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Wake-up Call

by Rob Harell

HENRY LAI has a vivid recollection of his introduction to the politics of big science. It was 1994, and he had just received a message from the National Institutes of Health, which was funding work he was doing on the effects of microwave radiation, similar to that emitted by cellular phones, on the brain. He and UW colleague Narendra "N.P." Singh had results indicating that the radiation could cause DNA damage in brain cells.

The news was apparently unwelcome in some quarters.

Someone had called the NIH to report that Lai was misusing his research funding by doing work not specified in the grant (the grant didn't mention DNA). And the agency wanted to know what was going on.

"It really scared the hell out of me," says Lai, a research professor in the UW's Department of Bioengineering who earned his Ph.D. from the UW in 1977. "I was awake all night, worrying about it, wondering what to do."

In the morning, he sent a fax to the agency, explaining how the research fell within the parameters of the grant. The NIH accepted his explanation and assured him that all was well. "They are usually fairly liberal in that regard," Lai says. "To do otherwise would stifle the scientific process."

The incident, he says, was only the beginning in a David-and-Goliath conflict pitting him – and other researchers – against an emerging technology that would rapidly become one of the most lucrative and powerful businesses on the planet: the cell phone industry.

The controversy goes back to a study by Lai and Singh published in a 1995 issue of *Bioelectromagnetics*. They found an increase in damaged DNA in the brain cells of rats after a single two-hour exposure to microwave radiation at levels considered "safe" by government standards.

The idea behind that study was relatively simple: expose rats to microwave radiation similar to that emitted by cell phones, then examine their brain cells to see if any DNA damage resulted. Such damage is worrisome because DNA carries the body's genetic code and breaks, if not repaired properly, could lead to mutations and even cancer.

When the study was first published, a spokesperson from the cell phone industry said it was "not very relevant because they didn't use the [same] cellular frequency or cellular power."

True, responds Lai. But effects at one frequency could also happen at another frequency, and the exposure level in the experiment was actually lower than one can get from a cell phone. What it indicated was potential problems with the type of radiation the devices emit.

To this day, the cell phone industry continues to dispute Lai and Singh's findings.

"I don't believe any of those studies have ever been replicated," says Joe Farren, director of public affairs for CTIA – The Wireless Association, a Washington, D.C. – based industry consortium that provides \$1 million a year in funding for cell phone research. "We believe you should follow the science. The science to date shows there is not a health risk associated with the use of any wireless device."

Technically, Farren may be correct about Lai's study, but that's because no one has tried to replicate Lai and Singh's exact experiment. And a 1998 experiment that used common cell phone frequencies did find biological damage in some cases. More recently, a European research effort by 12 groups in seven countries also documented DNA damage from cell phone radiation.

While Lai is the first to say there are "no solid answers" to the controversy over cell phones and DNA damage, there is "cause for concern" and more work needs to be done. Instead, Lai says, he and his colleague have been the focus of a campaign to discredit their research. Consider:

- Internal documents from Motorola in the 1990s point to an organized plan to "war-game" Lai's work.
- When a scientist in California published results that seemed to support Lai's findings, he lost research funding and eventually left the field.
- At one point, the director of a group created to manage \$25 million in industry-donated research money sent a memo to then-UW President Richard McCormick saying that Lai and Singh should be fired.
- Federal money for scientific investigation in the field has dried up, supplanted by funding from the industry – funding that Lai and others say can come with restrictions so oppressive they hamper scientific inquiry.

The stakes, both in terms of potential ramifications and profits, are high. According to consulting firm Deloitte & Touche, the global wireless market is expected to grow to two billion subscribers by the end of this year. An overall dollar figure for the industry would easily be in the hundreds of billions, according to Louis Slesin, who as editor of *Microwave News* has followed the ins and outs of research in the field of bioelectromagnetics for more than 20 years.

"It's all about science, politics and money, and not necessarily in that order," Slesin says. "Henry and N.P. had the courage to buck the system, and they have paid dearly for that."

In preparing this article, some industry officials didn't return phone calls asking about Lai's work and the controversy surrounding it. Others said they didn't have specific knowledge of the original study and the events it set into motion – it was more than 10 years ago – but they characterized such research as outside mainstream findings, which they say show that wireless technology is safe.

Still others maintain that possible hazards from recent studies could be discounted because those studies focus on older analog phones, which send out a steady wave of radiation. Newer digital phones operate at a lower intensity, sending out a pulsed stream.

A Swedish study published last fall that tracked 750 subjects who had used cell phones for at least 10 years made note of that difference, and included the following caveat:

"At the time the study was conducted, only analog mobile phones had been in use for more than 10 years and therefore we cannot determine if the results are confined to the use of analog phones or if the results would be similar after long-term use of digital phones."

But it would be a mistake to use that to support a stance that digital phones are proven safe, according to Slesin. The problem, he says, is that pulsed radiation is more likely than continuous wave radiation to have an effect on living things.

"There is a lot of work out there showing that digital signals are more biologically active," Slesin says. "At this point, no one knows whether the enhanced biological activity might compensate for the weaker signals."

Lai, a soft-spoken bespectacled man with an understated sense of humor – he once deadpanned to a national television reporter that the most difficult part of his research involved getting the rats to use tiny cell phones – still expresses surprise at being at the center of the ongoing, swirling debate.

"I'm just a simple scientist trying to do my research," he says. He sees the path that led to controversy as marked by chance and serendipity.

A Hong Kong native, Lai earned his bachelor's degree in physiology from McGill University in Montreal and came to the UW in 1972 to do graduate work. He earned his doctoral degree in psychology and did post-doc work in pharmacology with Akira Horita. His initial research involved the effects of alcohol on the brain. He also worked on a new compound to treat schizophrenia.

A shift came in 1979. Bill Guy, UW emeritus professor and a pioneer in the field of radio wave physics, offered Lai a chance to do research on microwaves through a grant from the Office of Naval Research.

The pair first examined whether microwaves can affect drug interactions (they can), then if there appears to be an effect on learning (there does). Then, in the early '90s, Singh arrived in Seattle. He approached Lai about joining his lab. "He was an expert on DNA damage," Lai recalls. "I said, 'Well, why not?'"

Singh is one of the world's foremost experts on a DNA analysis called the "comet assay." The assay gets its name from the appearance of a damaged cell. First, the cell is set in a gel and "lysed" or punctured. Then an electric current is run across the cell. When strands of DNA break, the broken pieces are charged. The electric current causes those pieces to migrate through the gel. As a result, a damaged cell takes on the appearance of a comet, with the bits of damaged DNA forming the tail. The longer the tail, the more damage has resulted.

With Singh's expertise now at hand, Lai decided to look at how microwaves affect DNA. Lai and Singh compared rats exposed to a low dose of microwave radiation for two hours to a control group of rats that spent the same amount of time in the exposure device, but didn't receive any radiation. The exposed rats showed about a 30 percent increase in single-strand breaks in brain cell DNA compared to the control group.

As Lai and Singh sought funding to conduct follow-up studies, word of the research began to get out. According to internal documents that later came to light, Motorola started working behind the scenes to minimize any damage Lai's research might cause. In a memo and a draft position paper dated Dec. 13, 1994, officials talked about how they had "war-gamed the Lai-Singh issue" and were in the process of lining up experts who would be willing to point out weaknesses in Lai's study and reassure the public. This was before the study was published in 1995.

A couple of years later, Lai got money from Wireless Technology Research (WTR), a group organized by CTIA to administer \$25 million in industry research funding, to do some follow-up studies. But the conditions that came with the funding were restrictive. So much so that Lai and Singh wrote an open letter to *Microwave News* recounting their experience. The letter, published in 1999, cited irregularities in processes and procedures that the two called "highly suspicious."

"In the 20 years or so that we have conducted experiments, for a variety of funding agencies, we have never encountered anything like this in the management of a scientific contract," the two wrote.

WTR leader George Carlo responded with a six-page letter to then-UW President Richard McCormick, complaining of the "libelous" letter to *Microwave News* and "a pattern of slanderous conduct by these men over the past several years." The letter closed with a threat of legal action and stated that Lai and Singh should be fired from the project. An answering letter from Vice Provost Steven Olswang stated that the University "encourages legitimate academic discourse" and would not intervene in the dispute.

While Lai and Singh were attempting to do their industry-funded follow-up study, the industry was looking for another opinion. Motorola approached Jerry Phillips, a researcher who worked in a lab at the Veteran's Administration Medical Center in Loma Linda, California. He was investigating electromagnetic fields and their biological effects. The lab had done work with Motorola before, and Phillips was interested. He made a proposal and was funded.

He sent people to Seattle to learn how to do the comet assay. And he decided to expose the animals in his experiment to actual cell phone frequencies. What they found were increases in DNA damage at some levels of exposure and decreases at others.

"That's not unusual," Phillips says. "It happens with chemicals. One dose can do one thing, while a higher or lower dose does the opposite. In this case, if you produce a little bit of DNA damage, you are stimulating the repair mechanisms and you could actually see a net decrease because the repair will be done. However, if you overwhelm the repair mechanism, then you could see an increase.

"Based on the data, I told them that we need to start looking at repair mechanisms," Phillips recalls. Motorola disagreed. Phillips says he was told the results were not ready for publication, was encouraged to do more work, and was offered additional money to continue the experiment.

"I said as much as I would like the money, this part of the study is done," he recalls. "I said it's time to move on." The study was published in Nov. 1998. Once the findings were released, Phillips' source of funding dried up.

Since then, another group, working out of Washington University in St. Louis with industry funding, has tried to replicate the experiment, but without success. According to Lai and Phillips, that group is doing the study differently, including using a different technique to gauge DNA damage.

"They haven't properly replicated the work that Henry did, or that I did," Phillips says.

In the meantime, recent findings from overseas, more than 10 years after Lai's work, seem to finally be providing support for a closer look at cell phone radiation.

Last fall, the journal *Epidemiology* published research results from a Swedish group that showed an increase in a rare type of non-cancerous brain tumor among cell phone users on the side of the head where the phone was most often held.

In December, a pan-European organization released results from an extensive four-year study carried out by 12 research groups in seven countries. Known as the REFLEX study, that research found significant increases in DNA damage in human and animal cells exposed to cell phone radiation in the laboratory. While not a cause for alarm, the results, which have yet to be published, underline the need for further study, scientists said.

A spokeswoman for the UK-based Mobile Operators Association called the results "preliminary," adding that, "It is not possible to draw conclusions from this preliminary data."

In 2000, Sir William Stewart, former chair of a British group that looked into the cell phone debate issued a report urging "a precautionary stance" while scientific data is gathered. This January he repeated that warning, adding that children should not use the devices for the time being.

Industry spokesman Farren says his organization sticks to its position. "Any official precautionary measures need to be based on the science," he says. "The majority of studies have shown there are no health effects."

It's a point well taken, Lai says. However, what the science seems to say depends on how you quantify it.

Lai says there have been about 200 studies on the biological effects of cell-phone-related radiation. If you put all the ones that say there is a biological effect on one side and those that say there is no effect on the other, you'd have two piles roughly equal in size. The research splits about 50-50.

"That, in and of itself, is alarming," Lai says. But it's not the whole story. If you divide up the same 200 studies by who sponsored the research, the numbers change.

"When you look at the non-industry sponsored research, it's about three to one – three out of every four papers shows an effect," Lai says. "Then, if you look at the industry-funded research, it's almost opposite – only one out of every four papers shows an effect."

The problem, he adds, is that there is no longer funding available in the United States that isn't attached to the industry. Lai, for one, refuses to take any more industry money.

"There are too many strings attached," he maintains. "Everyone uses the analogy of the tobacco industry and what happened there. It's like letting the fox watch the henhouse." While the FDA administers cell phone radiation studies, the money comes from the industry, he adds.

Microwave News Editor Slesin says he has pondered why government funding isn't available. His hypothesis is that it's a matter of attitude.

"There is a view out there among many scientists that this is just impossible – the radiation is too weak and there cannot be any effects," Slesin says. "We all know that ionizing radiation is bad. Ions are more reactive, there's no doubt it can lead to cancer, it's nasty stuff."

The people who work with ionizing radiation see EMF radiation – that from electromagnetic fields – as a 97-pound weakling, he continues. They believe it's not capable of doing anything.

"Yet, when you see effects like Henry reported, especially at the low power intensities, you have to ask what is going on to cause this?" he says. "As long as that attitude remains unchanged, you won't get more funding and you don't get anywhere."

As a result, many U.S. scientists have moved on, either focusing on other areas or leaving the research arena altogether, relying on the rest of the world to pick up the slack. In Lai's case, he is pursuing other research directions, where he can get funding. The most promising involves artemisinin, a derivative from the wormwood plant currently used to treat malaria. Lai's research shows it has promise as a powerful anti-cancer agent. Late last year, the UW licensed the technology to a Chinese pharmaceutical company that plans to take it to human trials and, if successful, to market.

After what happened in Loma Linda, Phillips and his wife left research altogether. They now live in Colorado Springs, Colorado, where he works for a company that develops science curricula. "I do have a lot of regret for those lost opportunities," Phillips says. "We were really in a position to develop some good basic understandings of how radio frequency affects biological systems."

It's an issue that desperately needs to be explored, according to Slesin. Right now, a solid understanding doesn't exist. If anyone says they absolutely have the answer, he cautions, absolutely don't believe them. "We are swimming in uncertainty."

And the issue becomes increasingly relevant with each passing day.

"We are making some fundamental changes to the electromagnetic environment in which we live," Slesin continues. **"Soon entire cities will be online so you can take your laptop anywhere and be on the Internet. What that means is we will all be exposed to electromagnetic radiation 24/7.** I don't know if there's a problem, but I think we owe it to society to find out." (Emphasis added)

In the meantime, Lai prefers to err on the side of caution. He doesn't use a cell phone and requires that cell-savvy family members use headsets. He doesn't see the problem as intractable, just one that needs serious attention. We engineered the technology, he says, and he's confident that we can engineer our way out of any problems. But first, we need to take a close look at the data and admit that there may be a problem.

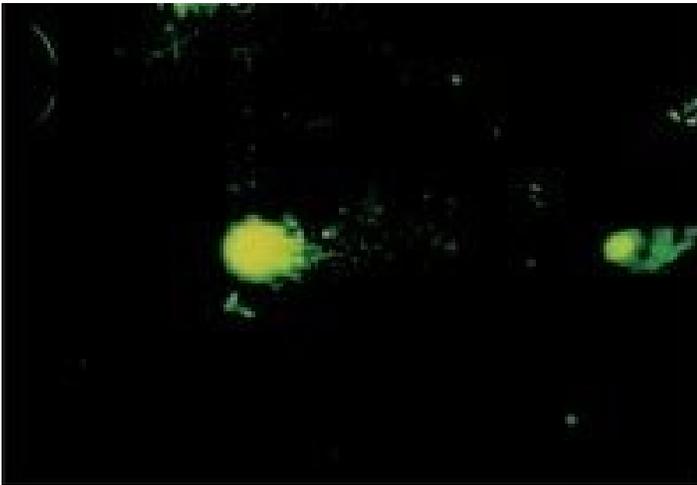
Either way, the answers will come, given time, Lai says. The question is will we get those answers in the way we want?

"We see effects, but we don't know what the consequences are," Lai says. "With so many people using cell phones, we will eventually know. The largest experiment in the history of the world is already under way. We will know, in about 10 or 15 years, maybe."

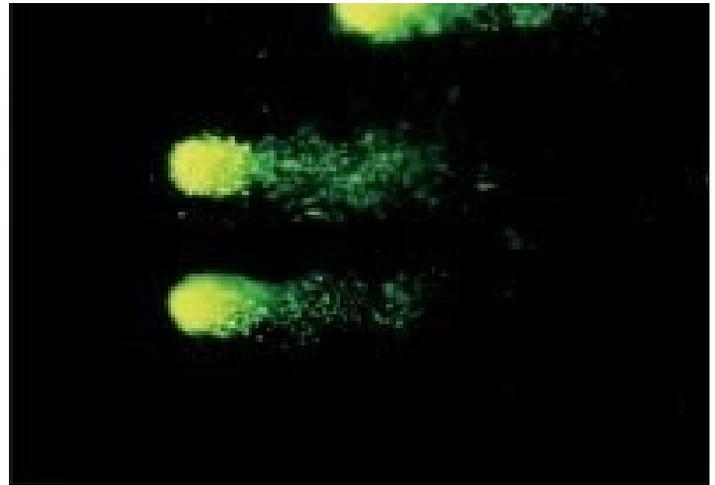
– Rob Harrill is the engineering writer in the UW's College of Engineering. Although his children are not allowed cell phones (despite repeated pleas), both he and his wife use one – sparingly.

<http://www.washington.edu/alumni/columns/march05/wakeupcall01.html>

Illustration photos (below) courtesy of Dr. Henry Lai



A Comet assay of a normal cell shows little DNA damage.



The same assay of cells exposed to low level microwave radiation shows tails of damaged DNA.