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Exploring the inner workings of materials

November 2 2011, by David L. Chandler

Growing up in an "idyllic" area of farms and orchards in southern New Jersey, Krystyn Van Vliet had little exposure to science or technology. And yet, it was that very environment that she credits with kindling her interest in engineering.

Van Vliet, awarded tenure this year as the Paul M. Cook Career Development Associate Professor of Materials Science and Engineering and Biological Engineering, says working on a farm during her summers in New Jersey is what initially sparked her interest. "Farmers are really creative engineers," she explains: They rely on extremely complex machines, such as potato harvesters, and spend the off-season repairing them. In addition, she says, they are constantly dealing with experimental questions in biology — "questions like, how much nitrogen should there be in the soil for the pepper fruit to grow faster than the leaves?"

Even though her farm jobs often involved the lowliest of tasks — "one of my jobs at the Rutgers Agricultural Research and Extension Center was separating the rotten potatoes and the mud clumps from the good potatoes," she recalls — "the people I worked with were very smart engineers. I learned about how things work, how complicated machines are made and repaired, and how people systematically ask and answer questions."

Besides her farm experiences, Van Vliet says another turning point in her growing interest in technology was a stint at Space Camp, an educational program in Huntsville, Ala., when she was 13. That's where, she says, "I got hooked on … really high-tech stuff."

Those ways of thinking have carried into her academic research, which spans topics from the microscopic structure of concrete to detecting how cancer cells attract new blood vessels to foster their growth. A common thread throughout: the combining of computer models and lab experiments to understand how chemistry and mechanics are closely intertwined in materials that are important to human existence.

"I always enjoyed being challenged," she says. "Like many here, I wanted to do something hard. Engineering seemed like it wouldn't be easy." Engineering related to biology and medicine in particular, she reasoned, "was something that sounded like you'd make a direct impact on people's lives."

Teaching was also a draw from an early age. Even as a child, Van Vliet recalls, "I always loved the idea of teaching." In fact, she says, "I would give classes in my backyard — to nobody." Mostly, these were "very rigorous cooking classes. I always wanted to have my own cooking show, explaining exactly why onion grass made such a great soup."

During her senior year of high school, Van Vliet was in a serious car accident, experiencing what is now termed traumatic brain injury. With much support, she was able to apply to colleges from her rehabilitation facility, and graduate from high school with her class that spring.

While both her parents are college graduates — her father worked at DuPont, and her mother taught Spanish — the idea of going away to college for engineering was "a new idea to all of us," she says. Van Vliet chose Brown University because it offered degrees in both biomedical engineering and bioethics, enjoying her undergraduate experience so much that she thought she wanted to stay at Brown for graduate school as well. She loved "the pace of the lab work — every day, solving a problem or making progress." But her professors encouraged her to expand her horizons.

Van Vliet applied, somewhat tentatively, to MIT's doctoral program in materials science and engineering. "I wasn't even going to visit," she recalls. "I wanted to be surrounded by people who like to play sports, to do African dance, debate philosophy," she says, and she figured MIT "would be all geeks and nerds."

But she received a phone call from Kirk Kolenbrander, who was then on MIT's materials science and engineering faculty (and is now vice president and secretary of the Corporation), urging her to make a visit and even explaining which bus and subway stations to use.

So Van Vliet did end up venturing north to Cambridge, and has vivid memories of that weekend — where, among other things, she met her future husband. She recalls "how much I was impressed by the enthusiasm, the breadth of intelligence" that she found, and how the students seemed "fun and well-rounded."

And, she adds: "I now love the geeky facets of MIT life, and I actively contribute to that!"

Van Vliet enrolled at the Institute, earning her PhD in just four years with a 2002 thesis on predicting defect nucleation in metals. Upon completing her degree, she accepted MIT's offer of a faculty position in the Department of Materials Science and Engineering. But first she spent two years as a postdoc at Children's Hospital Boston, researching how mechanical strain regulates chemical activity of enzymes related to the growth of blood vessels, before returning to MIT as an assistant professor in 2004.

She continues to conduct research on material chemomechanics, which she describes as "the coupling between chemistry and mechanics." Her group has described how tissue cells respond to changes in their mechanical and chemical environments — including changes that may lead to the onset of cancer — by studying nonbiological materials that share this chemical-mechanical coupling: polymers that can mimic some properties of tissues, nanocomposite coatings that can improve the toughness of car bodies, and even cement-based materials in which water confined in small pores can control mechanical properties.

Because her work is so inherently multidisciplinary, she says, “I get to populate our group with students and postdocs from all kinds of disciplines — materials science and engineering, biological engineering, mechanical engineering, solid-state physics, chemistry. It’s a very diverse group of talent. That’s part of our strength, and part of MIT’s strength.”

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Provided by Massachusetts Institute of Technology