Did You Hear The One About MIT's Little Nuclear Reactor?

By Grace Talusan, Boston Magazine, August 2011

"YOU MIGHT HAVE JUST lucked out," David Moncton, director of the MIT Nuclear Reactor Laboratory, tells me. "You might get lucky." We are sitting across a conference table in the brick building adjacent to the "blue mushroom," the cute, shiny-happy name scientists use for MIT's nuclear reactor in Cambridge. The reactor lies deep inside the center of a huge round building that's painted swimming-pool blue. Looking a bit like a water tower, it's set back from Mass. Ave. between the Paradise and the Metropolitan, a gay club and storage facility, respectively.

"Get lucky?" I ask.

Today, the reactor has been shut down for fuel management. Its 10-ton lid has been removed, exposing the small core where highly enriched uranium fissions 5,000 to 6,000 hours a year. A day like this happens only every few months, and getting lucky, it turns out, means I might get to stand at the edge of the reactor core's pool to see the quiet blue glow of radiation emitted from fissioning electromagnetic particles. I'm told it's beautiful, but I don't feel lucky. That's because I'm also told that it's dangerous, and the recent meltdowns of three reactors at Japan's Fukushima nuclear plant have me feeling nervous.

"Fun," I offer, trying to act excited — how many people can say they've looked inside a nuclear reactor's core — but all I can think is that I should be terrified.

[sidebar]**CAMBRIDGE'S LITTLE NUKE** has operated happily and quietly for years, and MIT absolutely intends to keep it that way. But the incidents at Fukushima have renewed concerns about its safety, stoking fears that the "blue mushroom" could wipe out Boston in a mushroom cloud.

During a Cambridge City Council meeting in May, just weeks after the disaster, City Councilor Sam Seidel requested that City Manager Robert Healy confer with MIT and the heads of relevant municipal departments, such as fire and police, to respond to residents freaking out about their nuclear neighbor. One by one at the meeting, citizens rose to face the elected officials, clearly having Googled in preparation. Sandra Foster, who seemed spooked, commented that "I'm sure if they continue to use that highly enriched uranium many, many people would die." James Williamson, in a Harvard baseball cap and unbuttoned white shirt, criticized the city manager's response to Seidel's request for information as "woefully inadequate," calling it "dismissive to say the least."

A question arose over who, exactly, operates MIT's reactor. Brad Bellows, who has lived in Cambridge for 35 years, urged the city council to investigate his understanding that "this thing is run by college students." Not so, countered the city manager, observing that "students obviously have a role in the research that's done there, but it's not controlled or operated by students." But he wasn't completely correct.

"The fact is that students do operate this reactor," David Moncton told me later. Fifteen full-time employees and nine undergraduate students run the reactor at what has to be one of the most unusual campus jobs around. Most undergrads study for many months, then take a two-day exam administered by the Nuclear Regulatory Commission (NRC). Frank Warmsley, who trains the students, said he has never had one fail the exam in 17 years, and that four of the nine current undergrads have qualified for senior operator status. They're not exactly Homer Simpson. Gerry Mahoney, deputy chief of the Cambridge Fire Department, told me in an e-mail that he felt "quite comfortable with the MIT reactor," and reported no major safety incidents in his time dealing with the thing, which goes back to 2003. For his part, Moncton dismissed the notion that student involvement at the reactor adds any risk. "There are a lot of 18-year-olds fighting the wars in Afghanistan and Iraq," he said, "and I think we have to be careful not to make these broad-brush indictments about their abilities or intelligence. We feel completely confident."


All photographs by Bob O'Connor

But elsewhere in the world, confidence in the safety of nuclear programs has been wavering in the aftermath of the Fukushima crisis. Japanese citizens have been demonstrating against nuclear power. Two months after the tsunami, German Chancellor Angela Merkel announced that her country would phase out 17 nuclear power plants by 2022. And while White House Press Secretary Jay Carney reiterated that “the president remains committed to nuclear energy as part of his clean-energy agenda,” the administration’s plans to expand a nuclear power plant in Burke County, Georgia, have been tied up by the NRC review process.

Here in New England, we have two full-fledged power reactors, Seabrook and Pilgrim, sitting within 50 miles of Boston. That’s become a touchy distance in the wake of the emergency in Japan — the NRC urged U.S. nationals living within 50 miles of the Fukushima Daiichi plant to evacuate — so you can understand how the meltdown has only exacerbated existing conflicts between residents and local plants.

Groups like Beyond Nuclear, the New Hampshire Sierra Club, Friends of the Coast, the New England Coalition, and the Seacoast Anti-Pollution League are challenging a request by the operator of Seabrook Station — NextEra Energy — to extend the New Hampshire plant’s license to 2050.

Then there’s the opposition to Pilgrim Nuclear Power Station in Plymouth. The citizen group Pilgrim Watch has been in litigation with the plant since 2006 over safety concerns about the on-site storage of spent fuel. And after discovering that Pilgrim operates the same General Electric–designed reactor that melted down in Fukushima, Marshfield resident Anna Baker founded Pilgrim Make Us Safe Today. Baker isn’t against nuclear power, but admits that had she known the risks, she would have hesitated to locate her young family just 22 miles from the plant.

Pilgrim’s license expires next June, and both of the opposition groups are protesting its renewal and demanding more-rigorous oversight by the NRC.

These concerns have also been shaking up the legislative agenda in Washington. Since March, there have been more Congressional oversight hearings about nuclear safety than in the previous five years combined. Many of those have been the doing of Massachusetts Congressman Edward J. Markey, who has been working on this issue for many years and says the disaster in Japan underlined the need
for stronger regulation. “We know what happened in Japan could happen here in the United States,” he wrote in an e-mail. “America is susceptible to earthquakes, floods, and power outages. We should not be giving the green light to new reactors, new reactor designs, or relicense applications, including those for Pilgrim and Seabrook, until we have incorporated the lessons learned from Fukushima.”

In March, Markey introduced the Nuclear Power Plant Safety Act of 2011, to “[e]nsure that nuclear power plants and spent nuclear fuel pools can withstand and adequately respond to earthquakes, tsunamis, strong storms, long power outages, or other events that threaten a major impact." Two months later, tornadoes touched down in Massachusetts.



THE FIRST TIME I approach MIT's reactor, I realize I've actually passed by it many times before without noticing. The Red Barn Mobile Coffee Break truck is parked out front, its patrons lounging on folding chairs, guzzling caffeine and eating grilled cheese sandwiches. Andrew Russo, owner of the coffee truck, is well aware of the reactor; after serving 750 guests that day, he's wishing he could plug into it for a little electrical recharge. That's a common misconception, actually, because the nuclear reactor doesn't produce power.

The truth is, most residents of Cambridge don't know much about the plant, if they know it exists at all. MIT's reactor is one of 32 research, or "nonpower," nuclear reactors in the nation, most of which operate on college campuses. After President Eisenhower created the Atoms for Peace program in the mid-1950s, MIT established a doctoral program in nuclear engineering and built the reactor lab for research in 1958. Since then, hundreds of students have completed the Reactor Operator Training Program, with some going on to work for the NRC.

For many years, cancer patients came to the lab for an experimental treatment called boron neutron capture therapy, but today its primary cancer-related function is irradiating gold seeds for patients with prostate cancer. In addition to support from MIT and grants, the lab generates income through commercial activities such as preparing semiconductor chips for use in electronics, like transistors and diodes. Using a process called neutron transmutation doping, the silicon chips go in through a rectangular opening in the reactor vessel and come out around the other side. It's like a giant, radioactive Easy-Bake Oven.

I've read that in the event of a nuclear incident, three crucial safety principles come into play: time, distance, and shielding. You want as much of them as possible between you and the radiation source. But here I am, walking *into* the source. I clip a pen-size dosimeter to my shirt before entering the reactor, so I'll know exactly what my exposure is. I'm told the radiation levels will be negligible, but I still worry about how close I'll be getting.

I bring up the subject of radiation with Moncton, the director of the nuclear lab, then watch as he grows increasingly irritated with the line of inquiry. We've been talking about our radioactive world for 20 minutes, about how humans have evolved to live with the low levels of radiation emitted from the earth's crust, from outer space, and even from the person we share a bed with, but don't do well when exposed to high doses. Too much radiation can lead to organ failure, resulting in an excruciating death. I pepper Moncton with anecdotes and questions: Remember what happened to former Russian spy Alexander Litvinenko, who was poisoned with radioactive tea? How about that *New York Times* story last year revealing that thousands of patients across the country had been given lethal doses of medical radiation? Why can cockroaches and chickens withstand higher doses than humans?

Moncton looks at his watch. "I don't want to spend the whole time on radiation because it's basically trivial," he says. "It's not a significant issue for us."

Okay, he's right. The MIT reactor has operated safely for more than 50 years, without any significant radiation release, and its relatively small size means that it poses a much smaller threat than the commercial reactors nearby. In fact, it operates at about one-500th of the power of a typical commercial plant: The average core temperature in the reactor is only 50 degrees Celsius. Cooler than a cup of coffee from the Red Barn truck.



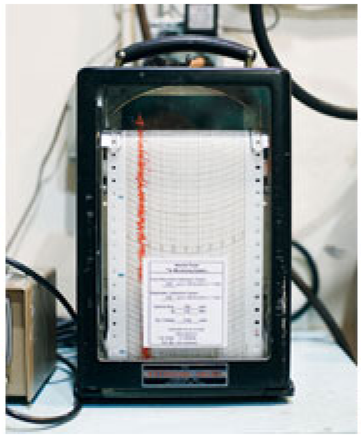
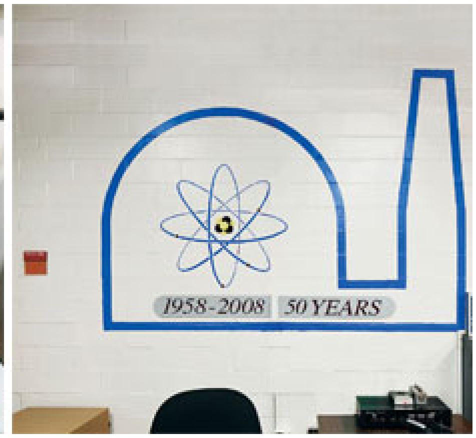
Researchers have grown weary enough of constantly assuaging our fears about nuclear energy that they keep useful comparisons at the ready. The most popular one, mentioned by all the experts I interviewed, is cars: We don't think twice about driving despite the thousands killed each year in crashes.

Newton native Seth Mnookin, author of *The Panic Virus*, a book, in part, about how fears can lead to overblown concerns about benign medical issues, says that people have trouble comprehending that you're "more likely to die driving to get milk than you are in a nuclear holocaust prompted by a reactor meltdown."

Probably true, but then again, stuff happens. How unprepared was Massachusetts when twisters touched down in Springfield in June? Fukushima demonstrated what can occur when a nuclear plant isn't ready for a natural disaster — and this at a time when we seem to be witnessing a spike in such disasters all around the globe. The NRC, in fact, recently specified new protocols to better prepare for catastrophic events...and just in time: In the same month, Missouri River floodwaters breached Fort Calhoun Station in Nebraska, and wildfires in New Mexico threatened Los Alamos National Laboratory, where worried residents feared that flames could set fire to thousands of gallons of nuclear waste.

No matter how unlikely, it's hard not to wonder: *What if?* All of this crosses my mind as I step inside the air lock to the containment building and the hydraulic doors seal me inside with the nuke. My eyes bounce from one warning to another posted on roped-off areas and equipment. I've never seen so many screaming yellow signs printed with three blades of magenta coming off a center circle, the trefoil international symbol for radiation.

In the control room under the reactor, Sarah Don, a junior in nuclear science and engineering, sits at a console that looks like it's from the spaceship in the 1950s film *Forbidden Planet*. There is always a supervisor on duty during every four-hour shift, but Don's job is to notice if anything goes wrong. Every half an hour, she does a status check of the core temperature. In between, she's free to catch up on homework or check e-mail. (In MIT's student newspaper, the *Tech*, one undergrad operator described his work as "essentially glorified babysitting.") Don is excited about her chosen career path, but I'm surprised that she feels safer operating the reactor than a steering wheel. She's taken the car comparison literally: She's operated the reactor for two years, but still doesn't have a driver's license. "Driving is much more scary," she says.

LET'S GET THIS OUT OF THE WAY once and for all: It is a mistake to conflate the "blue mushroom" with a mushroom cloud.

"It's not physically possible for a nuclear reactor to explode like a bomb," David Moncton explained. "We saw what happened in Chernobyl and Fukushima. These are not Nagasaki or Hiroshima." The Fukushima plant experienced hydrogen explosions that destroyed the structures housing the reactors, but the reactor-containment vessels themselves remained intact.

Vincent Manno, provost and dean of faculty at the Franklin W. Olin College of Engineering, put it this way: "You and I are as likely to explode as a bomb as a nuclear reactor is. It just cannot happen." Research reactors use fuel that may be 20 to 30 percent enriched with uranium-235, Manno said, while "a fission weapon such as what was dropped on Nagasaki and Hiroshima had percentages of beyond 99.9."

What's more, said David Lochbaum, director of the Nuclear Safety Project at the Union of Concerned Scientists, small research reactors "don't really have the ability to generate the amount of energy in a confined space that can lead to an explosion — not just the mushroom-cloud-type explosions, but also the steam and hydrogen explosions that occurred at Chernobyl and Fukushima — so that's the good news."

"Come on," added Sarah Gallop, codirector of MIT's Office of Government and Community Relations. "It's just not accurate." Gallop said that whenever concerns do come up, MIT tries to quickly address them. "We're always ready to talk. Come on in. Have a tour. We're not hiding anything."

Still we worry. Fears about terrorism after 9/11, for example, prompted a controversial ABC News investigation in which student interns were deployed to investigate nuclear safety on college campuses. MIT came in for criticism for posting its operating schedule and floor plans online, where a terrorist might see them. In addition, an ABC News producer parked a Ryder truck — the same kind that Timothy McVeigh used in the Oklahoma City bombing — near the reactor to provocatively raise the question: *What if this truck were a bomb?*

Moncton dismissed the ABC piece as a "complete distortion." He explained that if a truck exploded, "there'd be a lot of people killed, but it wouldn't be from the radiation, it would be from the bomb.... The radiological component of that wouldn't be significant."

What about terrorists getting their hands on the nuclear fuel? "The scenario is completely nuts," the lab director said. Terrorists sneaking into the reactor would set off alarms, the electricity would be shut off, and they would be plunged into darkness. And if they were somehow able to lift a 10-ton lid off the top of the reactor and fish down through 20 feet of water to get the reactor fuel out, Moncton said, "once they got it out, it's so highly radioactive that they would die."

Gallop added, "They've actually simulated 747s crashing into the reactor, earthquakes, typhoons.... They've simulated everything you can imagine and none of these things would actually cause problems."

But there is something else that could be deadly, Moncton admitted, the same thing that nearly happened in Japan: "Meltdown, that can happen. That can happen at any reactor." The issue then, is not about possibility, but probability. "Not only have we never had a meltdown," he said, "we've never had an accident where we've released any radiation into the environment that was above the minimum levels that we're regulated and allowed to release." And because the MIT reactor has a thousand times less fuel than Fukushima, there would not be "much of an impact" in the highly unlikely event of a meltdown.

Even that spent fuel, a major concern at reactors across the country — Pilgrim has almost 40 years' worth of spent-fuel assemblies stored on site — doesn't pose much of a threat at the school. Manno pointed out that "MIT's spent fuel gets taken away. There's not much ever there."

The fuel is shipped in very small quantities, less than 10 pounds at a time. It's carried in a 12-ton shipping container that's sent out overnight, escorted by state police like an overprotective prom date from Cambridge to South Carolina.

OKAY, WE'RE SAFE being neighbors of MIT's nuclear reactor. Then why are so many of us so terrified?

I think back to my own nuclear education, which began at age seven, when a neighbor gifted me a souvenir from a tour she'd taken at a power plant: a thumbnail-size black pellet affixed to a cardboard explanation of the wonders of nuclear power. It read, "A seven-gram pellet of uranium contains as much energy as 3.5 barrels of oil, 17,000 cubic feet of natural gas, or 1,780 pounds of coal." My comprehension of the explosive nature of nuclear fission was about as complex as my understanding of the magic beans in *Jack and the Beanstalk*. This was the future of energy?

My perceptions about nuclear power since then have remained vague. In elementary school, I heard about President Reagan's special red telephone that would ring only in the event of nuclear war. As a teen, I consumed a steady diet of campy yet terrifying images depicting nuclear fears: *War Games, The China Syndrome, Testament,* and *The Day After*, a 1983 made-for-TV film dramatizing the fallout after a nuclear bomb hits near a small town in Kansas. When the Chernobyl nuclear reactor exploded in 1986, I was old enough to read newspaper stories about the devastation and contamination released over tens of thousands of square miles. Twenty-five years later, photographs still show ghost towns ruined by radiation.

However erroneous it was to link them, nuclear weapons and nuclear energy were the same thing in my head growing up. All I knew was that if radioactive materials were released — whether from a bomb or a meltdown — the planet would be ruined for a long time.

I asked David Ropeik, a Concord-based author who has consulted for the International Atomic Energy Agency, why I'm so uneasy about my nuclear neighbor. "The very fact that you're writing this article captures the special nature of fears related to nuclear radiation," he said. "You're not, for example, writing an article about the explosive risks of the gas station on the corner." Ropeik's book *How Risky Is It, Really? Why Our Fears Don't Always Match the Facts* discusses the "perception gap" that nuclear power falls into. "Our fear of nuclear energy in the '70s and '80s contributed to energy policy that favored coal, which is way more dangerous," he said, noting that breathing "fine-particulate pollution from the burning of coal to make electricity kills several thousand Americans per year. Our excessive fear of the real, but relatively lower, actual risks of radiation from nuclear power continues to influence social policies."

Vincent Manno, the Olin College dean, pointed out that the average radiation dose for Americans rose during the '50s and '60s because of fallout from above-ground nuclear weapons testing. Our average dose had leveled by the '90s, but in the 2000s, the numbers began to curve back up, thanks to medical advances. "Whole-body CAT scans are an incredible dose of ionizing radiation," he said. So we're willing to submit our bodies to mammograms and airline travel, but the idea of radiation from nuclear plants unnerves us in a particularly chilling way.

“Actually,” said David Moncton, “the nuclear industry is the safest industry in this country by a long shot. Nobody ever got killed in a nuclear accident here.”

BY NOW I SHOULD know better. But as I tour the MIT facility for an hour, I continue to worry about my radiation exposure. What will my dosimeter register? *Don’t fixate on the fear*, I tell myself, repeating a strategy I’ve learned in the course of reporting this story. I keep reminding myself that some of the smartest scientists on the planet work here every day. I continue on.

Earlier in the day, Moncton had hinted that I might be able to get a glimpse inside the reactor’s core, to peer down into the concrete tank that’s filled with water and see the blue glow of Cerenkov radiation. Yes, that would put me close to the radiation source, but Moncton had promised that the water would act as a shield, allowing me to see the core. But in the end, I don’t get lucky.

We’re actually going to have to stay some distance away from the open top, Moncton tells me now, because the scientists, who are constantly measuring radiation levels, have decided that there is a risk of contamination closer in. So I’m left to stand on tiptoe glimpsing the reactor pool from afar. (Later, I’ll learn that my dosimeter reading ticked up one line — within the margin of error, I’m assured.) Eventually, the scientists, dressed in yellow coats, come down and introduce themselves. I stick out my hand to greet one, but he leaves me hanging. They chuckle. “He just came down from the top of the reactor, so we don’t do that,” Moncton explains.

“No offense,” the scientist says with a smile. None taken.

At the end of my tour, while we’re waiting for another radiation check, I’m asked if I want a look at the spent-fuel pool. “Um, sure?” I say, and am led into a space containing an open pool that’s the height of a touch tank at the aquarium. Moncton had said earlier that spent fuel was highly radioactive, “just lethal.” I creep close to the pool’s edge until I feel its lip against my waist. “Look at it,” I gasp. Way at the bottom, 20 feet down the dark pool, it glows a faint blue. In that damp, warm room, I shiver.