MOBILE TELECOMMUNICATIONS:

HEALTH EFFECTS AND SPECIAL INCENTIVES

Semester Project
The Nunn / MacArthur Security Program

by

Jason Sherwin

April 27, 2010

ABSTRACT

This paper attempts to answer two questions concerning mobile telecommunications: 1) Is electromagnetic radiation from mobile devices harmful to humans? 2) If there are ways to investigate this question then why have they not been done? The first question is a complex issue involving scientific methods in epidemiology, toxicology and other fields. Thus far, it has not been possible to conclusively link mobile telecommunication radiation to malignant health in users. But that does not prove that there is no link. In this uncertain middle ground, the second question arises: what has stopped conclusive investigations to address the health concerns? This paper presents an historical synopsis of how we have come to this puzzle. As part of this framework, special attention is paid to the incentives that various actors (e.g., companies, politicians, etc.) have demonstrated in their actions as they relate to mobile telecommunication.

By analyzing the past and current state of this issue, we can see that incentives exist for no action to be taken on the investigation of mobile telecommunications health risks. Furthermore, when other actors have threatened the uncertainty of the *status quo*, their results were discouraged or discredited through various channels of influence.

Under these circumstances, the burden of responsibility falls to elected officials to provide a safe environment for credible and independent research to be done. In the United States, this is not a simple action to take though, as the mobile telecommunications industry is a major lobbying force in Washington. But it is the goal of this paper to remind our elected officials to protect the general good of their electorate in this case.

Even though there has been no proof of danger, there is no disproof to claim otherwise. As we will see in this paper, there is a growing amount of evidence pointing towards non-negligible – and mostly, long-term – health effects from mobile telecommunication devices. Historically, such a situation resembles similar debates that arose around asbestos and tobacco usage. We know how industry and Congress acted and continue to act in these cases. These examples provide somewhat of a baseline for the mobile telecom debate. Until conclusive proof exists, in either direction, it should be the duty of Congress to protect its citizens in this regard. Both near-term and long-term proposals for how to do so will conclude this paper.

INTRODUCTION

Two questions are at the heart of the debate presented here: 1) Is electromagnetic radiation from mobile devices harmful to humans? 2) If there are ways to investigate this question then why have they not been done? The first question is scientific, while the second one involves political, economic and social factors. To answer the second question, an historical framework is utilized. In particular, we shall look at the politics and economics of mobile telecommunications – these two aspects readily have gone hand-in-hand. In light of the current prevalence of this technology, we will also consider the social

factors of mobile telecommunications: How ingrained is it in our culture? How central is to our society? By considering political, economic and social aspects to the problem, we will see what incentives of certain actors have produced the *status quo*. Specifically, we shall see that these incentives have been a persistent reason why investigations have not progressed to the point where a solid answer can be reached on health effects.

In light of this history and analysis of incentives, policy recommendations are later reviewed and compared to determine the most effective course forward. These policy recommendations focus on elected officials, rather than industry, because of the lack of a substantial incentive (thus far) for industry to consider a change. In contrast, elected officials are mandated via law to protect their electorate and the general good. Consequently, they have an incentive to act where industry does not.

As we will see, the focal point of the recommendations put forward in this paper is a further inquiry into the health effects of mobile telecommunications. This is a long-term aim. In the short term though, and in light of conflicting pieces of evidence, it is also recommended to educate people about the potential risks so that they may modify their use of mobile devices. By considering a near-term and long-term strategy, policy-makers can be satisfied that they are doing all that is in their power to protect the electorate that has given them their authority.

BRIEF HISTORY: TWO EXAMPLES OF INCENTIVES

To illustrate the incentives of various actors at the heart of this debate, we will examine two examples. The first involves a researcher named Allan Frey who started in the 1960's to find adverse health effects due to cell-phone spectrum radiation. The second involves another researcher, Henry Lai, who more than 30 years later found malignant effects on DNA due to cell phone frequency exposure. Neither of these examples covers the breadth of incentives at stake politically, economically or socially. Yet, each of them illustrates the kinds of nefarious actions that have occurred behind the scenes when any evidence of detrimental health effects arises. These examples will then provide a context for the historical analysis to follow.

Allan Frey: Grave Non-thermal Effects

Allan Frey discovered curious interactions between the human central nervous system and electromagnetic energy. In 1962, Frey published a paper in which he reported that low energy radio frequency (RF) signals could stimulate hearing perception in humans exposed to the radiation [1]. Frey emphasizes the fact that these are non-thermal effects, i.e., there is no temperature increase in tissue associated with these effects. Furthermore, these effects occur at low power densities. Frey writes the following synopsis of his findings (bolds added):

> Using **average power densities measured in microwatts per square centimeter**, we have found that other effects, which are transient, can be induced with this energy. Further, these effects occur the instant the

> transmitter is turned on. With appropriate modulation, **the perception of various sounds can be induced in clinically deaf, as well as normal, human subjects** at a distance of inches up to thousands of feet from the transmitter. With somewhat different transmitter parameters, **we can induce the perception of severe buffeting of the head**, without such apparent parameters again, one can induce **a "pins-and -needles" sensation**.

These findings from Frey clearly indicate a physiological interaction with human tissue. But they do not necessarily indicate any adverse effects from RF radiation.

Frey continued this research and in 1975 published an article [2] reporting adverse health effects from RF radiation. Frey writes that he found, "a difference in effectiveness of pulsed and continuous energy on behavior and brain permeability." Specifically, this paper discusses a heart arrhythmia induced in a frog from RF radiation. Furthermore, Frey reported an effect on the blood-brain barrier that separates the cerebral-spinal fluid from blood in the brain. Oscar and Hawkins corroborated this finding in 1977 on rats [3]. So we see that this 1975 article takes Frey's earlier work a step further to show actual adverse effects from some RF radiation.

In 1998, Frey published another paper that built on this work and in it he describes a troubling aftermath to his work in the 60's and 70's. Frey writes [4] the following (bolds added):

> Over a 2-year period, **J.H. Merritt made oral presentations in which he stated that he replicated the Frey et al. work** [2] and Oscar and Hawkins work [3] **and could not find an effect**. When he finally submitted a manuscript for publication, **a statistical analysis of the presented data** by the editor and a reviewer **showed that, in fact, his data supported the opposite conclusion** and provided a confirmation of the findings of Frey et al ... Merritt withdrew his manuscript.

Frey goes onto describe the differences in Merritt's methods from his own and shows how in fact Merritt substantiated Frey's findings experimentally, although he claimed not to in his conclusions. Then something very interesting happened: "At this point, the U.S. Department of Defense decided to effectively terminate funding for blood-brain barrier experiments that used low intensity microwave energy [5][6]." Frey had also received funding from the Office of Naval Research (ONR) for more than fifteen years [7], yet "he was told to conceal his blood-brain-barrier work or his contract would be canceled." So we see from this sequence of events how exterior incentives affected Frey's research into RF radiation health effects.

But Frey's findings on adverse health effects did not end with blood-brain barrier interaction. Another effect raised in his 1998 paper is that dopamine-opiate systems react to these electromagnetic fields. Frey links this effect also to headache symptoms, which are also some symptoms of blood-brain barrier breakdown.

Together, these non-thermal effects indicate that there is a non-trivial and adverse interaction between low energy RF signals and biological tissue. Furthermore, these adverse effects are demonstrated in the long-term and they are not immediately apparent from RF exposure, as was the induced perception of hearing. Frey admits that there have been studies showing that the biological effects from microwave exposure are negligible. "But the conflicts of interest and questions on the actions of those who decided what research was done and published have been documented by Steneck" [5][6]. Consequently, Frey is of the opinion that these searches for hazards are "hardly credible." As we will see later, other scientists (e.g., Davis) corroborate this opinion.

Henry Lai: Damage to DNA

After Allan Frey noted tissue-level interaction with cell-phone frequencies, Henry Lai found another disturbing interaction: damage to DNA. As with Frey's results, Lai's findings also came under intense pressure from non-scientific avenues. What did Lai find that caused such a response?

Lai examined the effects of low-intensity microwaves on the DNA of rat brain cells. In his experiments, he used 2450MHz microwaves in both pulsed and continuous waves [8]. As a point of reference, the Federal Communications Commission (FCC) licenses all spectrum usage from 3kHz-300GHz [9]. The band that includes Lai's frequency choice (2450MHz) is currently licensed for "amateur, radiolocation, fixed [and] mobile" usage. For example, in Fulton County, Georgia, although the FCC reports that there is no usage of 2450MHz, the closest spectrum usages are at 2496MHz. This range of frequencies are in use by Emory University, John L. Coble Elementary School and Georgia Institute of Technology for "Broadband; Fixed Wireless; Television" [10]. Of course, just because the frequency is close, it does not imply that DNA degradation should be witnessed at these places of learning. One reason for this is that the nature of the waves (i.e., pulsed vs. continuous) is not known in these locations, as it was specified by Lai's experiments. But Lai did report single-strand DNA breakdown for different exposure times from *both continuous and pulsed* waves.

In light of current standards and uses of mobile telecom, there is also another disconcerting aspect to Lai's findings: the Special Absorption Rate (SAR) of these studies is well below the safety limits used in both the U.S. and Europe. According to the Cellular Telecommunications Industry Association, SAR is "a way of measuring the quality of radio frequency (RF) energy that is absorbed by the body" [11][12]. In Lai's research, he reports single-strand DNA breaks for SAR values of 0.6-1.2 W/kg during periods of 2-4 hours of exposure. As a point of reference [11], "for a phone to pass FCC certification and be sold in the United States, its maximum SAR level must be less than 1.6 [W/kg]. In Europe, the level is capped at 2 [W/kg.]" **So Lai's SAR choice was approximately half of the allowable SAR values deemed by law in the United States and Europe. Yet, he saw single-strand DNA breaks.** As Lai notes in his paper, single-strand **breaks in DNA can lead to carcinogenicity** [13]-[15], **cell death** [16][17], and **aging** [13][18]. These adverse effects are long-term and not necessarily apparent immediately after RF exposure.

Considering that Lai is using frequencies and SAR's comparable to modern wireless networks and cell-phones, it should be quite clear now why the mobile telecommunications industry did not approve of his research. Subsequent to this paper being published, the University of Washington Alumni Magazine reports [19] that someone "called the [National Institutes of Health] to report that Lai was misusing his research funding by doing work not specified in the grant." When Lai was able to explain the scientific merit of his work, the discredit tactics then became more intense. For instance, in response to the study, Joe Farren, director of public affairs for CTIA-The Wireless Association, a Washington, D.C.-based industry consortium, said [19], "I don't believe any of those studies have ever been replicated [.]" However, both a 1998 experiment that used common frequencies and the INTERPHONE experiment across seven countries also documented DNA damage from cell-phone radiation. Other tactics included calls from industry for Lai to be fired and a lack of funding to pursue these health effects anymore.

In other words, Lai's story is quite similar to Frey's: both researchers found disturbing health effects from RF radiation – i.e., the medium of mobile telecommunication – and both were discouraged by more powerful interests from pursuing their investigations. These investigations began within a political and economic environment that originally supported them. It was only when the results of these investigations threatened parts of the political or economic power structure that they were stopped. So let us describe in more detail now what political and economic factors are at the current heart of the issue here. As we will see from this history, these considerations open the door to the social factors that define our present situation. Consequently, all of these factors must be considered together to influence how we can address health concerns from mobile telecom.

POLITICAL, ECONOMIC AND SOCIAL FACTORS

Many actors with different incentives have shaped the *status quo*. To understand the present state, it is important to recount how it came to be. Steneck, the author of *The Microwave Debate* [6], summarizes the current uncertain state with the following:

> Ever since [WWII], policy-makers in military and regulatory government agencies and in many private organization have grappled with the problems posed by increasing levels of RF radiation in the environment ... To date, they have yet to formulate a satisfactory solution to this problem.

As we will see, political forces created an environment for economic forces to take shape. Once these economic forces grew in significance, a synergy between the political and economic forces developed that has persisted to this day. This economic power grew out of the prevalence of mobile telecommunications technologies, thereby making them a social phenomenon. Consequently, the social aspects to the history are more recent, though not less important because they determine what the future will look like.

So we now proceed to recount this history, noting the incentives that have shaped the decisions of various actors along the way. This history will provide a useful context to the two examples provided by Lai and Frey above.

Political Aspects

In 1934, the U.S. Congress passed the Communications Act (CA), in which a newly created agency called the Federal Communications Commission (FCC) was given legal authority to regulate radio communications. Among other things, this law granted the FCC the authority to allot licenses over radio spectrum usage [20]. From this act, one of the mandates of the FCC is to "encourage the larger and more effective use of radio in the public interest." Consequently, it is written into law that the FCC is also responsible for the wellbeing of the public in its use of radio spectrum.

In 1996, the Telecommunications Act (TCA) resulted in the greatest overhaul of communications legislation since the Communications Act. But whereas the CA created a regulatory body to oversee activity in the radio spectrum, the TCA developed in response to the need for markets to open and be unimpeded by regulatory barriers [21]. Furthermore, the TCA granted the FCC the ability to continue its practice of auctioning spectrum to competitive buyers. This role of the FCC began in 1993 to speed up the rate at which spectrum would be allocated to potential users [22]. As of 1997, this role of the FCC allowed it to bring in $23 billion. As of 2009, the FCC reports that spectrum fees have totaled $52 billion [7].

Comparing the TCA of 1996 and the CA of 1934, we see different incentives at work to produce each act of the legislation. In 1934, the use of radio spectrum had not realized the same economic potential it would by 1996. Consequently, the creation of a regulatory body like the FCC created less industrial friction at the time, since there was not the same magnitude of an industry to consider. However, the TCA's story is different. Leading up to the TCA (Ketcham), "nearly $50 million in political contributions and lobbying largesse [came] from the telecom industry." Furthermore, since the FCC possessed the radio spectrum the telecom industry needed, the FCC received more than $8 billion for purchase of the microwave-frequency end of the spectrum. As a result, since 1995, industry estimates for the number of cell-phone antennas has increased ten fold to 247,000 (Ketcham).

Today, the story continues because the FCC has ceded much of the control over radio spectrum to its buyers and licensees. Now though, it faces a possible 'spectrum crisis', according to its Chairman Julius Genachowski, with the growth of mobile devices like the iPhone, Droid and 3G-enabled laptops. Recently [23], "The FCC is looking to free up to 500 megahertz of spectrum for wireless broadband over the next ten years, and it will try to buy the airwaves from broadcasters." The FCC has offered to give the broadcasters a share of the auction profits. Consequently, this move to open up spectral real estate for mobile telecom demonstrates complicity with industry as the TCA did in 1996.

The primary question to ask though is whether such a shift in ownership and usage is in the "public interest." Reports of DNA single-strand breaks (Lai), dopamine-opiate system interactions and blood-brain barrier perforations (Frey)

indicate that such usage is *not in the public interest*. Yet, as the evolution of communications legislation outlined here demonstrates, it has become increasingly difficult to separate economic interests from political ones.

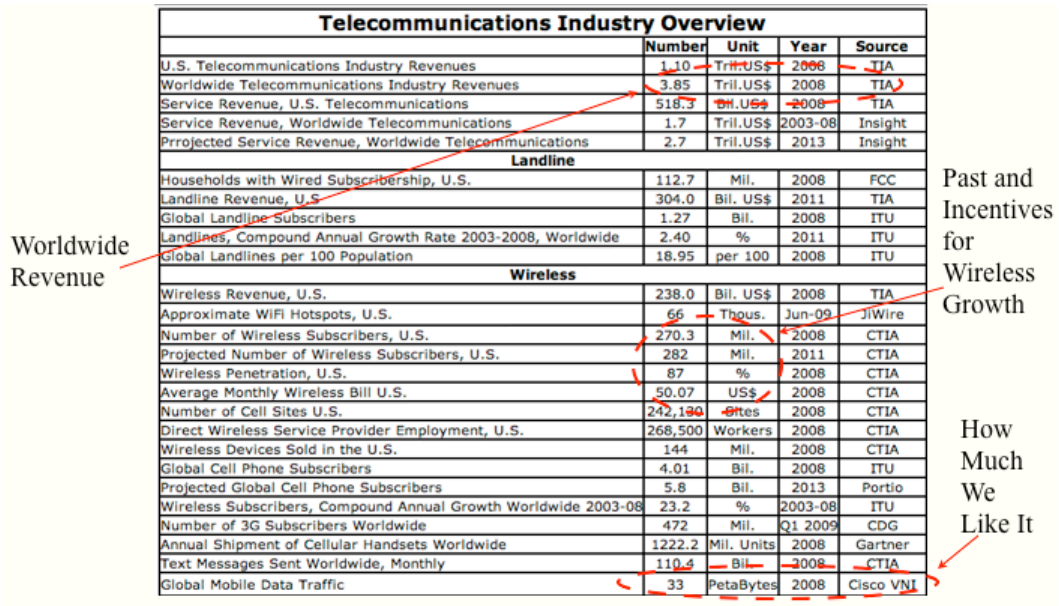
Compounding the problem, as legislation and affordable means to participate in mobile telecommunication have synergized, a society has developed around these technologies both in the United States and in other countries. Consequently, it has become difficult to extricate the mobile telecom industry from its users. So the question is not 'how to end mobile telecommunications usage?' but rather 'how to maintain mobile telecommunications usage within the bounds of public health and wellbeing?'

Before proceeding to an analysis of the social factors though, it is important to consider the magnitude of economic interests that have shaped the change in role of the U.S. Government from 1934 to 1996 and up to today. As we will see, these economic interests though do not end in the U.S., where they began. Rather, as inhabitants of other regions of the world are exposed to the utility of mobile telecom, the industry is presented with an undeniable opportunity for growth. But since these inhabitants live beyond the jurisdiction of regulatory organizations (e.g., the FCC in the United States), the laws that dictate mobile telecom usage in certain countries need not apply there. Consequently, if the health effects seen by Lai and Frey are real then the size of the population at risk could grow to the entire human population of this planet.

Economic Aspects

The mobile telecommunications industry is a massive economic force in the world today. What follows is not meant to be a comprehensive view of it – neither was the preceding discussion on telecommunications legislation in the United States. Rather, we hope to see from some illustrative numbers what is at stake if the interests of this industry are threatened with detrimental health effects to its users.

To start, an overview of the telecommunications industry can illustrate the amount of money at stake. Figure 1 provides just such an overview.



Telecommunications Industry Overview

	Number	Unit	Year	Source
U.S. Telecommunications Industry Revenues	1.10	Tril.US$	2008	TIA
Worldwide Telecommunications Industry Revenues	3.85	Tril.US$	2008	TIA
Service Revenue, U.S. Telecommunications	518.3	Bil.US$	2008	TIA
Service Revenue, Worldwide Telecommunications	1.7	Tril.US$	2003-08	Insight
Prrojected Service Revenue, Worldwide Telecommunications	2.7	Tril.US$	2013	Insight
Landline				
Households with Wired Subscribership, U.S.	112.7	Mil.	2008	FCC
Landline Revenue, U.S.	304.0	Bil. US$	2011	TIA
Global Landline Subscribers	1.27	Bil.	2008	ITU
Landlines, Compound Annual Growth Rate 2003-2008, Worldwide	2.40	%	2011	ITU
Global Landlines per 100 Population	18.95	per 100	2008	ITU
Wireless				
Wireless Revenue, U.S.	238.0	Bil. US$	2008	TIA
Approximate WiFi Hotspots, U.S.	66	Thous.	Jun-09	JiWire
Number of Wireless Subscribers, U.S.	270.3	Mil.	2008	CTIA
Projected Number of Wireless Subscribers, U.S.	282	Mil.	2011	CTIA
Wireless Penetration, U.S.	87	%	2008	CTIA
Average Monthly Wireless Bill U.S.	50.07	US$	2008	CTIA
Number of Cell Sites U.S.	242,190	Sites	2008	CTIA
Direct Wireless Service Provider Employment, U.S.	268,500	Workers	2008	CTIA
Wireless Devices Sold in the U.S.	144	Mil.	2008	CTIA
Global Cell Phone Subscribers	4.01	Bil.	2008	ITU
Projected Global Cell Phone Subscribers	5.8	Bil.	2013	Portio
Wireless Subscribers, Compound Annual Growth Worldwide 2003-08	23.2	%	2003-08	ITU
Number of 3G Subscribers Worldwide	472	Mil.	Q1 2009	CDG
Annual Shipment of Cellular Handsets Worldwide	1222.2	Mil. Units	2008	Gartner
Text Messages Sent Worldwide, Monthly	110.4	Bil.	2008	CTIA
Global Mobile Data Traffic	33	PetaBytes	2008	Cisco VNI

Figure 1: Telecommunications Industry Overview [24]

While Figure 1 contains much useful information, we can focus on a subset of the values here to get an idea of what the recent past has looked like and where it seems to be going for telecom, especially mobile telecommunications. For instance, as of 2008, the worldwide revenues from telecommunications amounted to $3.85 trillion U.S. The citation for this value comes from the Telecommunications Industry Association (TIA). It should be noted that this number includes non-mobile telecommunications, which does not rely on radio spectrum usage as mobile telecom does. To narrow the focus though, we can consider the bottom part of the figure, which shows 'wireless' telecommunications-related figures. For instance, just considering the U.S., we see that the projected number of wireless subscribers is expected to grow from 270.3 million to 282 million from 2008 to 2011. With an average monthly phone bill of approximately $50 in the U.S., this means a projected growth of approximately $600 million ($US 2008) in market share. Finally, it seems that there is no incentive on the part of customers to relinquish this ability, since Cisco estimates that global mobile data traffic was a substantial 33 PetaBytes in 2008.

This overview of the telecommunications industry illustrates both a growing dependence among users and a growing economy for mobile telecom providers. If the customers are satisfied, and the industry continues to grow, then what incentive is there to be concerned with health effects from these devices? In the absence of any information on detrimental health effects from mobile telecom, neither industry nor its users have any incentive to probe the question.

An interesting illustration of this hesitancy within industry can be seen from Apple with regards to its revolutionary iPhone. One of the groundbreaking features to the iPhone is that it opens up participation in technological development to non-Apple employees through its iPhone Applications ('apps'). These apps can be designed and sold through Apple's App Store by anyone able to design them [25]. By opening technological development to outsiders, Apple

has ensured a continuing state of development for the iPhone and other devices (e.g., iTouch, iPad). This culture of openness has been a defining trait of Apple and its products.

But when an iPhone app was submitted for sale that gave users information on electromagnetic radiation from their phones, Apple denied the developers the ability to sell the app on the App Store. In March 2010 [26], "Apple praised the [iPhone] app's interface but has rejected it because 'supplying information about radiation levels ... could cause user confusion." Some critics of Apple's response questioned why such an app would cause confusion. These critics reasoned that such information would actually calm user's worries about the radiation they receive from their iPhone.

But Apple's incentives are to protect their market and that can clearly be seen from the success of the iPhone. So in Apple's case, the culture of openness takes a backseat to the share of their market. If we use stock price as an indicator of the iPhone's popularity – granted, this is an approximation – then we can see why iPhone is quiet on the subject. Figure 2 shows the motion of Apple's stock price from the iPhone release date (July 11, 2008) to April 5, 2010.

Figure 2: Apple Stock Price Since iPhone Debut

First, it is worth noting that Apple's stock price rose from 172.58 on the iPhone release date to 238.01 over this time period. Not all of this movement can be attributed to the iPhone though, and we have stated that assumption. But a second point worth considering is that there was a worldwide financial meltdown towards the end of 2008 and the beginning of 2009. As Peter Bernstein, author of *Capital Ideas*, tells us [27], no stock is separated from the motion of the overall market, and Apple's stock price shows this correlation. Yet, despite this dramatic drop, Apple's stock price rose dramatically since the iPhone release date. Such profitability, in the midst of worldwide financial meltdown, only reinforces the incentives Apple has *not* to create 'user confusion' over radiation levels.

In singling out Apple, the aim here is not to castigate their products. Rather, we hope to demonstrate what is at stake for industry actors in the mobile telecommunications health effects debate. As telecom industry overviews and the

iPhone's popularity illustrate, both industry and consumers have reached an accord, whereby users benefit from the technology and industry benefits from the profits. On time scales of one or two years, this is the paradigm of economic symbiosis. But as this relationship continues, it is not clear what health effects could develop as a result of this relationship. Both Lai and Frey have shown that these effects can be seen in the short-term, and their severity can develop non-trivially in the long-term. So as more people use mobile telecommunications though, will the public interests be compromised?

Furthermore, the use of mobile telecom is not subsiding any time soon. Rather, there are many areas of rapid growth, and most of them are outside the U.S. and Europe. In particular, developing countries and other regions of the world with poor infrastructure are experiencing rapid growth in mobile telecom usage. For instance, *The Economist* has done a panoramic survey of telecommunications in emerging markets. Predominantly these markets have been in under-developed parts of the world. Why is this so? "The reason why mobile phones are so valuable to people in the poor world is that they are providing access to telecommunications for the very first time, rather than just being portable adjuncts to existing fixed-line phones, as in the rich world" [27]. Currently, approximately 4 billion people *subscribe* to a cell phone service [29]; this number does not include users of pre-paid cell phones. Consequently, greater than two-thirds of all people on the planet use cell phones and as this technology becomes more prevalent in under-developed regions their use will likely continue.

The mobile telecom industry recognizes this potential for further growth and there is no reason, from a business perspective, to stifle it. So a profit-driven industry like mobile telecom is faced with two choices: 1) increase its revenues by expanding its well-developed services to more people or 2) investigate some possibly detrimental side effects from using these services and alienate its customers. It should be clear from these two options that a profit driven industry would choose the first option. We have seen an example of this option being taken in Apple's decision to block the iPhone app giving radiation exposure information to users. Although this case is not emblematic of the entire mobile telecom industry, it is certainly indicative of the whole industry leaning towards the first choice, i.e., not to investigate detrimental side effects of RF exposure.

Social Aspects

With the legislation in place to back economic growth in mobile telecom, and with a symbiosis between industry and consumer, mobile technologies have become ingrained in society today. As a consequence, any future policy recommendation would have to consider this ubiquity. To get an understanding of its prevalence, we examine mobile telecom's role in how people interact and even think.

Mobile Telecom as Social Aid

As with the Apple example to demonstrate industry hesitancy in publicizing radiation information, we will focus on one example of social networking to illustrate its central role in social interaction: Facebook. This examination is not meant to be a comprehensive analysis of Facebook's ability to

facilitate societal interaction. However, by detailing some observations on its use, we aim to see its central role within society today. In particular, we examine its ability to foster 'weak ties' among people and its consequential explosion in popularity.

One of the central features to Facebook is that it allows its users to interact without the necessity of familiarity. Bernie Hogan in a lecture at the Oxford Internet Institute noted that this ability is due to the 'weak ties' of Facebook [30]. He goes on to say that an individual's power is multiplied via these weak ties. In this statement, Hogan indirectly asserts somewhat of an analogy with the Metcalfe Law. This law states that, for a given user, the value of a network is proportional to the square of the total number of users [31]. This law is more of an approximation and it is not exact. The point though is that if there are more users on Facebook then a given user can reap more value from it. According to Hogan, this is due to the weak ties that can develop between users.

As these societal ties are developed, they become ingrained in social interaction, consequently making their transition to mobile devices inevitable. If we recall the earlier statement by *The Economist* – but now in a different context – then we can see why this transition to mobility is likely: "mobile phones are so valuable to people in the [rich] world [because they are] portable adjuncts to existing fixed-line phones [.]" Could we not extend this line of thought then to fixed-line societal interaction via Facebook and other social networking sites? In other words, instead of mobile phones being the extension of only land-line phones, they are now capable of being the extension of many laptop computer functions, including the use of Facebook.

Furthermore, it seems that the popularity of Facebook grows unchecked in both fixed-line and mobile domains. This past March, Facebook logged more visits to its site than Google [32], illustrating for the first time a greater usage of the internet for social interaction than for information procurement. With Facebook's popularity soaring, and a growing mobile ability to use it, it seems inevitable that mobile telecom will become a primary way of participating in society. Consequently, the extrication of this ability from society as a whole would be difficult.

Mobile Telecom as Intelligence Aid

Despite the growing popularity of online social networking, the need to obtain information has not abated with the advent of mobile telecom devices. Rather, as with mobile phones being the extension of land-line capabilities, these devices have allowed information procurement to become mobile as well.

As with social networking sites, these abilities were first established in fixed-line settings and then became mobile. Furthermore, these flexible avenues of information transfer allowed information procurement to grow tremendously. For instance, the popularity of information procurement even reflected itself in language: as early as 2006 and 2007, both Merriam-Webster and Oxford Dictionaries recognized 'google' as a verb in the English language [33]. The popularity of obtaining information has manifested itself in other ways too. For example, as Nicolas Carr writes in *The Atlantic*, google-based information retrieval has become a support to our own intelligence [34]. Such an insight

resonates quite well with neuroscientific insight into how we read being tied to how we think as humans [35].

In the developed regions of the world, this ability to retrieve information is extended from fixed-line usage. But in developing countries, reiterating a point from earlier, this ability is available to mobile telecom users for the first time. If the utility of such usage in the developed world is any indicator of its utility in other regions of the world then it is likely that mobile telecom usage would be buoyed through this need as well – the need to obtain information. As with social networking, the consumers of such ability demonstrate the desire to see it continue, and even grow. So the extrication of this ability from society would also be difficult.

WHAT DO WE DO?

We have seen how political actions shaped an environment for the mobile telecom industry to grow. This relationship then developed into a quasi-symbiosis that allowed mobile telecom to become increasingly ingrained into our society. But we could be faced with a major public health problem in the future if there are even slight biological effects to mobile telecom technology users. How do we then balance these considerations as we proceed with policy recommendations?

As a starting point, we can consider recommendations from various actors at play in the mobile telecom arena. For instance, we can consider what the industry actors suggest, or what politicians suggest, or even what scientists suggest. But, to be consistent with our historical framework, we have to note the incentives fueling such suggestions. For instance, we have seen that Apple has suggested not to pursue the issue publicly. Their incentive is not to damage their market. What incentives would other actors have that motivate their suggestions though?

Another perspective to consider can come from similar debates from the past. Two notable examples that we will consider are tobacco and asbestos. As with mobile telecom, the controversy over each of these examples stemmed from apparent (though not directly clear) health risks in the context of overwhelming industry action not to pursue an answer for fear of market loss. Perhaps from these debates some answers will come as to how to proceed for mobile telecom and its potential health effects?

In what follows, we will first discuss these two examples and then reconcile their lessons in the context of recommendations from leading scientists. We focus on scientists' recommendations, in particular, because we have seen thus far that industry-based and political recommendations have been consistently laden with incentives not to investigate adverse health effects further.

The Tobacco Story in the United States

The recent legislative history of tobacco regulation in the United States began in 1962 with the Surgeon General's inquiry into the health effects of smoking. "All members [of the expert committee] were approved for appointment by the tobacco industry as well as the American Medical Association (AMA) and

several national health agencies" [36]. On January 11, 1964, the Surgeon General issued its unanimous report stating, "cigarette smoking is a health hazard of sufficient importance in the United States to warrant appropriate remedial action" [37]. Comparing these events to the mobile telecom controversy, a similar panel of experts from industry and the AMA and/or other health agencies could be created to answer the same questions about cell-phone and wireless technology use.

As the history of tobacco regulation shows, the conclusions of the Surgeon General did not prompt immediate stifling of the tobacco industry. Rather, the battle shifted to the way that tobacco was advertised. In this realm, the industry was able to lobby Congress heavily to vitiate rulings against advertising tobacco products [38]. This was possible because the tobacco industry, "has been an extremely powerful force in American politics ... [employing more] than 100,00 employees [who] receive $500 million in wages annually from tobacco manufacturing companies ... [Furthermore, peripherally] affected are those involved in producing [cellophane, aluminum foil, printed packs and cartons]" [39]-[41][36]. As with the mobile telecom industry today, the tobacco industry's economic interests were at the time quite related to political interests. Additionally, the attempts to discredit health concerns about tobacco were quite similar to what Henry Lai experienced with regards to cell phone effects on health [36][37]:

> At House and Senate committee hearings, committee members friendly to the industry attempted to discredit both the Surgeon General's Report and the testimony by the Surgeon General, the Chairman of the Federal Trade Commission, and the representatives of various medical and health organizations. The **tobacco industry then presented a number of physicians who testified** that they disagreed with the conclusions of the Surgeon General's Advisory Committee and that in their opinion there was **no real evidence that cigarette smoking is harmful**.

With uncertainty in the studies about health effects, the tobacco lobby exploited the careful steps of the scientific method to protect its market. Are we seeing similar steps being taken now by the mobile telecom industry?

What is important to note about the tobacco controversy is that the steps taken to warn the public did not help immediately. For instance, the Federal Trade Commission concluded, after the warnings were placed on packs [36], "There is virtually no evidence that the warning statement on cigarette packages had any significant effect." It was not until the FCC became involved in the debate that the U.S. Government ramped up its efforts against the tobacco industry. "Most observers agree that the dramatic entrance of the FCC into the smoking controversy was probably the most important single event during the three-year moratorium on requiring health warnings in cigarette advertisements imposed by Congress on the FTC" [40]. This event culminated in President Nixon signing the law on a ban of such advertising on television and radio on April 1, 1970.

But there has been much debate about whether such a ban has been useful. For instance, the "live dangerously novelty" of cigarettes contributes to gains in their consumption [39]. Also, after the Surgeon General's first report in 1964, cigarette sales increased by 5 billion in the following year [36], indicating how quickly the general public loses interest in such warnings. Looking ahead to possible warnings and/or regulations for mobile telecom uses, these lessons from the tobacco story are important to consider if we hope to curtail adverse health effects from mobile telecom devices.

The Asbestos Story in the United States

The legislative history of asbestos in the U.S. provides a useful foil to that of tobacco, especially when considering the current state of the mobile telecom health effects debate. As opposed to the tobacco debate, there was no widespread warning on the use of asbestos. Neither was there a ban on its use in the U.S. Without a legislative reason to curtail its use, many industries continued to use asbestos in their manufacturing.

Without an incentive to remove it from manufacturing processes, companies continued to use asbestos despite the known risks. For instance, Pfizer/Quigley, General Motors and Viacom all had knowledge that asbestos could be harmful to those who came into contact with it during manufacturing [41]. Consequently, a mound of litigation has built up over the years and there seems to be no sign of abatement in the near-term.

The most recent proposed legislation with regards to asbestos was the Fairness in Asbestos Injury Resolution Act of 2004. This legislation was primarily concerned with how best to clear these cases from the judicial system, since they continue to grow in volume. So the consequence of industry not acknowledging the risks of asbestos in their practices has spawned complicated litigation and legislation that continues to this day. Without warnings to mobile telecom users, could similar problems arise for companies like Apple or AT&T?

Looking Ahead: The Mobile Telecom Story in the United States?

The tobacco and asbestos legislation histories in the U.S. provide somewhat of a baseline about how to proceed with the mobile telecom health effects debate. Neither of these histories provide a complete guide, nor are they the only possible source of inspiration. But one history – the tobacco one – tells how government-driven warnings had to run a gauntlet of political and economic interests. Then, once those warnings became law and the advertisements became curtailed, the tobacco regulations fought the fact that smoking had become ingrained culturally. And that battle still continues today. Strangely enough, the warnings to protect consumers though seem also to have protected the tobacco companies, since the central focus of current class action suits are actually brought by *non-smokers* exposed to second-hand smoke [42]. In other words, since consumers were warned via the Surgeon General, the smokers had knowledge that they were undertaking an activity dangerous to themselves. **So the smokers have no grounds for legal action, since they were warned.** This was not the case though for people exposed to second-hand smoke. This debate transfers non-trivially to the mobile telecom realm because, while it might be

possible to influence user practices, what kind of danger is there to those in the vicinity of a mobile device? For instance, Frey raises this concern in one of the earlier cited articles [4]. Consequently, this would be another research question to answer with scientific inquiry.

The other history – the asbestos one – demonstrates what kind of litigation problems will lie ahead for companies that knowingly ignore health effects of their products. As we saw earlier, Apple and other mobile telecom companies have tried to avoid such topics for fear of market share loss. In fact, if they do not seek to answer the question then they cannot be held accountable, as asbestos companies have been thus far. If asbestos legislation and litigation is any indication, these companies could be at substantial risk if they learn of risks to their consumers and do not acknowledge them. Currently, the scientific answers are still vague and so the corporate visibility is relatively low. But as firmer answers are revealed, and if these answers indicate possible harm to users, then these companies could find themselves in bankruptcy like ten former asbestos companies have thus far [41].

One point from the asbestos debate that transfers quite well to that on mobile telecom is how to fund solutions. In the asbestos debate, the 2004 bill before Congress was meant to create a fund to which at-risk companies would contribute for claimant relief. This bill did not pass though. But the idea is worth noting and it is similar to a proposal mentioned in Congress in September 2009 with regards to mobile telecom health effects. Specifically, Dr. Devra Lee Davis suggested in her testimony the following [43]: "Let's put an extra research fee of $1.00 on every cell phone for three years and use these funds to support the conduct of a major independent research program to address the questions raised by this panel and by the National Academy of Sciences in its 2008 report on the subject." Using our earlier numbers from the telecom industry overview, this would mean approximately $282 million ($US 2011) available to fund critical research on possible health effects. In other words, the research would be well funded. Furthermore, this is a useful suggestion because we have seen from the experiences of Lai and Frey that special interests have routinely undermined sources of funding for research efforts [44]. However, if the funding pool is distributed across a wide-enough network then it is less likely that special interests (e.g., from industry) can stifle it.

Alternatively, the impetus to stimulate research could come directly from the U.S. Government, as it did in the tobacco debate. However, with such demonstrated common interests between the FCC, Congress and the mobile telecom industry, it is difficult to find a suitable check to balance the incentive of keeping mobile device use where it currently is. As stated before though, elected leaders in the U.S. Congress are mandated to protect public interest. So it is hoped that this concern trumps the other benefits originating from mobile telecom usage.

Whether it is through a government-backed study, as with tobacco, or a consumer-funded study, as proposed by Davis, there is still a need to find conclusive results about the health effects from mobile device radiation exposure. In spite of the mounds of evidence that have pointed towards malignant effects [44][2]-[4][8], and the counterarguments [43]-[45], the most recent suggestions

from leading scientists can be used as a guide for how to proceed next. Of the six scientists who testified before U.S. Congress in September 2009 in hearings on mobile telecom's health effects, five of them suggested courses for further research.[1] For instance, John Bucher, the Associate Director of the National Toxicology Program, outlined an ongoing project due to yield results in 2013-2014 [29]. This project investigates effects to animals from non-thermal radio frequencies. As with many projects though, it is susceptible to loss of funding before completion. Another testifying scientist, Darius Leszczynski, stated the need for programs that would be independent of familiar funding constraints like those seen by Lai and Frey [46]:

> We need a few well-designed studies, executed by consortia of scientists, not by single research groups. These studies should be aimed at proving or disproving whether human body responds to mobile phone radiation and whether the response is of a sufficient magnitude to alter normal human physiology. ... **[We] still do not have the answer to the fundamental question: whether human bodies (tissues, organs) react to mobile phone-emitted microwaves.**

As opposed to Bucher, who is speaking from the U.S., Leszczynski represents the Finland Radiation and Nuclear Safety Authority, which has already issued advisories to cell-phone users on how to reduce radiation exposure, especially to children. Leszczynski's suggestion is particularly useful because it distributes the access to results across a broad network of peers, rather than a "single research [group]," whose results can be subjected to funding constraints and other pressures. Consequently, a research consortium that transcends international boundaries might be a useful way to deflect incentives that can exist within one country (e.g., those that have existed in the United States). The other three scientists (Sadetzki from Israel, Davis and Naidenko from U.S.) reiterated the call for more research into the health effects from mobile telecom.

Of course, as with industry and political actors, we must consider scientists' incentives: funding. But, even though funding is the concern, as it is for industry (e.g., revenues) and political actors (e.g., campaign contributions, lobbying), their concern over financial matters is based on the fact that it allows the research to happen. Contrastingly, in industry, the incentive is to maximize revenues from products sold. But in research, in general, there is no need to maximize funding over time because the project ends once results have been achieved. Thus, while funding is the common factor behind scientific inquiry and industry/political incentives, the quest for it ends sooner in research science than it does in the

---

[1] The only one that did not suggest a future course for research (Erdreich) is a private consultant, who works for a company that receives funding from government and industry. While such a connection does not directly imply a conflict of interest, it is more likely to exist in her case than it is in the cases of the other scientists from either academia or government labs.

economic or political realm. This is because, once the results have been published, they are public knowledge and there is no need to keep purchasing their access. **In the long-term, these types of studies would conclusively end the debate as to whether mobile telecom radiation has any adverse effect on humans.**

For the near-term though, advisories on how to reduce exposure from mobile telecom appear to be sensible until firm results are in hand. For instance, the guidelines from the Finnish Radiation and Nuclear Safety Authority could be a guideline [46]. In the context of the noted social ubiquity of mobile telecom, such a suggestion is useful also because it would not curtail the overwhelming benefits to social interaction and information retrieval that have been made possible with these technologies.

CONCLUSIONS

In the course of this paper, we have attempted to address two questions: 1) Is electromagnetic radiation from mobile devices harmful to humans? 2) If there are ways to investigate this question then why have they not been done? To answer these questions, we have focused on two examples of scientific inquiry that were met with stiff resistance from both government and industry incentives. Using these examples, we launched a chronicling of the recent history of political, social and economic factors that have led to the current state of mobile telecom usage. This framework has focused on the United States, primarily, but we have given consideration to the issues as they transcend international boundaries. Furthermore, the framework used here can be of use in analyzing this issue in other regions of the world.

As a guide for the future, we have also analyzed the history of asbestos and tobacco legislation. With these histories as a template, we have discussed how their precedents could affect the mobile telecom health debate. Finally, we examined some current suggestions about how to proceed in this debate and we have noted how these paths fit with the histories recounted here. In summary, for the long-term, well-funded and distributed research must be done to answer questions in the health debate. In the short-term, advisories on how to limit radiation exposure should be promoted.

REFERENCES

[1] FREY, A., "Human auditory system response to modulated electromagnetic energy," Journal of Applied Physiology, vol. 17, no. 4, pp. 689–692, 1962.

[2] FREY, A., FELD, S., and FREY, B., "Neural function and behavior: Defining the relationship," Annals of the New York Academy of Sciences, vol. 247, pp. 433–439, 1975.

[3] OSCAR, K. L., and HAWKINS, T. D., "Microwave alteration of the blood-brain barrier system of rats," Brain Research, vol. 126, pp. 281–293, 1977.

[4] FREY, A., "Headaches from cellular telephones: Are they real and what are the implications?," Environmental Health Perspectives, vol. 106, no. 3, pp. 101–103, 1998.

[5] STENECK, N. H., *Risk/Benefit Analysis: The Microwave Case*. San Francisco Press, 1982.

[6] STENECK, N. H., *The Microwave Debate*. The MIT Press, 1984.

[7] KETCHAM, C., "Warning: Your cell phone may be hazardous to your health," Gentleman's Quarterly, February 2010.

[8] LAI, H., and SINGH, N. P., "Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells," Bioelectromagnetics, vol. 16, pp. 207–210, 1995.

[9] National Telecommunications and Information Administration, "United States frequency allocations: Radio spectrum", http://www.ntia.doc.gov/osmhome/allochrt.pdf (Accessed April 26, 2010).

[10] Federal Communications Commission, "Spectrum Holdings: Fulton County", http://reboot.fcc.gov (Accessed April 15, 2010).

[11] LEE, N., "Cell phone radiation levels", http://reviews.cnet.com/cell-phone-radiation-levels/ (Accessed April 4, 2010).

[12] JIANMING, J., *Electromagnetic Analysis and Design in Magnetic Resonance Imaging*. CRC Press, 1998.

[13] TICE, R. R., "Aging and DNA repair capability," *The Genetics of Aging*. E. L. Schneider (Ed.), Plenum Press, 1978.

[14] CERUTTI, P. A., "Peroxidant states and tumor promotion," Science, vol. 227, pp. 375–381, 1985.

[15] AMES, B. N., "Endogenous DNA damage as related to cancer and aging," Mutation Research, vol. 214, pp. 41–46, 1989.

[16] WALKER, P. R., SMITH, C., YOUDALE, T., LEBLANC, J., WHITFIELD, J. F., and SIKORSKA, M., "Topoisomerase II-reactive chemotherapeutic drugs induce apoptosis in thymocytes," Cancer Research, vol. 51, pp. 1078–1085, 1991.

[17] PRIGENT, P., BLANPIED, C., ATEN, J., and HIRSCH, F., "A safe and rapid method for analyzing apoptosic-induced fragmentation of DNA extracted from tissues of cultured cells," Journal of Immunological Methods, vol. 160, pp. 139–140, 1993.

[18] HART, R. W., and SETLOW, R. B., "Correlation between deoxyribonucleic acid excision repair and life span in a number of mammalian species," Proceedings of the National Academy of Sciences of the United States, vol. 71, pp. 2169–2173, 1974.

[19] HARRILL, R., "Wake-up call," The University of Washington Alumni Magazine: Columns, March 2005.

[20] United States Congress, "Communications Act of 1934: An act to provide for the regulation of interstate and foreign communication by wire or radio, and for other purposes," Public Law No. 416, 73rd Congress, 1934.

[21] United States Congress, "Telecommunications Act of 1996: An act to promote competition and reduce regulation in order to secure lower prices and higher quality services for American telecommunications consumers and encourage the rapid deployment of new telecommunications technologies," Public Law No. 104-104, 104th Congress, 1934.

[22] Federal Communications Commission, "The FCC report to Congress on spectrum auctions," WT Docket No. 97-150, 1997.

[23] PEREZ, M., "FCC seeks more wireless spectrum for mobile broadband data networks", http://www.intomobile.com/2010/02/24/fcc-seeks-more-wireless-spectrum-for-mobile-broadband-data-networks.html (Accessed April 26, 2010).

[24] Anon., "Telecommunications Industry Overview", http://www.plunkettresearch.com/Telecommunications/TelecommunicationsStatistics/tabid/96/Default.aspx (Accessed April 26, 2010).

[25] Anon., iPhone Developer Center, http://developer.apple.com/iphone/index.action (Accessed April 26, 2010).

[26] SHARP, R., "Wrong number: Apple hangs up on iPhone radiation app", News release of the Environmental Working Group, http://www.ewg.org/Apple_Hangs_Up_On_Radiation_App (Accessed April 5, 2010).

[27] BERNSTEIN, P., *Capital Ideas: The Improbable Origins of Modern Wall Street*. The Free Press, 1992.

[28] Anon., “A special report on telecoms in emerging markets: Mobile marvels”, http://www.economist.com/specialreports/displaystory.cfm?story_id=E1_TQQRPRJG (Accessed April 5, 2010).

[29] BUCHER, J., “Testimony from hearing on health effects of cell phone use”, U.S. Senate Committee on Appropriations, http://www.mapcruzin.com/news/cell-phone-health-effects-hearing.htm (Accessed April 5, 2010).

[30] HOGAN, B., “Facebook: The strength of weak ties”, Oxford University Institute, http://www.sciencelive.org/component/option,com_mediadb/task,view/idstr,OX-tag_2009_02_06_111330_189_internet_all_audio/Itemid,26 (Accessed April 26, 2010).

[31] SHAPIRO, C., and VARIAN, H. R., *Information Rules: A Strategic Guide to the Network Economy*. Harvard Business School Press, 1999.

[32] Anon., “Facebook most visited site in U.S., beats Google”, Techtree News Staff, http://www.techtree.com/India/News/Facebook_Most_Visited_Site_in_US_Beats_Google/551-109993-643.html (Accessed April 5, 2010).

[33] BYLUND, A., “To Google or not to Google”, The Motley Fool, http://www.fool.com/investing/dividends-income/2006/07/05/to-google-or-not-to-google.aspx (Accessed April 5, 2010).

[34] CARR, N., “Is Google making us stupid?”, The Atlantic, http://www.theatlantic.com/magazine/archive/2008/07/is-google-making-us-stupid/6868/ (Accessed April 5, 2010).

[35] WOLF, M., *Proust and the Squid: The Story and Science of the Reading Brain*. Harper Collins, 2007.

[36] MCGREW, J. L., “Marihuana: A signal of misunderstanding”, A Report by the National Commission on Marihuana and Drug Abuse, http://www.druglibrary.org/schaffer/library/studies/nc/nc2b_1.htm (Accessed April 26, 2010).

[37] DIEHL, H., *Tobacco and Your Health*. McGraw Hill, 1969.

[38] DREW, E. B., “The quiet victory of the cigarette lobby: How it found the best filter yet -- Congress”, The Atlantic, http://www.theatlantic.com/past/docs/unbound/flashbks/smoking/drewf.htm (Accessed April 25, 2010).

[39] Anon., “Cigarette Advertising and the Public Health,” Columbia Journal of Law: Social Problems, vol. 6, no. 1, pp. 110–114, 1970.

[40] WAGNER, S., *Cigarette Country*. Praeger Publishers, 1971.

[41] Anon., “Federal asbestos legislation: The winners are...,” Public Citizen, http://www.citizen.org/documents/master%20report.pdf (Accessed April 25, 2010), 2005.

[42] Anon., Action on Smoking and Health, http://www.ash.org (Accessed April 25, 2010).

[43] DAVIS, D. L., “Testimony from hearing on health effects of cell phone use”, U.S. Senate Committee on Appropriations, http://www.mapcruzin.com/news/cell-phone-health-effects-hearing.htm (Accessed April 5, 2010).

[44] DAVIS, D. L., *The Secret History of the War on Cancer*. The Basic Books, 2007.

[45] ERDREICH, L., “Testimony from hearing on health effects of cell phone use”, U.S. Senate Committee on Appropriations, http://www.mapcruzin.com/news/cell-phone-health-effects-hearing.htm (Accessed April 5, 2010).

[46] LESZCZYNSKI, D., “Testimony from hearing on health effects of cell phone use”, U.S. Senate Committee on Appropriations, http://www.mapcruzin.com/news/cell-phone-health-effects-hearing.htm (Accessed April 5, 2010).