Final Work, Assembly & Research; Geet Duggal
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Effects of Low Level Radiation on Genetics Material

Foreward

As with the last research, I have gone through various sites and read through a lot of them. I have copied and pasted information relavent information at this point. In between the itallic print, there is little side notes by me. This time, I decided to focus more on finding specific theoretical incidences/statistics to support long-term electromagnetic effects on genetic and other finer biological material.
Site 1: Neurological Effects;
http://www.mapcruzin.com/radiofrequency/henry_lai1.htm

On the other hand, since a relatively constant amount of body tissue is exposed, cumulative effect could occur and lead to an eventual breakdown of homeostasis and adverse health consequences. Data from some of the experiments described below do suggest that RFR effects are cumulative over time.

The key here, is cumulative over time. That and the fact that the data obtained is very theoretical and only speculatve at this point.

Blood-Brain-Barrier

The blood-brain-barrier is a biological barrier surrounding the brain. It blocks the entry of certain, and possibly harmful, molecules in the general blood circulation from entering the central nervous system. Studies on the effects of RFR on the

blood-brain-barrier were performed on animals in vivo, and SARs, if reported, are mostly given as average whole body SAR. Local SARs at the surface of the brain, where the blood-brain-barrier is located, were usually not known.

With regard to the intensity of exposure, the conclusion from most of the studies is that a high intensity of RFR is required to alter the permeability of the blood-brain-barrier. Significant changes in brain or body temperature seem to be a necessary condition for the effect to occur. For example, Chang et al. [4] studied in the dog the penetration of 131I-labeled albumin into the brain. The head of the dog was irradiated with 1000-MHz continuous-wave RFR at 2, 4, 10, 30, 50, or 200 mW/cm2. At 30 mW/cm2, 4 of the 11 dogs studied showed a significant increase in albumin penetration compared to that of sham-exposed animals, whereas no significant difference was seen at the other power densities. Lin and Lin [5] reported no significant change in the permeability of sodium fluorescein and Evan's blue into the brain of rats with focal exposure at the head for 20 min to pulsed 2450-MHz RFR at 0.5-1000 mW/cm2 (local SARs 0.04-80 W/kg), but an increase was reported [6] after similar exposure of the head at an SAR of 240 W/kg, which increased the brain temperature to 43 oC. In another study, Goldman et al. [7] used 86Rb as a tracer to study the permeability of the blood-brain-barrier in the rat after 5, 10, or 20 min of exposure to 2450-MHz pulsed RFR at an average power density of 3 W/cm2 (SAR 240 W/kg) on the left side of the head. Brain temperature of the animals was increased to 43 oC by the radiation. Increases in 86Rb uptake in various regions in the left hemisphere of the brain were observed. That increase in brain temperature played a critical role in the effect of RFR on the permeability of the blood-brain-barrier was further supported in an experiment by Neilly and Lin [8], in which they found that ethanol infusion could attenuate RFR-induced increase in penetration of Even's blue into the rat brain. Ethanol reduced RFR-induced increase in brain temperature.

So from the above text and its sourroundings in the article, the key points I got out of it was the fact that only fairly intense radiation (that above 30 mw/sq cm) which is far greater than the 1.2 mW/sq cm that a cellular phone outputs. (see subsite)

Subsite 1: http://www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html

These radiofrequency standards are expressed in "plane wave power density", which is measured in mW/cm-sq (milliwatts per square
centimeter) [8, 169]. For PCS (about 1800-2000 MHz) antennas, the 1992 ANSI/IEEE exposure standard for the general public is 1.2
mW/cm-sq. For analog mobile phones (about 900 MHz), the ANSI/IEEE exposure standard for the general public is 0.57 mW/cm-sq [9]. The
ICNIRP standards are slightly lower and the NCRP standards are essentially identical [10].

Another key point is the relation between radiation intensity and brain temperature level. As expected, there is, for the most part, a direct proportionality for middle values.

Even though most studies indicate that changes in brain-brain-barrier occurs only after exposure to RFR of high intensities with significant increase in tissue temperature, several studies have reported increases in permeability after exposure to RFR of relatively low intensities. Frey et al. [18] reported an increase in fluorescein in brain slices of rats injected with the dye and exposed for 30 min to continuous-wave 1200-MHz RFR (2.4 mW/cm2, SAR 1.0 W/kg) as compared with control animals.

OK, so there is evidence (still greater than the typical cell phone intensity) that lower levels of radiation have an effect. But an increase in flouroscien levels means absolutly nothing to me at this point. I need to look up what flouroscien levels in the brain actually mean.

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Subsite 2:
http://www.emory.edu/COLLEGE/NBB/students/projects.html

I have been doing research in the department of ophthalmology, under the direction of Henry Edelhauser, Ph.D. I have been investigating the effects of intraocular pressure on the permeability of human sclera to certain drugs, namely, rhodamine 6G (from solution and on a coil), dexamethasone-fluorescein, and methotrexate-fluorescein. Understanding how drugs permeate the sclera will provide avenues for treatment of certain diseases of the posterior eye, and could be applicable to neuroactive compounds as well. These investigations involve the use of perfusion apparatus which simulates an intraocular pressure by perfusing BSS (balanced salt solution) on the uveal side of the sclera. The drugs are placed on the extraocular side of the sclera and allowed to permeate for up to 21 hours. This data has allowed a constant(K Trans) to be calculated for each of the drugs, as a measure of its ability to cross the sclera.

Easily said, there is evidince from this and other stuff I've seen on the net that greater flouroscien actually increases permeability to the sclera, which in this case (kinda funny) is a good thing because certain drugs can be induced for treatment! I'm sure (but haven't quite researched it yet) that this increased permability also opens itself to more dangerous conditions.

Frankly, the rest of the section is basically using more examples to state the same idea that only more intense radiations actually have a significant difference. Note that this never really hit into long-term type effects.

Neural Electrophysiology

Exposure of neural tissue to RFR can conceivably cause electrophysiological changes in the nervous system. Changes in neuronal electrophysiology, evoked potentials, and EEG have been reported. Again, the possible involvement of of RFR-

induced tissue heating cannot be ruled out in some of the experiments. However, some effects were observed at low intensities and after repeated exposure suggesting cumulative effect. Chou and Guy [34] exposed temperature-controlled samples of isolated frog sciatic nerves, cat saphenous nerve, and rabbit vagus nerve to 2450-MHz RFR. They reported no significant change in the characteristics of the compound action potentials in their samples during exposure to either continuous-wave (SARs 0.3-1500 W/kg) or pulsed (peak SARs 0.3-220 W/kg) radiation. Thus, no direct field stimulation of neural activity was observed.

Same idea, small intensities don't induce stimulation of neural activity.

Several studies reported changes in EEG after prolonged repeated exposure to RFR. In some of these studies, RFR of relatively low power densities was used. Dumansky and Shandala [44] reported in the rat and rabbit that changes in EEG rhythm occurred after chronic RFR exposure (120 days, 8 hr/day) using a range of power densities. The researchers interpreted their results as an initial increase in excitability of the brain after RFR exposure followed by inhibition (cortical synchronization and slow wave) after prolonged exposure. Shandala et al. [45] exposed rabbits to 2375-MHz RFR (0.01-0.5 mW/cm2) 7 h/day for 3 months. A pitfall of this study is that metallic electrodes were implanted in various regions of the brain (both subcortical and cortical areas) for electrical recording during the exposure period and post exposure. Metallic electrodes can interfere with the RFR fields. After 1 month of exposure at 0.1 mW/cm2, they observed in the sensory/motor and visual cortex an increase in alpha rhythm, an EEG pattern indicative of relaxed and resting states of an animal. An increase in activity in the thalamus and hypothalamus was also observed later. Similar effects were also seen in animals exposed to the RFR at 0.05 mW/cm2; however, rats exposed to a power density of 0.5 mW/cm2 showed an increase in delta waves of high amplitude in the cerebral cortex after 2 weeks of exposure, suggesting a suppressive effect on EEG activity.

OK, some good evidence for longer-term cell phone usage to actually make a difference. But the question is what kind of difference? There is conclusive evidence for suppressive effects on EEG activity, but what does that mean?

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Subsite 3: http://www.crhsc.umontreal.ca/dreams/zinfo.htm

An electroencephalogram (EEG) is a visible record of the amplified electrical activity generated by neurons in the brain. The word EEG as ancient Greek roots and means: electro = electrical, encephalo = brain, and gram(ma) = picture.

So I didn't include more details about EEG that were givin in the website, but the main idea is that suppressed EEG activity means your neurons are, in general, less electrically active (for

example, high activity is commonly associated with the REM stage of sleeping where the most vivid dreams occur). So although I won't go into detailed biological ramifications, basically, suppressed EEG values can be interpreted as a not-so-good thing. The evidince above is really the only real evidence I've seen so far in strong support for prolonged cell phone usage.

A good point to bring up is the fact that this is not very related to humans. All of these experiments are laboratory experiments, on other species. The upshot of this is the fact that these data might not translate into bad things for humans, even though the thought is they will.

(For further information on EEGs and Electrophysiology refer to Diagnositic EM)

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Cytogenetic Effects

Recently, several studies have reported cytogenetic changes in brain cells by RFR, and these results could have important indication on the health effects of RFR. Singh et al. [90] reported significant decreases in poly-ADP-ribosylation, a process involved in chromatin functions, in the brain of rats after sixty days of exposure to 2450-MHz RFR (1 mW/cm2). Sarkar et al. [91] reported changes in DNA sequences in mouse brain cells after exposure to RFR (1 mW/cm2, 2 hr/day for 120, 150, and 200 days). Lai and Singh [92] reported an increase in single strand DNA breaks in brain cells of rats after 2 hours of exposure to 2450-MHz RFR (whole body SAR 0.6 and 1.2 W/kg). Genetic damages to glial cells can result in carcinogenesis.

OK, good, there is some more longer-term low-level exposure evidence. This time, it hits even more of what I want to cover, which is genetic and other lower level biological effects.

However, since neurons do not undergo mitosis, a more likely consequence of neuronal genetic damage is changes in functions and cell death, which could either lead to or accelerate the development of neurodegenerative diseases. We have recently reported [93] an increase in DNA double strand breaks in brain cells of rats after acute exposure to RFR. Double strand breaks, if not probably repaired, is known to lead to cell death. Indeed, we have observed an increase in apoptosis (scheduled cell death) in cells exposed to RFR (unpublished results).

So relating back to last time's research, the explanation for this increase in apoptosis can be linked "electromagnetically" (oh God, terrible joke) to the Lorentz Effect. So I'm piecing together some things here. The only real studied theoretical explanation for genetic damage that I've found so far is the Lorentz Effect I described last time. Now, we have specific evidence on DNA molecules of the celular results of this.

6.00 radicals also play an important role in aging processes,

which have been ascribed to be a consequence of accumulated oxidative damage to body tissues [98, 99], and involvement of 6.00 radicals in neurodegenerative diseases, such as Alzheimer's, Huntington, and Parkinson, has also been suggested [100,101]. Furthermore, the effect of 6.00 radicals could depend on the nutritional status of an individual, e.g., availability of dietary antioxidants [102], consumption of alcohol [103], and amount of food consumption [104]. Various life conditions, such as psychological stress [105] and strenuous physical exercise [106], have been shown to increase oxidative stress and enhance the effect of 6.00 radicals in the body. Thus, one can also speculate that some individuals may be more susceptible to the effects of RFR exposure.

The above, of course, is just some additional information, the end of it which is not quite tested yet.

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Site 2: http://infoventures.com/emf/federal/ota/ot95-11c.html
This site is particularly good at giving a good picture. Which is nice to know. I've seen a lot of other sites with similar information to what I've already stated (but in various, weird ways).

Research Is Inconclusive

While considerable research has been conducted on the effects of electromagnetic fields generally, very little work has yet been done on the possible health effects of exposures in the specific frequency and intensity ranges generated by wireless communications devices and systems. A particular weakness in the existing literature is the lack of research on the impact of long-term exposures.

There are two fundamental issues concerning radio-frequency electromagnetic radiation and human exposure. The most obvious is the thermal or heating effect of such radiation on tissue. It is well known that high-power radio waves will generate heat in exposed tissues. Microwave ovens, high- powered radars, and other high-power microwave devices, for example, radiate energy--a small portion of which is absorbed by body tissues. The rate at which this energy is absorbed is called the specific absorption rate (SAR). Absorbed energy raises the temperature of the tissues through the excitation of water molecules (the typical microwave oven operates at about 600 watts at 2450 MHz). The higher the power level the more heat is generated at a given distance for a given sample, and the higher the frequency, the more of the incident energy is superficially absorbed.

The thermal effects of radio communication devices are generally not considered harmful. Wireless devices are required to comply with well- established standards governing human exposure to electromagnetic radiation. These standards incorporates a substantial safety factor as a cushion against unanticipated effects or exposure in unusual situations. As a result, researchers have been unable to measure heating of

tissue at the low power levels used by hand-held cellular telephones. Microwaves do not penetrate metal, so shielding against them is fairly straightforward. In addition, power densities decline rapidly with distance from the source, so exposure can be reduced by lowering the power level and maintaining proper distances from operating antennas.

The second, and more controversial, issue is the possibility that RF radiation may cause nonthermal effects, including changes in genetic structure, the changes in the permeability of cell membranes, and disturbances in cell metabolism. These nonthermal effects theoretically could occur at lower power levels and under different modulation schemes than would be necessary to generate thermal effects. Much research in this area remains to be done, as government, industry and the academic communities agree. While there is no evidence that low-power, high-frequency radio signals cause cancer in cells, the possibility has been raised that such low-power radio waves could stimulate the growth of cancerous or precancerous cells, although early evidence is very weak (see box 11-1). Some preliminary evidence of microwave effects on DNA has also been reported, but not yet confi rmed

All self explanatory. Supports some conclusions I made earlier!

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Exposure Standards Are Still Being Debated

Disputes over biological and health effects revolve around the continued acceptability of this standard as new research is performed. (see footnote 15) As of spring 1995, the FCC was still considering whether to adopt the C95.1-1992 standard for all devices operating at microwave radio frequencies. Analog cellular telephones are presently exempt from testing under FCC rules because of their low power levels. However, the FCC indicated in 1994 that PCS phones would be subject to testing and SAR level limitations unless their maximum power output was less than 0.1 watt and a 2.5 centimeter separation was maintained between the user and any radiating structures. (see footnote 16) The standard has been endorsed by the cellular industry and the FDA's Center for Devices and Radiological Health, but EPA, the National Institute for Occupational Safety and Health and others have objections. (see footnote 17)

The above paragraph really simply highlights the debates. The other parts of the section pretty much talk about the IEEE standards set now.

Government Initiatives

Skipping the section on research activities (which is what a lot of my past stuff involved)...

The General Accounting Office (GAO) completed a short study of research performed on the safety of analog cellular telephones in November, 1994. The report notes that no one federal regulatory agency in the United States has responsibility

for wireless communications device emissions; EPA has overall responsibility for advising the government on EMF exposures, the FDA establishes standards for devices that emit radiation, and the FCC approves wireless communications devices for use and assures that their emission levels meet safety standards.

Just a quick overview of what government organization does what :)

Conclusions and Further research:

So now I think I have some decent evidence to show the physical cause for teh E&M damage (first research...) and now, the linked effects of that damage. A huge thing to get out of this is the true infancy of the whole research situation. There aren't 50 theories to debate upon, and there certainly isn't too much realistic long-term experimental evidence, but nevertheless, the topic is important and actually could have a very strong electromagnetic link (that could be brought up in future E&M courses decades from now, eh?...taught to 5th graders by then, of course).

For future research. I plan on simply going over this stuff, making sure there's no other major ideas out there, and possible (I have some speculations of my own) bringing up some of my own thoughts on the matter.

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Northwestern University Physics & Astronomy Department - Phyx 135-2 (General Physics) -- Professor Donald Ellis (Student Projects)