

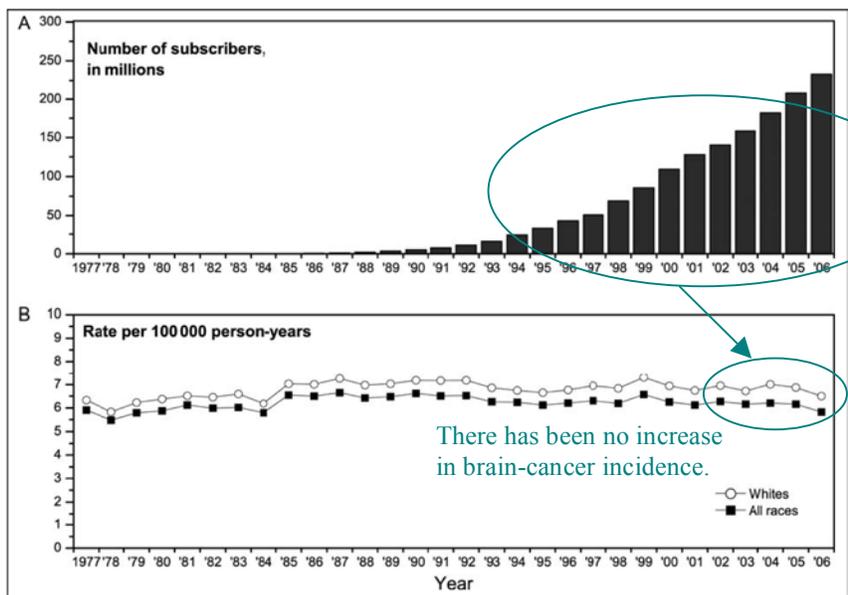
## Cell phones and brain cancer: a scientific view

There has been a flurry of reports claiming a causal link between cell-phone use and brain cancer, particularly in blogs, popular literature, television, and the internet. The increased risk of brain cancer is purported to be caused by electromagnetic radiation in the microwave range used in cell-phone transmission.

This report will present information on the incidence of brain cancer and cell-phone usage, and on the interaction of electromagnetic radiation with matter. The physics underlying chemistry and biology must ultimately provide the most fundamental explanations of mechanisms which could relate cell-phone use to brain cancer. A brief final section will discuss the decline of science education in the United States, the rise of distrust of authority, and ways in which medical and scientific reports can reach erroneous conclusions.

### Cell-phone use and incidence of brain cancer.

The first question to ask is whether there is epidemiological evidence of brain cancer caused by cell-phone radiation. The steep increase in the use of cell phones in the world since the early 1990's should—if cell-phone radiation causes brain cancer—be accompanied by an increase in the incidence rate of brain cancer, with some delay to be expected for an assumed latency period. Latency is the average time it would take for brain cancer, if caused by cell-phone use, to be diagnosed. Figure 1 shows cell-phone use and brain-cancer diagnoses in the US as a function of time over the period since cell phones have become ubiquitous.



**Figure 1.**  
(A) Number of wireless subscribers in the United States, 1984-2006; (B) age-adjusted incidence of brain cancer.

*SEER 9, 1984-2006. [Inskip, Hoover, and Devesa, National Cancer Institute, National Institutes of Health, Neuro-Oncology, July 16, 2010]. [Neuro-Oncology 2010 Nov;12(11):1147-51]*

- **Update rate of brain cancer:**  
Year 2006: 6.23 per 100,000.  
Year 2007: 6.36 per 100,000.  
*seer.cancer.usa.gov*
- **Update cell phones:**  
Year 2010: 292M.

Figure 1 shows that the incidence of diagnosed cases of brain cancer in the US has not changed in thirty years, while the number of cell-phone users in the US has increased to about one cell phone per person. If cell phones were to cause brain cancer, we should see the rate increase, whatever latency period one may assume. There is no increase.

A similar study of time trends (1998-2007) of brain-cancer incidence rates in England reaches a similar conclusion [de Vocht et al, Bioelectromagnetics (2010)]. “Our analysis suggests that the increased and wide-spread use of mobile phones, which in some studies was associated with brain cancer risk, has not led to a noticeable increase in the incidence of brain cancer in England between 1998 and 2007. Therefore it is very unlikely that we are ‘at the forefront of a cancer epidemic’ related to mobile phone use...we interpret the present data as not indicating a pressing need to implement a precautionary principle to reduce exposure to RF [radio-frequency radiation] from mobile phones by means of population-wide interventions.”

Some activists claim that the latency period is thirty years, which could explain why one might expect to see a modest increase in brain-cancer incidence. In fact, there is no increase in the incidence of brain cancer. The 30-year figure is made up, because there is no evidence for any latency period for brain cancer related to cell-phone use. A claimed analogy with exposure to atomic-bomb blasts or to x rays is unscientific and incorrect. De Vocht et al. [previous reference] assume a 5-10 year average latency period between exposure and the clinical manifestation of the tumor. The presumed latency period is anybody’s guess. The inescapable conclusion is that there are no apparent cases of brain cancer to date caused by cell-phone use, as shown in incidence studies. This observation leads to an obvious question: since there are no cases of brain cancer caused by cell-phone use found in incidence studies, which cases of brain cancer purportedly caused by cell-phone use are being studied and reported?

### **Interaction of light with matter (1): Heating effects of microwave radiation.**

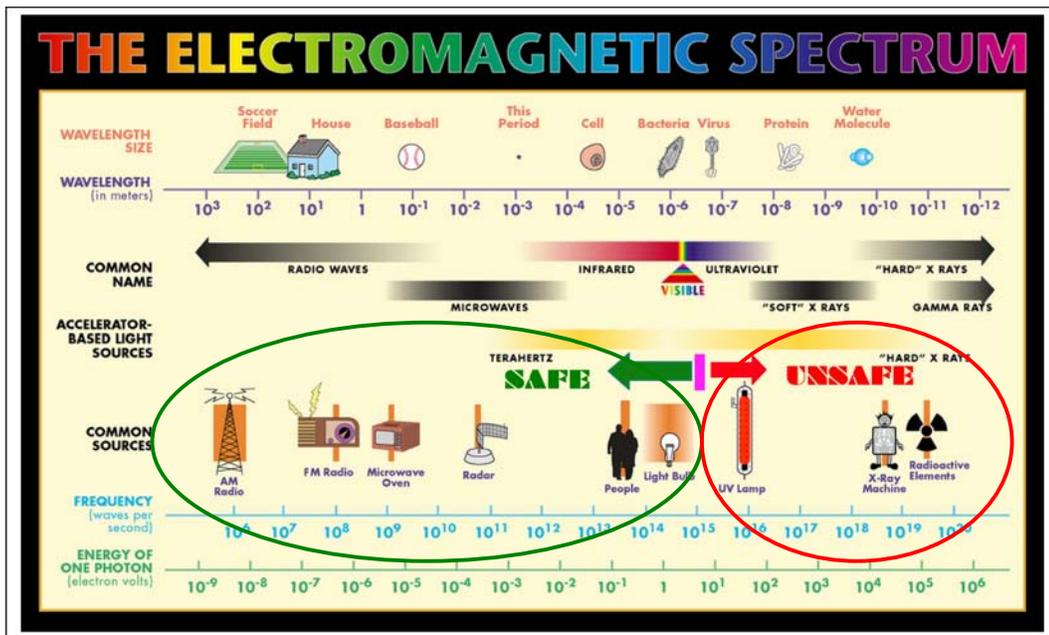
It is well known that microwaves of a selected frequency can be used to heat food in a microwave oven. Microwaves of 2.45 GHz (2450 MHz) resonantly excite rotation of water molecules. Since water is contained in most food, food can be heated with microwaves of this frequency. A cup or bowl in a microwave oven does not get hot, except by thermal conduction from heated food, because glass and ceramic do not contain water. Microwaves of a frequency different from 2.45GHz will not efficiently heat water because the microwaves of another frequency will be only slightly absorbed by water.

Microwaves in the frequency range used by cell phones—800 MHz to 1.9 GHz—are not as efficiently absorbed by water or body tissue as is radiation at 2.45 GHz. These microwaves will cause slight heating of tissue. However, the head has massive blood circulation, thus massive cooling capability, and a half watt of radiation from a cell phone—being out in the sun puts more than a watt of sunlight onto your head—would be rapidly removed by blood flow. Heating of the brain by cell phones is negligible.

## Interaction of light with matter (2): Ionizing effects of electromagnetic radiation.

The spectrum of electromagnetic radiation is shown in Fig. 2. Electromagnetic radiation covers a very broad spectrum, from low-frequency (long-wavelength) radiation, in the form of ubiquitous radio and television emissions, through infrared and visible light, to ultraviolet light and x rays.

Einstein already answered the question of whether or not microwaves can break chemical bonds and thus cause cancer. In his 1905 paper on the photoelectric effect—for which he won the Nobel Prize in 1921—he explained that light is “quantized,” i.e., that light behaves like individual particles called photons. Photon energy is related to wavelength or frequency of light by a constant called Planck’s constant. Photons with wavelengths longer than blue light (such as microwave photons) have energies much too low to break chemical bonds. As we know, photons with short wavelengths (such as ultraviolet light or x rays) *can* break chemical bonds. They can cause cancer.



**Figure 2.** The electromagnetic spectrum.

Photons with long wavelengths (to the left of the vertical pink line) have energies too low to break chemical bonds, and are thus safe. Photons with energies to the right of the vertical line have energies sufficient to break chemical bonds, and are thus unsafe.

Activists in Berkeley and elsewhere have proposed posting the power of cell phones at the point of sale, suggesting that phones with higher power poses a greater health risk. It is important to distinguish between “energy” and “power.” *Energy* refers to the ability of a single photon to cause an action, such as breaking a chemical bond. A photon must have an *energy* greater than 4 electron volts to break a chemical bond; microwave photons have *energies* of only millionths of an electron volt. *Power* refers to the number of photons per second (actually, total energy per second), often measured in watts. Increasing the *power* of a cell phone does not change the fact that microwaves cannot break chemical bonds. Microwaves cannot break chemical bonds, and they cannot cause cancer, no matter how high the power nor how prolonged the use.

## Reliable sources of information

The internet and published literature are full of biased and unreliable information, as are many advocate and industry websites. It is essential to rely only on information published by recognized non-partisan authorities: the World Health Organization, the National Institute of Health, and the Environmental Protection Agency. A few recommended sources of unbiased information are:

<http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones>

“The Interphone study suggests that overall there is no cancer risk from cell phones.”

“Incidence data from the [Surveillance](#), Epidemiology and End Results (SEER) Program of the [National Cancer Institute](#) (NCI), which is part of the [National Institutes of Health](#) (NIH), show no increase in the age-adjusted incidence of brain and other nervous system cancers between 1987 and 2007, despite the dramatic increase in the use of cell phones (21). NCI continues to monitor cancer incidence data to detect any change in the rates of new cases of brain cancer. If cell phones play a role in the risk of brain cancer, one would expect to see an increase in rates because average monthly hours of cell phone use have increased regularly for the past decade in the United States.”

“With the publication of the Interphone study, research has fairly consistently demonstrated that there is not a link between cell phone use and cancer, but scientists caution that further surveillance, especially of heavy users and children and adolescents, is needed before definite conclusions can be drawn. There are currently no data on cell phone use and risk of cancer in children. No published studies to date have included children.”

<http://www.who.int/mediacentre/factsheets/fs193/en/>

“To date, no adverse health effects have been established for mobile-phone use.”

“There is an increased risk of road-traffic injuries when drivers use mobile phones while driving.”

## Studies

The most comprehensive epidemiological study to date of the possible impact of mobile phone usage on cancer risk is the Interphone Study, by Cardis et al., *European Journal of Epidemiology* 22:647-664 (2007) and *International Journal of Epidemiology* 1-20 (2010). This study concludes that cell-phone users show no increased risk of brain tumors “Overall, no risk of glioma or meningioma was observed with use of mobile phones. There were suggestions of an increased risk of glioma at the highest exposure levels, but biases and error present a causal interpretation.”

Many activists have launched an impassioned attack on the Interphone



study, as in a widely circulated report, the cover of which is shown above. <http://archive.radiationresearch.org/pdfs/15reasons.asp>. The inflammatory image implies a brain red hot from use of a cell phone, which is physically not possible. Activists often call cell-phone radiation a carcinogen, and make an analogy between cell-phone use and brain cancer, and smoking and lung cancer, which have no common etiology. This is not science.

This critique of the Interphone study cites other studies which claim that cell-phone radiation causes brain cancer. Due to the very large number of studies published, it is easy to select a subset with conclusions consistent with a set of beliefs. This is not science. One must consider all extant studies to reach a reasonable conclusion. Most reliable studies find no link between cell-phone use and brain cancer.

There are many reports and studies on health and cell phones published. A meta-analysis by Myung, Ju, McDonnell, Lee, Kazinets, Cheng, and Moskowitz reports some positive findings. A presentation by Moskowitz reports many cell-phone health hazards, including impaired immune system, genetic damage, memory loss, DNA alteration, eye problems, among others; he also reports damage to sperm. The senior author, Moskowitz, is closely aligned with the activists who wrote “15 reasons.” Another review, by Khurana et al, also reports epidemiological evidence suggesting a link between cell-phone use and brain cancer. Behari reports in the Indian Journal of Experimental Biology a long list of health risks. The leading activist, Devra Davis, and the Environmental Health Trust, make many claims of positive findings and risks. These articles do not answer the basic questions: how can there be cases of brain cancer caused by cell phones, since the incidence rate has been constant from before cell phones were invented until the present; and what do we need to understand to support claims which do not appear to be consistent with physics as we know it. Most studies have not received serious review, and are open to question. Even the most comprehensive study to date, the Interphone study, is open to question (see above).

Many scientists are concerned that anecdotal and profoundly unscientific reports are common in the press and the internet, sometimes in the form of first-person experiences, sometimes in the form of law suits. This is not science.

### **Statistical treatment of data: “the truth wears off.”**

An interesting article entitled “The Truth Wears Off” was published in the New Yorker magazine issue of December 13, 2010. The essential point is that many published effects are found to diminish as an experiment is repeated; eventually, after sufficient repetition and better statistics, the effect vanishes. This phenomenon, not surprisingly, arises from the intense pressure to publish a finding rather than a non-finding, and from improper statistical treatment of data with small sample populations. Subsequent studies with a larger population and better statistics find the effect diminished, and eventually the purported effect disappears.

The most comprehensive study of cell-phone use and brain cancer—the Interphone study mentioned above—suffers from the problems of statistics of small sample populations. In fact, the report concludes that biases and errors limit the strength of the conclusions that can be drawn from analyses in the report, and prevent a causal interpretation. Eventually, as was the case for cancer purportedly caused by 60-Hz radiation from power lines, any link between cell-phone use, no matter how small, will almost certainly disappear when the study is repeated with a larger sample population.

## **Conclusion**

There has been no increase in the rate of brain cancer over the past thirty years. This should end the discussion of brain cancer caused by cell phones. If the presumed latency period is too long, then there are at present no cases of brain cancer caused by use of cell phones.

Physics, which underlies chemistry, which underlies biology, does not support any interaction with matter of long-wavelength radiation—microwaves— which could cause cancer.

The most comprehensive and reliable case-control study to date reports no elevated risk for glioma or meningioma for users after more than ten years of first phone use. Other contradictory results are considered by the authors to be subject to biases and errors, thus preventing a causal interpretation. These findings do not support activist claims that cell-phone use causes brain cancer.

A combination of poor science education in America, growing distrust of authority, research studies marred by the limitation of statistics of small samples, and recent events such as the nuclear disaster in Japan—leave a public subject to fear of radiation, with no tools to distinguish what is dangerous from what is not. There is widespread conviction that “radiation” is by definition a health hazard, while, in fact, there are many kinds of radiation. Some forms of radiation are dangerous, like ultraviolet light and x rays, and some forms are harmless, like radio waves and microwaves. Some radiation is even beneficial: sunshine helps our bodies produce vitamin D. The irrational fear of radiation extends from cell phones and wi-fi to power lines to smart meters and other aspects of modern life. It is our duty as commissioners to help educate the public, to warn of real environmental dangers, to mitigate these dangers to the extent possible, and to minimize risk to public health. At the same time we must avoid fostering fear of non-existent dangers. Brain cancer from cell phones falls in this latter category.

Labeling the power of cell phones at the point of sale, while relatively benign, would contribute to the public’s fear of radiation by linking cell-phone power and brain cancer. Posting cell-phone power would make as much sense as posting radioactivity signs in the banana department at supermarkets: bananas are slightly radioactive—as are our own bodies and the very earth we stand on—yet they pose no risk to health...in fact bananas are very good for health.

*Report prepared by Fred Schlachter, Ph.D  
March 30, 2011 fsschlachter@gmail.com*