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Cellular Phone Radiation and Potential Risks to the Human Brain: A Review of the Scientific Literature

Introduction

The notion that cellular phone radiation emissions might result with adverse health effects is the 21st century's first great environmental challenge. By most admissions from experts and advocates on both sides of the issue, the introduction of broad-scale public exposure to radiofrequency and

microwave radiation by the use of cellular phone technology represents uncharted territory.

According to the wireless industry's trade association, Cellular Telecommunications & Internet Association, at the time of this writing, 137,458,902 Americans were cellular phone subscribers. This number has

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Cellular Phone Radiation & Human Brain

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skyrocketed since the advent of low-priced phones and service plans became widely available to the general public in the mid-1990s. Some estimates report that there are 1 million new subscribers every month. (See Figure 1.)

Worldwide, it is estimated that over 400 million people now use cellular phones, and by 2005 that number will rise to 1.3 billion. At the same time, this technology is now giving rise to important questions about possible long-term health consequences of cellular phone use. Because of the immense numbers of present and future users, some scientists and public health experts are worried that even if only a small percentage are adversely affected, that could still equate to a public health issue of epidemic proportions.

This article surveys the scientific literature relating to the possible adverse effects of exposure to cellular phone radiation to the human brain. There is, additionally, a sufficient body of evidence that also suggests an association between

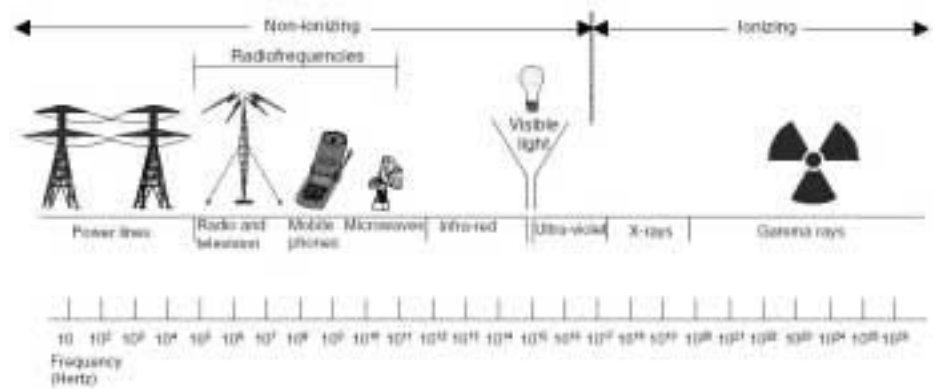


Figure 2 Electromagnetic Spectrum

From "Report to Congressional Requesters: Telecommunications - Research and Regulatory Efforts on Mobile Phone Health Issues" (Report GAO-01-545), US Government Accounting Office, May 2001.

these emissions and:

- general malaise
- immune system dysfunction
- sexual and reproductive issues
- changes in the central nervous system and cardiovascular system
- elevations in blood pressure
- skin damage
- changes in red blood cells, possibly leading to kidney stones or heart disease

Cellular Phone Radiation *Electromagnetic Fields*

Electromagnetic fields (EMFs) are waves of electric and magnetic energies that travel together, at the speed of light, and they permeate the world around us. Electromagnetic fields represent one of the most common and fastest growing environmental influences, and exposure in all populations of the world will continue to increase with the advancing availability of technology.

The electromagnetic (EM) spectrum groups radiation into two types (see Figure 2):

- "Ionizing" - having energy levels sufficiently high enough to strip electrons from atoms and molecules (resulting in "ionization"). It is well established that exposure to ionizing radiation can cause serious biological damage, including the production of cancers.
- "Non-ionizing" - of an insufficient energy to cause ionization. Within the "non-ionizing" portion of the EM spectrum, radiofrequency (RF) radiation includes bands used by radio and television, cellular

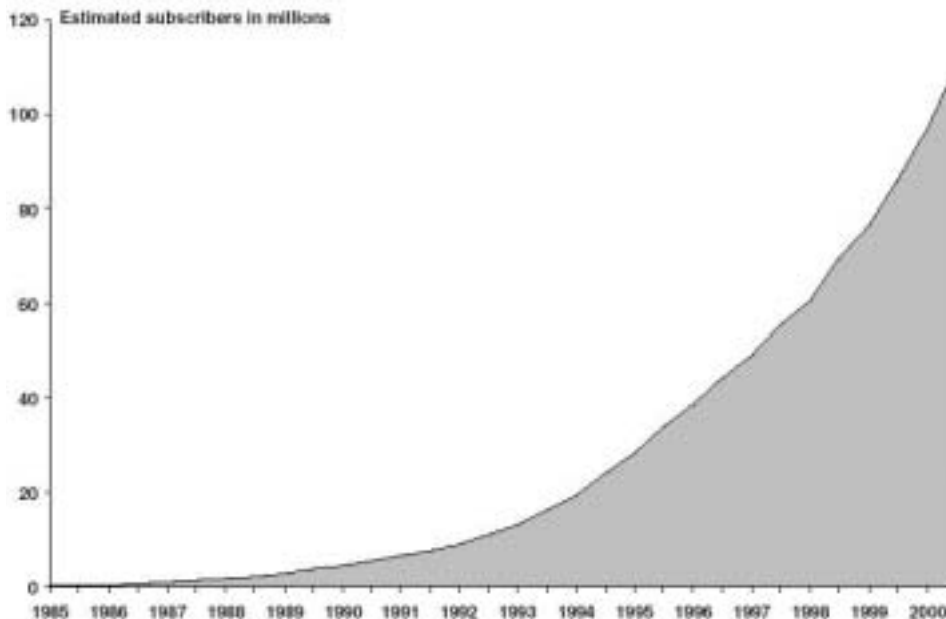


Figure 1 Growth in Cellular Phone Subscribership

From "Report to Congressional Requesters: Telecommunications - Research and Regulatory Efforts on Mobile Phone Health Issues" (Report GAO-01-545), US Government Accounting Office, May 2001.

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AAMN Editorial Note: This article is an excerpt from the new book, Cellular Phones: Medical Menaces of a Modern-Day Convenience, by Dr. Robert Goldman and Dr. Ronald Klatz, the physician founders of the A4M. Their keen interest in emerging risk factors that compromise either the quantity or quality of the human lifespan has prompted them to spearhead an educational initiative on the subject of the potential biological hazards of cellular phone radiation. Visit The World Health Network, www.worldhealth.net, for availability details on the release of this must-read book.

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phones, and microwaves. RF, particularly at the high end of the cellular phone band and in the microwave band, can rapidly heat biological tissue. This heating (“thermal effect”) can cause harm by increasing body temperature, disrupting behavior, and damaging biological tissue. Early in the short history of cellular phones, scientists suspected that the radiation caused damage by heating, but subsequently “non-thermal” effects have become of greater concern (see *Mechanisms of Damage* below).

RF Fields

Radio frequency (RF) fields are used in many facets of everyday life, such as radio and television transmission, mobile telecommunications - namely pagers and cellular telephones, some medical diagnostic and treatment equipment, and in industry for heating and sealing materials. The biological effects of RF are not well understood because the prominence of this form of radiation is a relatively new addition to our everyday EMF landscape.



“Cellular telephones are the most radiative appliance we have ever invented apart from the microwave oven and people are putting them by their heads - arguably the most sensitive part of the body,” stated bio-

electromagnetics scientist Roger Coghill, who continued that “cellular phones emanate microwave radiation, and human brains may absorb up to 60 percent of that energy.” Indeed, the cellular phone is, essentially, a low-powered radiotransceiver (combination transmitter and receiver). With the widespread public adoption of cellular phones, there has been a particular focus of attention on potential problems associated with “near field RF exposure” - namely, exposure to the head from the phone.

Types of Cellular Phones & Radiation Emissions

There are three types of cellular phones, categorized based on the radiofrequency at which they transmit and receive. From a health perspective, the signals from each of these technology types are more similar than different in terms of potential biological impact:

- Analog cellular phones: operate at frequencies between 824 MHz and 894 MHz. As energy hogs, analog phones beam eight times as much energy into the user’s head as digital phones do.
- Digital cellular phones: operate at frequencies between 800 and 900 MHz.
- Digital PCS (personal communication system) phones: in the US, PCS operates in the range of 1850 MHz to 1990 MHz.

NOTE: Global System Mobile (GSM) is the digital standard that operates worldwide outside of the United States. It operates at 900 and 1800 MHz in Europe and Asia, and at 1900 MHz in the US.

The amount of radiation emitted by cellular phones depends on a number of factors:

- The Specific Absorption Rate (SAR) of the unit. The SAR is the amount of RF energy absorbed from the phone into the local tissues. SAR varies by cellular phone manufacturer and model, but in the US, all FCC-compliant

phones must have a maximum SAR less than 1.6 watts per kilogram (W/kg). Information on SAR for a specific phone model can be obtained for many recently manufactured phones by visiting the Internet address, www.fcc.gov/oet/fccid, and keying in the FCC identification number

“There is currently insufficient scientific basis for concluding that wireless communication technologies are *safe* or that they pose a *risk* to millions of users.”

~ US Federal Drug Administration,
February 8, 2000

- for that unit.
- Number of “cells” in a geographical area, which depends upon the cellular phone traffic in that area. Large cities may have many cells per square mile, whereas a less-populated, rural area may have a single cell stretching over several square miles. The farther away a cell phone antenna is from its base station, the higher the power level needed to maintain the connection. Very small cells are therefore associated with much lower exposures.
- Each geographical cell has a different number of available channels. Cellular phones operate ideally with the least amount of interference from neighboring channels. To help achieve optimal operation, cellular phones automatically step down to the lowest power level available that still maintains a connection with the base station. On the other hand, any physical obstacle, such as buildings or trees, interfering with

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the connection between base station and cell phone forces the base station to increase the power sent to that phone. Therefore the amount of power sent from a base station to a particular cellular phone can vary, even within a single call.

Note that for all types of cellular phones, the emissions are highest when the device is attempting to establish a connection (initialization), followed by when it is attempting to receive or transmit signals. "Stand-by" mode is generally associated with lower radiation emission.

Your Brain on Cellular Phones

Various research indicates that between 20% to 60% of the energy emitted from a mobile phone is absorbed by the user's head. The percentage absorbed depends on the design of the phone, type of aerial or antenna (the stubby ones which you can not extend are worse because they concentrate energy into the user's

brain), and how far it is to the nearest base-station (the weaker the base station signal, the more the phone will power up to maintain contact with the network).

Figure 3 is an image of a computer model of a human head in cross-section showing the distribution of the energy absorbed from a cellular telephone handset radiating 600 mW at 835 MHz. Most of the energy is absorbed within the first 1 to 2 cm (0.4 to 0.5 in.) beneath the surface of the skull.

Mechanisms of Damage

Cellular phone use can heat up brain structures. An Australian government discussion paper issued in March 1997 warned that "There is evidence that localized hot spots of energy deposition in the brain may occur as a consequence of internal reflections" that perpetuate the radiation after it enters the head. This "thermal" biological effect is characterized by irreversible damage to the most basic components in cells of living organisms: raising the temperature of cells by as little as a fraction of one

degree Fahrenheit can be "genotoxic" - that is, cause damage to cellular genetic material. In the earlier years of cellular phone health hazards research, it was suspected that RF radiation caused DNA breakage. DNA breakage can cause problems with replication of the molecule, thus impairing cell division and causing problems to tissue and organs. More alarmingly, the DNA damage may show up as

"For the first time in history, we are holding a high-powered transmitter against the head. when you talk on your mobile phone, (you use radiation in) a range that's right in the middle of microwave territory."

~ Dr. Ross Adey, one of the world's most respected and senior research scientists, interview with *PC Computing*, Nov. 30, 1999

mutations that can be replicated and passed on to other cells, a mechanism that is suspected to contribute to cancer. Noted EMF expert Dr. Henry Lai of the University of Washington (USA) has published several papers (1995, 1996, 1997a, 1997b) in which he observed that DNA damage occurred in the brain cells of live rats after only two hours of relatively low-level microwave exposure. The lowest intensity at which Dr. Lai identified DNA strand breaks was well within the range of the electromagnetic range of cellular phones, and most closely matched to that of the popular PCS-type phones.

Recently, however, scientists have revised their suspicions relating to how cellular phone radiation causes genetic damage. A series of studies found that human blood cells could be damaged by the formation and accumulation of micronuclei - smaller versions of the cell nucleus that compete with the main nucleus, thereby altering proper cell function and division. Cells exposed to cellular phone radiation became unable to repair their broken DNA, thus producing micronuclei. In a compilation of research (1998) edited by public health expert Dr. Carlo, separate teams led by Drs. Donner, Tice, and Lai all have reported that

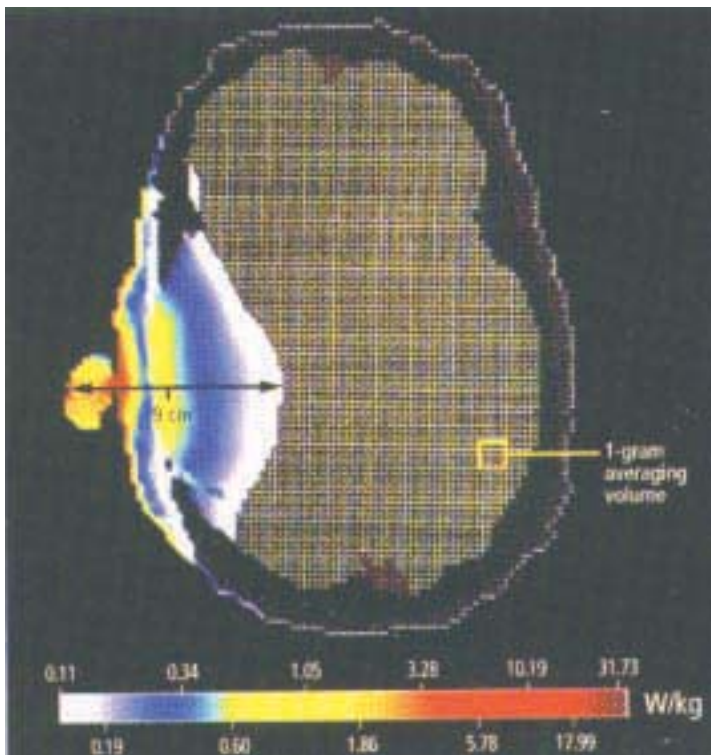


Figure 3 Radiation Absorption from a Cellular Phone into the Human Head

From Foster K and Moulder J, "Are mobile phones safe?," *IEEE Spectrum*, August 2000.

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genetic damage to human blood cells, manifesting as micronucleus formation, could “unequivocally” result from “all cellular phone technologies.”

Based on more recent studies, scientists presently suspect that the temperature rises in cells induced by RF radiation typical of cellular phones can cause other types of thermal stress. Dr. Mason and colleagues reported (1997) that two areas of the brain - the hypothalamus (responsible for maintaining balance of the nervous and endocrine systems) and caudate nucleus (responsible for coordinating movement) - were particularly sensitive to thermal stress. In this study, the researchers observed that rises in the temperature of cells in the brain, resulting from cellular phone emissions, caused distinct alterations in levels of amino acids - building blocks of neurotransmitters, the chemicals involved in communications between brain cells and the brain and the nervous system.

It is important to be aware that the main biological effect of cellular phone radiation may not be in heating-related damage. Indeed, these “non-thermal” biological effects are mechanisms that may account for the role of RF radiation in diseases including cancer, respiratory ailments, and infertility. On this possibility, Dr. John Stather, the Assistant Director of the United Kingdom’s National Radiation Protection Board (NRPB) remarked: “Until recently we believed any harmful effects from microwaves were due to their heating effects, which would be negligible at the low powers

used by mobile phones. Now there might be another effect at work and we are much less certain.”

An important type of non-thermal effect of cellular-phone type radiation involves the blood-brain barrier (BBB). Research from Lund University (Sweden) (1999) tracked the migration of albumin across the BBB in rats that were exposed to cellular phone radiation. Albumin is a protein that is naturally present in the blood but not in the brain; previous studies have shown that brain nerve cells that are exposed to albumin die. The



researchers found that albumin leaked through the rats’ BBB after cell phone radiation exposure. Even when the microwaves were not strong enough to heat up the rats’ heads, the scientists detected the effect deep in the center of their brains. The researchers remarked that the length of time using a cellular phone was irrelevant, the BBB was opened at once upon exposure. Moreover, the albumin remained in the rat brains for several days. As a result of these findings, the team warned that their study indicates that molecules of equal or smaller size to albumin could also get into the brain. According to the researchers, this increased permeability could:

- allow certain proteins found in the blood to cross into the brain,

causing autoimmune diseases such as multiple sclerosis

- result in damaged nerve cells that may be implicated in dementia, premature aging, and Parkinson’s disease
- result in inflamed brain cells that may be indirectly be linked to Alzheimer’s disease
- allow the brain to become exposed to medications not normally allowed past the BBB and thus possibly cause unexpected damage

Because the BBB of humans and rats are similar in function, medical experts

urged for attention to this study. Professor Leif Salford, the lead researcher and a neurologist, remarked that: “We saw opening of the blood-brain barrier even after a short exposure to radiation at the same level as mobile phones. We’re seeing extremely small amounts of protein and we don’t know how dangerous it is.”

Subsequent research at the University of Munster (Germany) (2000) found that radiation at the high-end of the range for cellular phones significantly increased the permeability of the BBB to sucrose, a sugar molecule that, like certain proteins, is safe in the blood but not in the brain. Additionally a report (1999) from Canada’s Radiation Protection Bureau cautioned that RF radiation can “increase the permeability of the blood-brain-barrier and modulate the action of some psychoactive drugs.”

Studies on the non-thermal effects of cellular phone radiation also have focused on heat shock proteins (HSPs). While there are a wide range of heat shock proteins that our brains can make, they all perform a similar

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function - to bind to unfolded proteins, which are not useful to cells, and refold them. On a normal basis, the brain releases HSPs as a defensive mechanism in response to heat stress and chemical toxins, triggers that can cause proteins to unfold. The HSP response can be activated by a brief non-thermal radiation at RF and microwave frequencies, and can take a number of hours to disappear out of the system. This is disconcerting for heavy users of cellular phones for two reasons. First, some scientists suspect that heat shock proteins may be chronically present, and, over a number of years, may increase the risk of cancer. Secondly, some scientists believe that in heavy cellular phone users, repeated activation of the heat shock protein response causes the mechanism to shut down, making it unavailable when most needed. As a result, the normally protective HSP

response can become a health problem, as indicated by the following studies:

- Microwaves at non-thermal power

“Gradually, cells don’t work properly, so the life process becomes less efficient.”

~ Dr. De Pomerai, Nottingham University School of Biological Sciences (United Kingdom), 1999, commenting on continual cellular phone use

levels have been shown to elicit the heat shock protein response in organisms. (Daniells 1998, De Pomerai 1999)

- Fertility of organisms is altered by the HSP response (De Pomerai 1999, 2002)
- Microwave radiation can cause physiological changes in brains and brain cells
- In a review of research on heat shock

proteins and their role in cancer, Dr. Jolly (2000) found evidence that repeated activation of HSPs could cause cells to become cancerous.

- Reporting on findings (2002) of a two-year long study, Dr. Dariusz Leszczynski at Finland’s Radiation and Nuclear Safety Authority found that an hour of cellular phone exposure shrinks human BBB cells in culture, causing gaps between the cells through which toxins could enter the brain. Additionally, the activity of one HSP in particular - HSP27 - was markedly increased. Because HSP27 is associated with the proper functioning of the BBB, these findings are suggestive that RF radiation could promote permeability of the BBB through overactivity of a HSP.

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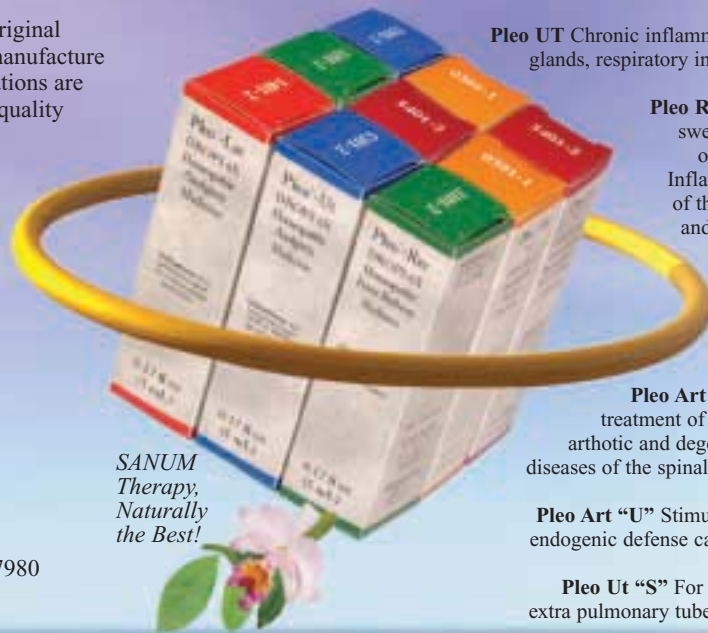
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Cancer

There has been a fair amount of respectable research documenting at least a weak association between prolonged and/or intense exposures to various types of electromagnetic fields and the onset of brain cancer, leukemia, and lymphoma. Overall, the data available to-date on RF radiation and cancer are too inconsistent to establish a direct and indisputable cause-and-effect relationship. However, taken as a whole, the body of evidence of association between cellular phone radiation and cancer is substantial enough to raise concern.

The first laboratory study to associate cellular phone radiation with an increased rate of cancer was published by a team of scientists from Royal Adelaide Hospital. Dr. Repacholi and colleagues (1997) conducted an 18-month long study using 200 lymphoma-prone mice as highly sensitive detectors of possible cancer promotion over their lifespan. Half of the animals were exposed and half not, to pulsed digital phone radiation (GSM-type) at a power density roughly equal to a cellular phone transmitting for two 30-minute periods each day. Dr. Repacholi found that cancer rates doubled in the exposed group - lymphomas were the major type of tumor that occurred with increased incidence. Extrapolating from the United Kingdom's National Radiation Protection Board figures, most GSM digital cellular phones put out between 10 to 30 times more radiation into the user's head than to which the mice in Dr. Repacholi's study were exposed. Many scientists agree that if there are cancer connections with the use of cellular phones, they are most likely to be expressed in adult leukemias, which typically take between 10 and 30 years to appear and be diagnosed. As a result, it is unlikely that the cancer trend will begin to appear for another three to five years, at the earliest. Extended period chronic exposure to radiation of the

type emitted by cellular phones may be already wreaking havoc on the human organism.

Data on the effects of analog (Nordic Mobile Telephone [NMT]-type) cellular phones is expected to yield the first broad-based findings on possible cancer trends in humans. This is because the NMT technology was adopted in the early 1980s, giving it a ten-year head start over the now-preferred digital (GSM-type) system. In one of the first case-controlled studies of humans and cellular phones, studying residents of Sweden - one of the first countries to engage in widespread cellular phone use -



Swedish cancer specialist Dr. Lennart Hardell and colleagues at the Orebro University Hospital found (1999) an increased risk of the occurrence of tumor in the temporal (side) or occipital (back) area of the brain, on the same side as the cellular phone had been used. Regardless which side of the head it was held against, the risk of a brain tumor increased by almost 2 1/2 times in analog phone users. In a follow-up case-control study with exposure assessed by questionnaires, Dr. Hardell (2000) again and separately determined that "use of a cellular telephone was associated with an increased risk in the anatomic area with highest exposure." On his findings, Dr. Hardell has commented that "there

is a biological indication that there is a problem ... I think that until we have the definite conclusion, the definitive results of much larger studies, we need to minimize exposure to human beings."

A study (1999) conducted by Dr. Joshua Muscat and colleagues at the American Health Foundation (New York USA), is suggestive of potential risk. The team collected data on newly diagnosed cases of brain cancer from five hospitals across the United States, and analyzed the duration and frequency of cellular phone usage in these patients. The majority of the brain cancers in the study were found to be outside of the 2- to 3- inch exposure pattern that is accepted as the depth of RF radiation penetration from a cellular phone (see Fig. 3). However, by cross-correlating the cellular phone usage interviews, the researchers identified a statistically significant increase in risk of neurocytoma - a type of brain tumor that grows from the outside edges of the brain inward - with cellular phone use. Additionally, those patients who reported using their phone on the right side of the head had a significant increase in tumors on that side of the head.

In a study conducted by Dr. Dreyer and colleagues (1999), the rate of brain cancer mortality in hand-held cellular-phone users, as compared with car phone users (antenna is physically detached and located outside the rear of the car), was nearly three times greater.

A 20-year study of servicemen in Poland (2000) has established the strongest link yet between mobile phones and cancer. It correlated a high cancer death rate among soldiers exposed to microwave radiation - the same as that emitted by cellular phones. This research is widely acknowledged as the world's first significant study to demonstrate a link between humans, microwave radiation and cancer. In the study, conducted at the Military Institute of Hygiene and Epidemiology in Warsaw and led by

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Dr. Stanislaw Szmigielski, the researchers reviewed the medical records of hundreds of thousands of servicemen, 3% of whom were exposed to the radiation, including at frequencies and modes similar to cellular phone emissions, between 1970 and 1990. It then compared their medical histories and death rates to a group of soldiers who were not. Researchers found those exposed - largely through using military equipment - were more likely to get some cancers. They were also more likely to develop a whole range of cancers 10 years earlier than those who had not been. There were higher death rates from cancers of the skin, brain, blood, digestive system, blood and lymphatic system among the exposed group.

Dr. W. Ross Adey from University of California (USA) (2000) reported that a pregnant rat's exposure to phone-like radiation at any of three power levels alters the activity of an enzyme - ornithine decarboxylase, associated with cancer onset - in the fetuses' brains. Dr. Adey suggests that the increased enzyme activity may explain tumors observed in rats exposed to RF energy for extended periods of time.

A large-scale study in Denmark (2001) linked data on all of the 420,095 cellular phone users in that country between 1982 and 1995 to the Danish Cancer Registry. Study investigators, led by Dr. Johansen, did not find an increased risk of developing brain tumors overall. They also did not find that brain tumors occurred with greater frequency on the side of the head for which cellular phone users reported using the device. Additionally, Dr. Johansen and team did not find any significant association with other cancers, including salivary gland, eye, leukemia, and 22 other cancer types. However, this registry-based approach to brain tumor analysis came under scrutiny when Dr. Auvinen and colleagues from the Finnish Cancer Registry reported (2002) that this technique has "limited value in risk assessment of cellular phone use owing to lack of information on exposure."

In an epidemiological study by Dr. Inskip and colleagues (2001), the researchers compared 782 brain cancer patients diagnosed in Phoenix (Arizona USA), Boston (Massachusetts USA), and Pittsburgh (Pennsylvania USA) between 1994 and 1998,

and compared them with age- and sex-matched controls. Dr. Inskip found no evidence of increased risk for people using cellular phones on any regular basis, and tumors did not occur at a greater rate on the side on which the phone was used. It is important to note that the method by which the researchers defined cellular phone use

“When you have 200 million people who are being exposed to cell phones, you can’t wait around for the slow scientific process to work”

~ Dr. George Carlo, public health expert and head of the cellular phone industry's Wireless Technology Research program, interview with Wired Magazine, June 21, 1999

may have been somewhat flawed: the make and model of the phone was not collected, as the researchers believed that other variables that were more significant were not able to be collected, namely the distance of the users from the nearest base station at each time a call was made.

Dr. Stang and colleagues from the University of Essen (Germany) (2001) found that mobile phone use may be associated with cancer of the eye. The researchers conducted a hospital-based analysis of the relationship between uveal melanoma (a type of eye cancer) and occupational exposures to different sources of electromagnetic radiation. They interviewed a total of 118 men and women with uveal melanoma and 475 healthy counterparts. Dr. Stang found a significantly elevated risk for those people whose jobs involved heavy or extended use of radiofrequency/microwave transmitting devices such as radio sets and cellular phones. The team was able to rule out other sources of electromagnetic radiation (high-voltage lines, electrical machines, complex electrical environments, computer monitors, and radar units) as contributing to eye cancer.

Dr. Muscat and the American Health Foundation published (2002) a report that found no correlation between acoustic

neuromas (tumors of the inner ear) and cellular phone use. However, a number of shortcomings with this study have been identified. First, the study only included infrequent cellular phone users, as opposed to individuals who use cellular phones more often and/or every day. Secondly, the study group consisted only of 90 cases, which, according to Dr. Carlo, is too small a group from which to extrapolate to make a public health statement.

Continuing on his works published in 1999 and 2000, Dr. Hardell and colleagues again found (2002) a higher incidence of brain tumors on the sides of heads most frequently involved in hand-held cellular phone use. The most frequently found tumor type of with this lateral association was acoustic neuroma.

Analog NMT cellular phones were found to place users at a noticeably increased risk of developing brain tumors than those who did not use the phones, according to a startling large-scale study (2002) conducted by Dr. Kjell Hanson Mild of the Swedish Institute for Working Life and Dr. Hardell of Orebro University Hospital (Sweden). The researchers studied data on 1,617 Swedish patients diagnosed with brain tumors between 1997 and 2000 and age- and sex-matched controls. Those brain cancer patients who used NMT cellular phones had a 30% higher risk of developing brain tumors. For people using the phones for more than 10 years, the risk shot up dramatically to 80%. As for the location of the tumors, the risk was 2.5 times higher for the same side as the phone was used, and specifically a 3.5 times greater risk was found for auditory nerve tumors to occur.

Cognitive Functions

In addition to a potential for cancers in the brain, non life-threatening brain changes - namely cognitive alterations - can also result from cellular phone emissions. It is important to be aware that changes in memory, learning, reaction time, etc. may persist well after the exposure itself. In a series of experiments with 24 volunteers exposed to RF radiation typical of cellular phones, Dr. Lebedeva and colleagues from the Russian Academy of Sciences (2000) found it caused direct stimulation of the cerebral cortex - the region

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of the brain responsible for consciousness and the complex thinking processes in humans - which continued even after exposure was stopped.

Memory

A number of studies implicate cellular phone radiation in causing adverse memory changes. Dr. Rick Hold and colleagues from the Defense Establishment Research Agency (United Kingdom) (1998) discovered that cellular phone signals disrupt the part of the brain that controls memory and learning. The researchers found that the "signals made no difference in their measurements for a short time, but then readings plunged off the graph ... the effect would have caused sudden memory loss and confusion."

In research conducted by Dr. Lai (2000), he found that microwaves similar to those emitted by cellular phones impaired long-term memory. Dr. Lai subjected 100 rats to a swimming maze in which they all learned to find hidden safety platforms in a pool of cloudy water. Afterwards, he exposed some of



the rats to short bursts of low-level microwaves. When they were challenged to navigate the maze again, the exposed rats forgot the location of the safety platforms, while the unexposed rats retained their spatial

memories. Dr. Lai remarked on his findings that "the long-term memory of virtually all the exposed rats appeared to have been affected. Short-term memory loss is just

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being unable to remember something which you have just done or glanced at. Long-term memory is something which has been learned or recalled and stored in the brain. The data from this latest study is certainly a cause for concern.”

Dr. Kraus and colleagues from the University of Turku (Finland) (2000) found that high-frequency cellular phone radiation significantly modified several aspects of brain responses during a memory task.

Learning

Nitric oxide is a gas that mediates cell-to-cell communication in the brain. Nitric oxide is produced by an enzyme, nitric oxide synthase (NOS). Increased levels of NOS are released by the hippocampus and cerebellum areas of the brain to promote the learning process. A study by Dr. Ding and team found (1998) that the number of NOS neurons, as well as the extent of their activity, was decreased as soon

“Anyone who uses a (cellular) phone extensively runs a risk of adverse health effects. We estimate that 10 percent of the population may be at risk of milder effects such as headaches and loss of concentration.”

~ United Kingdom consumer advocacy group Powerwatch, interview with *The Express* (London), April 4, 2000

as 1 1/2 hours after exposure to RF radiation. As a result, Dr. Ding observed that the rats’ ability to learn was obstructed.

Reaction Time

In a British government-funded study, Dr. Alan Preece of Bristol University (United Kingdom) (1999) tested the memory and reaction times to visual stimuli. Thirty-six university volunteers were exposed to 20 to 30 minutes of mobile phone type radiation, then asked to make decisions that relied on the visual cortex - the part of the brain involved in processing visual cues. RF emissions from both digital and analog signals correlated with a reduction in the time it took users to answer simple questions. The improvement was small, just 15 milliseconds. A separate study, conducted in Finland, also recorded a similar drop in reaction time among people during RF exposures. Dr. Preece proposes that the quickened reaction times demonstrate that cellular phone emissions are biologically active, suggesting that the RF radiation stimulates production of

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Cellular Phone Radiation & Human Brain

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Sleep

Fairly low levels of electromagnetic radiation have been shown to alter the human body's sleep rhythms. Dr. Mann (1996) showed that in asleep volunteers, cellular phone radiation exposure can shorten the stage of REM sleep. When Dr. Borbely and colleagues (1999) exposed healthy young men and women to alternating 15-minute on/off intervals of digital-frequency cellular radiation during an overnight sleep, they experienced an increase in non-REM sleep and a reduction in the amount of waking time after sleep. Taken together these studies indicate that cellular phone radiation modifies the brain patterns associated with sleep. Such alterations may impact learning, given that the loss of REM sleep and increase in non-REM sleep may reduce attention and increase fatigue.

A world-renowned sleep laboratory at the University of Zurich reported (2000) that using cellular phones just before going to sleep can disturb the normal sleeping

EEG patterns. The researchers found that exposing volunteers to digital GSM-type cellular phone radiation for 30 minutes while awake significantly alters their EEG activity after they fall asleep, compared to

FACT

In the United States, the Federal Communications Commission (FCC) has issued safety guidelines for RF environmental exposure since 1985. The FCC, however, maintains that its guidelines are not safety regulations, because FCC is not a health and safety agency.

unexposed controls. In an accompanying editorial, Dr. Michael Petrides notes that "the currently available literature suggests that some aspects of cognitive function and some direct measures of brain physiology may be affected by exposure to electromagnetic fields of the type emitted by cellular telephones."

Cellular phone radiation may depress levels circulating levels of the hormone melatonin. In the case of people living near cellular phone masts, the effects on sleep can be dramatic. The University of Berne studied (1995) residents near the Schwarzenburg (Switzerland) short-wave radio transmitter. The transmitter operated in continuous mode at a frequency and modulation that approximated today's cellular phone transmitting masts. The researchers found that even the most modest doses of radiation exposure caused changes in sleep quality - which then adversely affected learning abilities. These effects were reversed when the mast was not operating for several days. Additionally, cattle living near the radio transmitter were found to have significantly elevated levels of melatonin when the mast was not operational. Since there was no reason to suppose that human nocturnal melatonin levels were not similarly reduced when the transmitter was operating, and that scientists know that peaks in nocturnal

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Cellular Phone Radiation & Human Brain

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melatonin levels correlate to quality sleep quality, the researchers suggested that human sleep was degraded by the radio transmitter. Because melatonin is considered to be an important cancer-fighting hormone, the reduced nocturnal melatonin levels also led the researchers to become concerned that the residents of Schwarzenburg could have been at increased risk of cancers. In 1997, transmissions at the Schwarzenburg were ceased, and the tower was closed the following year.

Dr. Burch and team reported (1997) that people who used cellular phones as little as once a day had lower levels of melatonin than people who did not use a cellular phone or used it less than once a week. Those with occupational exposure to cellular phone radiation were also found to have reduced levels of melatonin production during the daytime.

Concluding Remarks

Millions of cellular phone users worldwide are now also exposed daily to radiofrequency and microwave radiation under prolonged and physically close conditions. It is necessary for each of us who uses a cellular phone to become responsible users. We encourage you to become familiar with the body of scientific study on the biological effects of cellular phone radiation, a segment of which has been reviewed in this article. As new data become available, our understanding of the role of these emissions in human health will improve. However, the explosion of utilization of this technology in society creates a unique necessity for ongoing monitoring and interpretation of the scientific data. The sheer numbers of current and future cellular phone users creates great cause for worry. Even if only a small percentage of cellular phone users are adversely affected, that could still equate to a public health issue of epidemic proportions. Adjusting for latency of disease states to the initial triggering exposure, it may be 2020 before a full-scale

epidemic hits. Or it might not happen at all.

It thus becomes incumbent upon each cellular phone user to evaluate the extent of his/her exposure to cellular phone radiation and determine whether it places them at increased health risks. If so, adopting techniques to minimize our exposures to cellular phone radiation may be prudent. We have outlined ten simple ways and present them as a Tips Sheet (see pages 36-37).

Finally, we urge that our *Anti-Aging Medical News* readers - many of whom are physicians, health practitioners, and scientists, to whom the public entrusts their health and well-being - share this article with your loved ones, colleagues, and patients/clients. It is our position that consumers should be given the opportunity to know what potential health consequences they may experience as a result of using cellular phones, and by all rights should have the opportunity to make informed judgements as to whether they wish to continue such risk-related use. In the words of public health expert Dr. George Carlo, "We're now in a gray area that we've never been in before with this. When we're in a gray area, the best thing to do is let the public know about the findings so that they can make their own judgment."

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Top Ten Tips for Minimizing Cellular Phone Radiation



Produced as a Public Service by The American Academy of Anti-Aging related disease and to promote research into methods to retard aging portal and official website of the A4M. Read the latest life-en-cellular phone radiation.



#1. Call Length and Frequency

A number of the scientific studies have shown a correlation between the length of calls and/or frequency of use, with biological changes.



TIP Reserve cellular phone use for short, necessary conversations. Public health expert Dr. Carlo has recommended (2000) that incoming mobile phone calls be kept as brief as possible and returned on a corded phone.

#2. Distance

The concentration of radiation emissions is directly related to the power of the emitting device. The farther you can put yourself from the cellular phone handset, the less emissions you will receive. Radiation from all sources obeys the inverse square law. That is, the further you are from the source the less intense your exposure to the radiation. In fact, it drops off with the square of your distance from the source.



TIP Many cellular phones now have a “speakerphone” option, permitting a substantial distancing between the user and the handset during conversations.

#3. Phone Antenna

The type of antenna that on your cellular phone may contribute to the amount of radiation it emits. Stubby antennae cannot be extended, and have been shown to be worse because they concentrate energy into the user’s brain.



TIP Select a phone with an extendable antenna.

#4. Signal Path

The steel construction of vehicles and buildings creates an electrical shielding effect (“Faraday cage”). As a result, using a cellular phone inside an enclosed vehicle or building causes the phone to increase the power output it needs to establish a connection, receive signals, and transmit signals, all of which causes increased radiation emissions. A presentation by the House of Commons (United Kingdom) Science and Technology System reported (1999) that using a cellular phone inside an enclosed vehicle can cause radiation levels to rise by 10 times.



TIP If using the cellular phone inside a vehicle, open the window or door (if not in motion). This will improve the path for the cellular phone signals and possibly reduce the phone’s need to increase its power level.

#5. Phone Mode

The highest cellular phone emissions occur when the phone is establishing a connection with a base station. When using the phone in a mobile setting, the phone is constantly re-establishing its base station connection. The emissions in the mobile setting are further compounded by signal path issues (see preceding tip).



TIP When inside a vehicle, avoid keeping the cellular phone handset turned on unless you are expecting an incoming call, or making a call.

#6. Carrying the Phone

Avoid keeping the cellular phone (when switched-on) adjacent to the body.

In particular, do not keep it in on-mode in clothing pockets or clipped to the waist. The soft tissues of the body - namely heart, liver, kidneys, intestines, and reproductive organs - are very vulnerable to penetration by radiation, moreso than the brain (which is protected to a degree by the skull). According to Dr. Hyland’s report to the Economic Union (2000), three sudden deaths occurred from colon cancer amongst members of a secret surveillance unit of the former Royal Ulster Constabulary, all of whom had worn radio or microwave transmitters in the lower part of their backs for extended periods of time. In 2002, US jeans maker Levi Strauss & Co. debuted to clothing retailers a new line of trousers fitted with a lining which the makers say shields against radiation.



TIP Women: carry your phone in a purse that is carried away from the body. Men: do not carry the phone in the on-mode in your chest, jacket, or pants pockets, unless you are expecting a call or making a call.

#7. Eyeglass Wearers

The House of Commons (United Kingdom) Science and Technology System report (1999) also found that cellular phone users who wear metal-rimmed glasses intensify their exposure to radiation emissions to the eye by 20% and to the head by 6.3%.



TIP Take glasses off when making or receiving cellular phone calls, or use the phone when you are wearing contact lenses.

#8. Proximity to Base Stations

The number of “cells” (zones of service) in the geographic area, in addition to the proximity of the cellular

Reducing Your Cellular Phone Radiation Exposure

ing Medicine (A4M), a non-profit medical organization dedicated to the advancement of technology to detect, prevent, and treat and optimize the human aging process. Visit The World Health Network, at www.worldhealth.net, the Internet's leading anti-aging, life-extending news, sign up for our free bi-weekly e-newsletter, and visit our special information clearinghouse on

phone to a base station, factor into the power necessary for the phone to establish a connection and receive and transmit signals. The fewer the number of cells, and the farther apart the base stations, the greater the power (and radiation emission) necessary to maintain contact with the network.



TIP Many cellular phones can display the signal level at which they are operating when turned on. When receiving or making a call, take note of the reported signal level. If it is weak, keep the call short and continue it later on a corded phone or when you reach an area where the signal level is stronger.

Accessories

Radiation-reducing cellular phone accessories appeal to those consumers who do not wish to give up their frequent and lengthy use of the device.

IMPORTANT: Responsible accessory manufacturers and retailers will openly share independent laboratory studies, validated by third-party testing reviewers, documenting that their devices reduce the amount of radiation delivered from the cellular phone to the user. This, however, should be the limit of their product claims. Most of these RF protective accessories have only been on the market for less than five years - and many of them for less than a year. To our knowledge, none of these accessory manufacturers have conducted controlled studies of humans to determine if and how their products alter the biological effects of cellular phone radiation. As a result, we consider it to be premature and irresponsible for any accessory manufacturer to state or imply that their product alters, in any way, the effect that cellular phone radiation has on the human organism.

#9. Hands-Free Kits

Hands-free kits include a headset or earbud/microphone that connects by way of a cable into a special plug on cellular phones. They offer cellular phone users freedom of



movement while using the phone, for example freeing up the hands for writing or typing. There is conflicting evidence on whether exposure to cellular phone radiation is reduced.

To use hands-free kits, many people tuck the phone handset into a chest or jacket pocket, or attach it to their belt. Positioning the phone at this location has possible risks to the soft tissue of the body (see *Carrying the Phone* above). Additionally, some cellular phones have been shown to require greater power to use hands-free mode, thus placing the soft tissue near the handset at greater risk.

A laboratory evaluation commissioned by Britain's Cancer Association reported (2000) has raised concern over possible magnification of the radiation when using hands-free kits. Two of the most popular brands of hands-free kits were studied. The Cancer Association determined that the hands-free kit cable can create a standing wave that can propel the cellular phone signal wave through the cable and, by way of the earbud, deliver that signal directly into the ear. Additionally, the hands-free kit earbud channeled as much as 3 times the dose of radiation into the ear as opposed to using that same phone without the kit. Dr. Carlo has stated that this "coupling effect" can be remedied by using hands-free kits that incorporate ferrite filters in the cable. He suggested that, in selecting a hands-free kit, consumers choose the "filtered" rather than "non-filtered" version.

#10. Shields

Shields are patches made from various types of material that, by self-adhesive, fit atop the earpiece of the phone. The goal of shields is to reduce the amount of radiation delivered to the user's head from the phone. By positioning the shield accessory in



between the phone and the user, the purpose of shields is to absorb the emissions. It has been reported that Motorola has patented technology similar to these shields, leading to a frenzy of interest in these accessories.

Manufacturers of shield accessories acknowledge that a significant portion of radiation is emitted by cellular phone antennae. However, shield manufacturers submit that antenna radiation delivered to phone users is significantly reduced due to its distance from the user, the reach of the antenna emissions following the inverse square law (see *Distance* above). Additionally, shield manufacturers submit that antenna emissions are partially obscured by the battery, before they can reach the head. Some makes and models of cellular phones emit notable radiation emissions from points on the handset - not just the antenna. As a result, when users hold the handset to the head, the earpiece is in direct, close proximity to the brain.

Many shields are made of mesh consisting of carbon and lead. Shields made of this material from responsible manufacturers provide a fair amount of reduction - 90% or better - in cellular phone radiation delivered from the phone to the head.

Shields that are constructed from radar absorbing materials are also available. These shields are made of solid state materials and operate as passive circuit analog devices. No external power resource is required. Radar-absorbing material shields from responsible manufacturers are effective at reducing cellular phone emissions delivered from the phone to the user's head to a greater extent than mesh shields.

These tips are excerpted from the new book, *Cellular Phones: Medical Menaces of a Modern-Day Convenience*, by Dr. Robert Goldman, A4M Chairman, and Dr. Ronald Klatz, A4M President. Visit The World Health Network, at www.worldhealth.net, for availability details on the release of this must-read book.