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Q to the Rescue!
By Tom Matlack

Bostonians know the Quabbin Reservoir as the source of their city's water supply. Thanks to a tenacious UMass researcher and a zealous entrepreneur, the world may soon know it as the home of a microbe that could fuel a clean-energy revolution.
By Tom Matlack

Seventy-five miles west of the State House, between Worcester and Springfield, a huge reservoir built in the 1930s holds the water that ultimately gushes from Boston's showerheads every morning. On the western shore of this 39-square-mile lake, the Quabbin, near the town of Pelham, there stands a forest of hemlocks and beeches. Running through the forest is a small tributary that feeds into a stream that empties into the Quabbin. And at the bottom of that tributary is a muck of partially decayed leaves and sticks. In 1996, UMass Amherst microbiologist Thomas Warnick waded into the muck, leaned down, and dug up a tablespoonful. He scooped the black slop into a jar and sealed the lid tightly. He was holding what just might be the Holy Grail of microbiology.

At the time, of course, Warnick didn't know that. He simply climbed out of the water and an hour later was back in the Amherst lab of his colleague, professor Susan Leschine, where he stuck the jar in a pile of containers holding the finest soil from Brazil, Mexico, France, and Hawaii. Leschine was researching microbes that break down plant waste—and within the Quabbin sample, she soon isolated an unusual bug. When she looked through her microscope, she saw a single-celled microbe that wasn't round and fat like the ones collected from around the globe, but slender, with a circular spore at one end, which made it resemble a tiny lollipop. She came to call this microbe "Q," a nod to its reservoir home.

Over time Leschine discovered that Q not only looked different from any microbe she had seen, but also acted like no other microbe. It had the ability to home in on many compounds—particularly cellulose (the fibrous, insoluble molecules that form a plant's cell walls), and turn it into sugars, and then, even more surprising, transform the sugars into pure ethanol. This was huge: Currently, plant waste has to be run through machines (which consume energy of their own) in order to make ethanol, a process that carries a steep price tag. But Q could make ethanol on its own—in one step, with no machinery involved. Its ethanol would be nearly as clean a power source as solar or wind. All of which meant Q could probably make someone a lot of money, too.

Susan Leschine is 62, with blond hair and freckles. She's known around campus as much for her warmth as her intelligence; in her lab, she greets visitors with a smile and

a touch on the arm. Leschine has the ability to explain very complicated things very easily, a useful skill for someone whose research deals with the physiology, ecology, and diversity of polymer-decomposing members of microbial communities.

Leschine has spent 30-plus years identifying new species of anaerobic bacteria—the kind that don't need oxygen to grow—and figuring out how they work. She's always been interested in microscopic bugs that eat big stuff without the benefit of a mouth. The small number of microbes that can find and feed on much larger plant material underwater actually turn themselves inside out to accomplish the trick. "Sticks and leaves obviously do break down at the bottom of a pond," Leschine says. "But how is a mystery," since the cellulose they contain won't break down on its own.

In 1996, she tested the Quabbin soil for its ability to consume plant cellulose by putting a small sample on a piece of filter paper and pouring water over it. Then she waited a few days to see whether the paper disappeared. It did. The Quabbin muck ate the paper. Intrigued, she examined the zoology in the soil in an attempt to isolate the individual microbe doing the work. It took Leschine several months of comparing microbes against textbooks and then peering back at the soil to single out Q.

She noticed that Q, trying to locate its food, released dozens of enzymes into the water; she'd never seen a microbe release so many. These enzymes attacked almost any plant cellulose, breaking it down into sugar. The microbe then "smelled" the sugar in the water, swam toward the plant, and gorged itself.

Leschine initially focused on Q's adaptability, its ability to eat any waste, as its unique trait; it didn't occur to her to think about the importance of its ethanol-generating prowess. Then, in 2005, she conducted an experiment, feeding Q more plant material to see if ethanol production would jump. While Leschine had discovered other bugs that consumed sugar and made trace amounts of ethanol, there was never a 1:1 ratio of increased food intake and increased ethanol production. In fact, with other bugs, the ethanol production had hardly budged at all. But with Q, the more sugar she fed it, the more ethanol it put out. "That was the moment that the light bulb went on."

Leschine loved being a professor, and had never dreamed of starting a company. Yet as UMass faculty, she had a contract with the state requiring her to divulge any discovery made in her lab that might have commercial application. "In the end, I felt obligated to disclose what I had found," she says. "I thought, ‘Wow, this could actually be really useful to humans.' As opposed to much of microbiology."

Parviz Tayebati grew up around oil fields. Today the 48-year-old entrepreneur lives in the Ritz towers in Downtown Crossing with his wife and two small children. Though he looks like a Harley rider—shaved head, dark eyes, closely cropped goatee—he is also a farmer, with a second home in Sherborn where he raises chickens and goats. But he's

not much for the slowed-down life. Tayebati speaks so quickly and with such enthusiasm that it's sometimes tough to follow him.

The man has always known energy. He was born in 1960 in Azna, Iran, along the Zagros Mountains, halfway between Tehran and the Iraqi border. The town existed to produce oil; his father was an oil field technician. Though Tayebati didn't come from a particularly academic family, he loved mathematics and physics. They kept his mind from the speeches of Muslim insurrectionists beyond his window.

Tayebati went to college in Great Britain at the University of Birmingham, leaving Iran just months before the shah was overthrown in January 1979. He never returned home. Tayebati received a Ph.D. in quantum electronics from the University of Southern California in 1989, and four years later founded a company called CoreTek that developed technology to help phone companies switch calls across fiber-optic cables. In 2000, just after becoming a U.S. citizen, Tayebati caught the peak of the Internet boom, selling his business to Nortel for $1.43 billion. After the tech bubble burst, he searched for something new to invest in. He chose what he knew, but with a twist: green energy.

Tayebati quickly sized up the problem. Though energy independence has become a national goal, 70 percent of America's gasoline is imported. The alternative thus far has been corn ethanol, which in theory burns cleaner than oil. Last year, 6.5 billion gallons of the stuff were produced in the U.S. But using corn to make ethanol means it is not being used to feed people or livestock, which, according to some research, has driven up food prices. Worse, the conversion of corn to fuel burns more energy than it produces.

Plant waste would be an ideal substitute for corn. The Energy Independence and Security Act of 2007 mandates as much: 16 billion gallons of renewable fuel must come from cellulosic ethanol by 2022. The problem with cellulosic ethanol at this point is that you need two factories to produce the stuff: one to break down the waste into sugar, and another to turn the sugar into ethanol. That's not efficient. Or cheap. But Tayebati would learn that a new entry to the market could be both.

In October 2006, Tayebati attended a CleanTech conference in Boston, where he met Jef Sharp, an entrepreneur from Northampton. Just days before, Sharp and Leschine—who were introduced by a mutual friend—had launched SunEthanol, with Sharp as CEO and Leschine as chief scientist.

As he talked with Sharp, Tayebati immediately understood the importance of what Sharp was describing. If Q could break down plant waste on its own, it meant there now existed a one-step process for producing cellulosic ethanol. But Tayebati wanted to see it for himself. So he drove to Amherst to meet with Leschine a week later. "When I walked into her lab, I smelled gas," he recalls. "I looked around to see if they had been

using ethanol to clean instruments or something. Sue said it was just her bug. I thought, ‘Oh, my God!'"

Since Q was a newly discovered species, exclusive to the Quabbin Reservoir, the chances of market duplication, in mogul-speak, were nil. As soon as Tayebati got back into his car, he called his friends at Battery Ventures, a large Boston venture capital firm, to tell them what he'd found. Soon Battery was spending days meeting with Leschine. After that, two more companies wanted in: a small western Massachusetts VC firm named Long River; and South Dakota–based Verasun, the largest corn ethanol producer in the world. In May 2007, they all poured $4 million into SunEthanol. They're now in the process of raising $20 million more.

The Department of Energy sees Q as a crucial technology, and it has already given SunEthanol four research grants. The ultimate goal is to produce energy in a manner that is truly carbon-neutral: Cars will burn ethanol, emitting the carbon dioxide that plants will absorb through photosynthesis. Then Q will eat plant waste to create more ethanol.

SunEthanol's first pilot plant is scheduled to start production in 2009, likely in Springfield, and currently awaits approval of $2.8 million in federal funding. The company is negotiating with paper and cardboard plants to use their paper remnants, with the hope that the ethanol produced at the facility will power factories now using coal.

Q has another booster in Governor Deval Patrick, who called it a "transformational breakthrough" while speaking to the Greater Boston Chamber of Commerce in May. He is also proposing the state exempt the gas tax on SunEthanol to help the company bring its products to market quickly. "If Massachusetts gets clean energy right," he said, "the whole world will be our customer."

For all the talk of how Q improves on the model of corn ethanol, it still has to borrow some of its language. Ethanol yield is similar to a commodity's yield: How much product can you glean from an area of land? Take corn. The bushels you get from an acre are the corn's yield. The same holds true for Q: The ethanol you get from a microbe is the bug's yield.

The original microbe found at Quabbin produced a yield of just under 1 percent ethanol. Six months after forming SunEthanol, Leschine and her team had Q tripling the yield. They have since kept at the task, preserving only the most potent strains of the microbe so that each successive generation puts out more ethanol than the last.

Five percent is the tipping point at which distilling becomes commercially viable. SunEthanol says Q will be there, and beyond, within the next three fiscal quarters. The superbug just keeps getting more super.