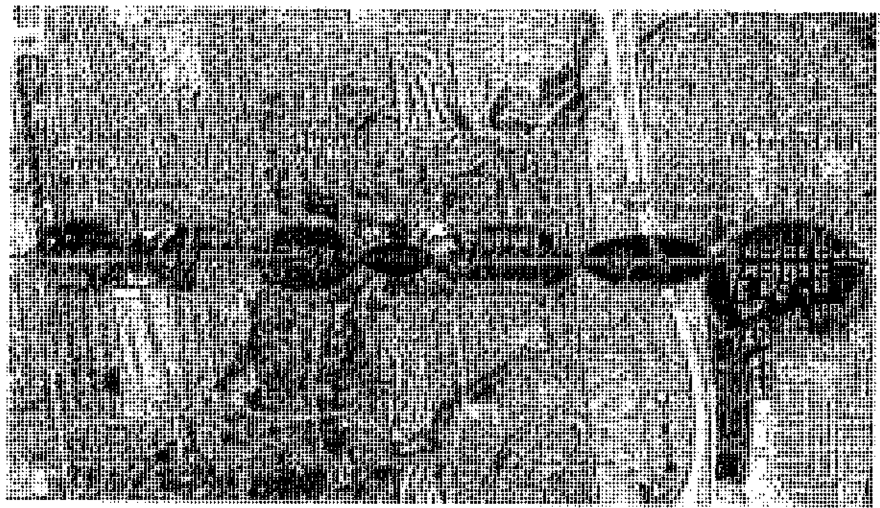
Work Plan

Phase 1: Research, Site Inventory & Analysis	Phase 2: Vision Statement & Design Principles/ Objectives	Phase 3: Streetscape Concept Plan	Phase 4: Detailed Design Guidelines & Standards	Phase 5: Implementation Strategy, Documentation & Confirmation

AUG 2010 — OCT — NOV — MAR 2011 — JUL — OCT

Phase 1

Overall Site Conditions



Slide 9

Phase 1 Findings

Opportunities

- Bold, sustainable and achievable streetscape plan
- Advance implementation of planning / urban design visions
- Integrate TOD with multi-purpose streets
- Powerful and iconic gateway
- Consistent streetscape treatment
- Partnership opportunities

Challenges

- Integration of subway development
- Transit development / interim streetscape condition
- Multi-jurisdictional study area

Slide 10

Phase 2

Visioning Workshop

- York Region
- City of Vaughan
- Town of Markham
- Town of Richmond Hill

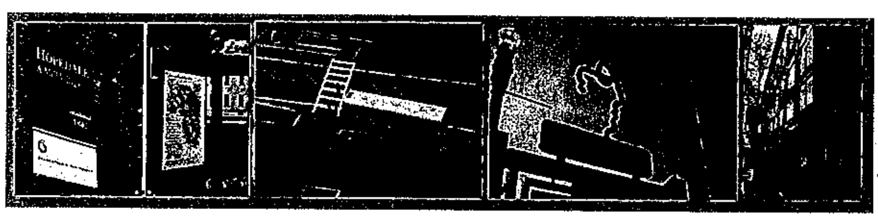
Vision Statement, Principles and Objectives

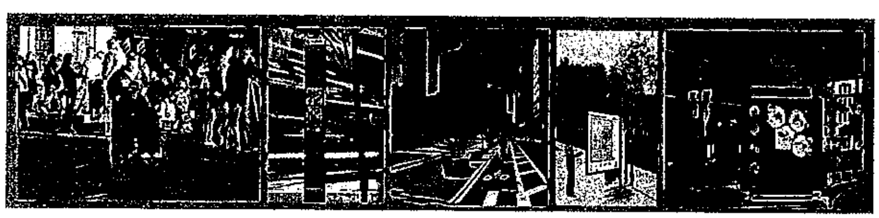
Bold
Vibrant and Engaging

Sustainable
Natural, Social and Economic Environment

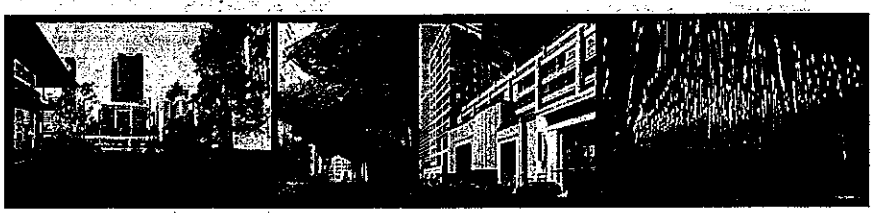
Achievable
Partnerships, Consistency, Supports Local Character

Access & Wayfinding

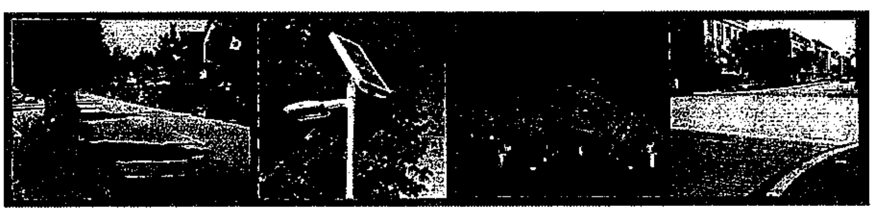


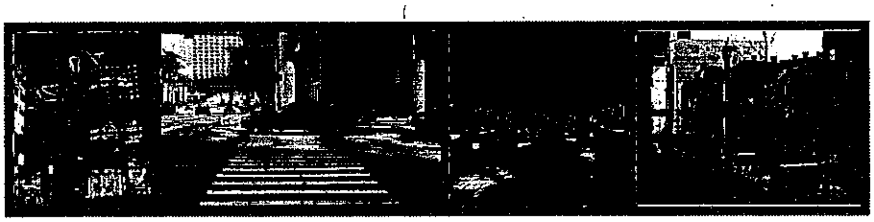


Architectural Built Form, Place Making & Public Art

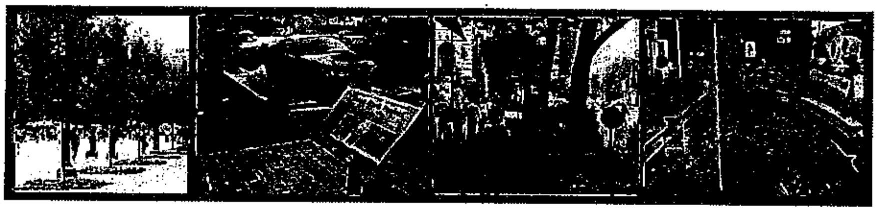


Fundamentals of Street Design





Green Streets & Sustainable Design



Slide 17

South Yonge Street Corridor Streetscape Master Plan

Implementation

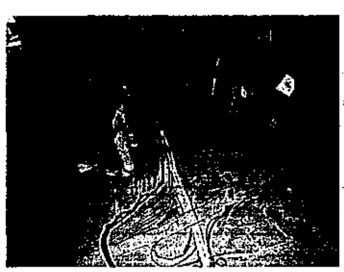
Slide 18

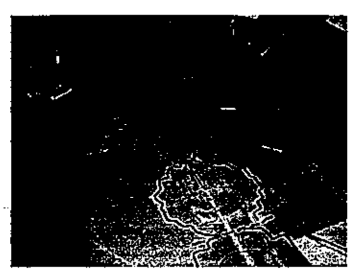
South Yonge Street Corridor Streetscape Master Plan

Phase 3

Team Charrette Workshop

- York Region
- City of Vaughan
- Town of Markham
- Town of Richmond Hill
- City of Toronto, MTO, 407/ETR

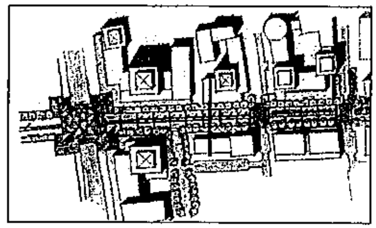


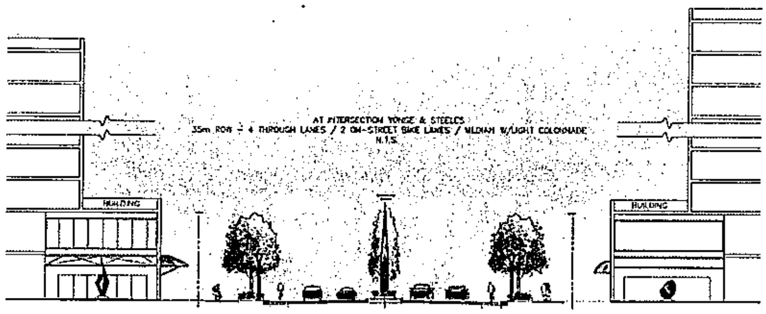


Master Plan

Yonge / Steeles District

- Distinctive Urban Character
- 4 Corner Treatment
- Vibrant Streetscape and People Friendly Spaces

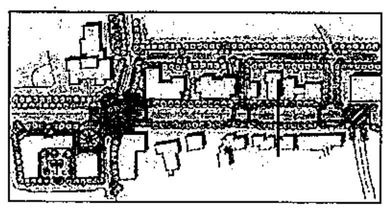


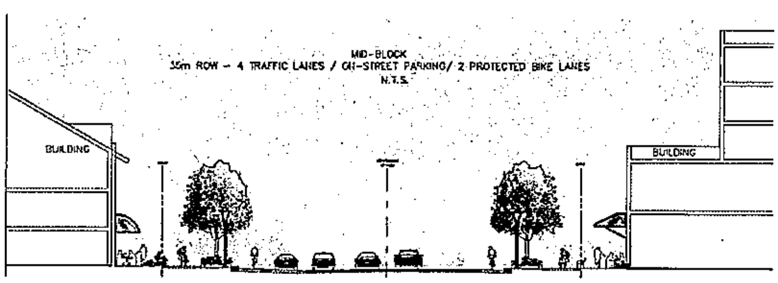


Master Plan

Thornhill Village

- Heritage Community Character
- Streetscape as Integrator
- Old and New

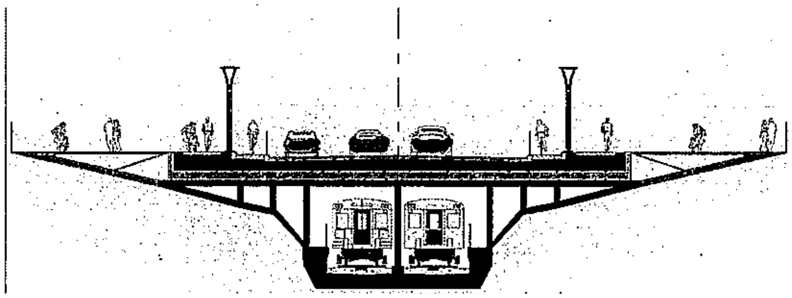




Master Plan

Don River Bridge

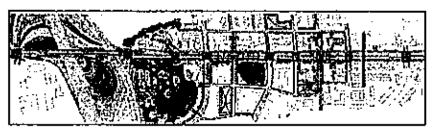
- Enhance Natural Valley Features
- Public Art as Infrastructure
- Pedestrian Connection and Viewing



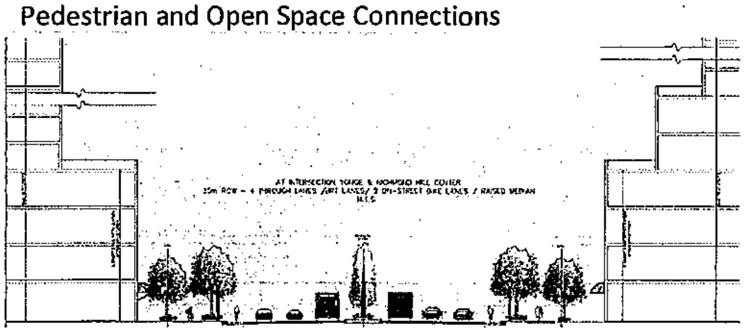
Slide 23

Master Plan

Highway 407 to Bantry



- Richmond Hill Centre/ Langstaff UGC
- Transit Integration
- 407 - Hydro Art Park (Potential)
- Pedestrian and Open Space Connections



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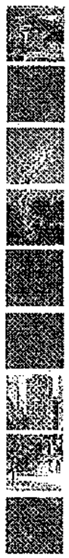
Next Steps

<u>Phase 4</u>:
Detailed Design Guidelines & Standards

- Urban design guidelines – detailed level
- Urban design checklist – design criteria

<u>Phase 5</u>:
Implementation Strategy, Documentation & Confirmation

- Policy recommendations
- Implementation strategy
  - Options for project delivery
  - Capital and maintenance cost matrix
- Final draft
- **Public information session (Fall 2011)**
- Final presentation to Regional and Municipal Councils



Questions?