A Scientific Star

by Gary M. Stern

Mariel Vázquez, an associate professor of mathematics at San Francisco State University (Calif.), is a scientific star. In July 2012, President Barack Obama named Vázquez a recipient of the Presidential Early Career Award for Scientists and Engineers based on her scientific research. She was one of 96 scientists to receive the award.

Vázquez, who is 41 years old, is a pioneer in the emerging field of DNA topology, which applies pure math to the biological mysteries of DNA. San Francisco State University President Robert A. Corrigan said Vázquez "embodied the model of teacher/scholar that San Francisco State values so highly." Vázquez has been teaching at San Francisco State since 2005.

She was nominated for the Presidential Early Career Award by the National Science Foundation. The award was based on innovative research. Vázquez's award cited her "excellent interdisciplinary and international research at the interface of mathematics and biology, and for creativity and dedication to recruiting, training and mentoring, and helping students from underrepresented groups achieve their goals."

Vázquez's research has groundbreaking potential. She is investigating how DNA interacts with cells and affects radiation and cancer treatment.

San Francisco State University epitomizes a multicultural campus. Of its 29,540 students who enrolled in fall 2012, 35 percent were Asian-American; 30 percent, White; 24 percent, Latino; and 6 percent, African-American. Over 4,200 students were majoring in science, though business administration and biology were the two most popular majors.

Born and raised in Mexico, Vázquez immigrated to the U.S. in 1995 when she was 24 years old to earn a master's degree and doctorate at Florida State University. She learned English in Mexico and was already bilingual when she arrived in the U.S.

The Hispanic Outlook in Higher Education Magazine interviewed Vázquez on how she came to specialize in DNA topology and became an award-winning scientist.

***The Hispanic Outlook*:** Some people might say that your earning a Presidential Award for Science defies the stereotype of immigrants. What's your take?

Mariel Vázquez: I think it defies the view that most people have, but it's really hard to generalize about immigrants. Most immigrants are hard workers. It's good to receive an award to show that people can do very good work and succeed even if the U.S. isn't their native country. We're a nation of mixed people and diverse ideas, and there's plenty of talent among immigrants.

***HO*:** What adjustments did you have to make when you moved to a new country and started at Florida State University?

Vázquez: I was already 24 years old and had gotten my undergraduate degree in Mexico City. But this was the first time I was taking all my classes in English. I had to adapt to the Southern dialect of my professors. But I adjusted quickly and earned my doctorate at Florida State.

***HO*:** What influence did your parents have on your academic life?

Vázquez: Both my father and grandfather were engineers. As a child, I loved numbers and anything mathematical and geometrical. Having a father and grandfather who were engineers stimulated me and helped encourage my curiosity. My mother spent a lot of time with my brother and me, and she was an arts and literature lover. In my work, I combine mathematics with molecular biology, which is also very geometrical, visual and three-dimensional.

***HO*:** What drew you to mathematics?

Vázquez: I always liked the patterns and numbers in mathematics. I did well at math in elementary and middle school. Having parents who were well-educated showed me not to fall into stereotypes that I couldn't accomplish something. I felt free to explore math.

***HO*:** You earned an undergraduate degree in math at the National University of Mexico (NUM). How did that set the foundation for your mathematical pursuit?

Vázquez: That was fantastic. NUM appears as one of the top 100 ranked universities in the world. One of their specialties is in the pure sciences like mathematics. The environment for learning in the classroom and doing outside research was excellent. The education in Mexico is a hybrid between the American and European systems. When we study math in Mexico, we do four years of only mathematics, but it's not as rigid as Europe and is more flexible like in the U.S.

***HO*:** You started as a mathematician and morphed into a research sci-

Blossoms at San Francisco State University

entist. How?

Vázquez: In high school, I loved mathematics and molecular biology. I wanted to apply mathematics to molecular biology. I tried to apply pure math into the study of knots and DNA. Hence, my knowledge of math merged with my knowledge of DNA.

***HO*:** Describe the impact of being a research and teaching assistant in the math department at Florida State University.

Vázquez: I had a research fellowship from my Ph.D. advisor DeWitt Sumners, a professor of mathematics at Florida State. He was the reason I chose Florida State. He specialized in mixing pure mathematics and knot theory with the study of DNA. At that time, there were no interdisciplinary programs between math and biology in the U.S. Professor Sumners developed a mathematic theory to understand DNA topology. He allowed me to follow my passion and work on both mathematics and molecular biology simultaneously.

***HO*:** You served as a visiting scholar at University of California-Berkeley. What did you do there?

Vázquez: I spent five years at Berkeley as a postdoctoral fellow. Half of my time involved doing TNA topology research, working with Professor Rainer Sachs, whose specialty was in mathematical models for radiation biology. You take human cells and eradiate them with low-dose X-rays. In essence, we used mathematics to determine how the DNA had been rearranged. It's equivalent of finding the right radiation and dosage in cancer treatment. We're exploring the effect of radiation on human cells and determining how cells are coping. These studies can help understand the instability of the cells.

***HO*:** You were named an assistant professor of mathematics at San Francisco State in August 2005. Describe why the job appealed to you.

Vázquez: I like the academic track, teaching people, mentoring them and doing research. I teach a variety of courses including one I developed in DNA topology with my colleague Javier Arsuaga, who also happens to be my husband. I spend about 20 percent of my time teaching in the classroom, and 30 to 40 percent mentoring undergraduates and graduate students one on one, who are majoring in mathematics, molecular and cell biology, bioengineering. We also have an affiliation with Berkeley, so I mentor their students too. My mentoring of students also involves doing research with them. In fact, I spend about 20 percent of my time doing service to the university and community, including reviewing grants and talking on panels. All told, half of my time is spent doing research.

***HO*:** Describe your undergraduate thesis on knot theory and DNA.

Vázquez: Knot theory is part of mathematics that studies knots. A knot is like your shoelace knot. You take a shoelace and tie the first part of it and then glue the ends of the shoelace together. Once you tape it together, you have a mathematical knot. If you don't tape it, it can be untied. If you don't tie the knot, you just have a piece of string that can be untied. It functions like DNA.

***HO*:** In what sense?

Vázquez: DNA molecules sometimes are circular, like the chromosomes of bacteria. Our DNA isn't circular. The DNA of bacteria is circular, and every time you have a circle, the circle can be knotted. It's like taking your headphone from your iPod and putting it in your backpack. Invariably, when you take it out, it'll be knotted. The same thing happens inside cells. If the DNA becomes circular, in the process it may become knotted. This process may be helped by larger proteins called enzymes. We're trying to figure out how the DNA became entangled using mathematics. The long-range implication is we're trying to figure how the DNA is sitting inside these viruses and how enzymes change the topology of DNA (topology involves how the DNA is sitting inside the three-dimensional space like a rubber band).

Official White House Photo by Pete Souza

President Barack Obama addressing 2011 Presidential Early Career Awards for Scientists and Engineers (PECASE) recipients in the East Room of the White House, July 31, 2012

(Vázquez is in the front row, fifth from the right)

HO**:** What is the impact of knot theory in biology?

Vázquez: Before cells divide, circular DNA is copied or replicated. It forms two circles that are interlinked or interlaced. The cell is trying to divide into two cells. Each cell requires one circle, but the circles are interlinked. One pulls to the left; and the other, to the right, but either circle can break. Either cell can break or the two circles could migrate to the same cell, leaving one cell with no DNA. But this is not good. You want each cell to have exactly one intact circle. Certain enzymes ensure that this happens. Some anti-cancer and antibacterial drugs target the enzymes that remove the DNA knots and links. If you try to understand the mechanics of these enzymes, you can design drugs that eliminate those enzymes. By doing that, the cancer or bacterial cells will die.

HO**:** What are your goals in conducting this research?

Vázquez: I would like to standardize ways of studying the topology of DNA. There's been a lot of attention on DNA because of human genome research. That attention has focused on the sequence and code of DNA. We've been moving toward trying to understand how DNA topology affects the cells.

HO**:** What has being named one of 96 recipients of this Presidential Early Career Award done for you?

Vázquez: It's been fantastic recognition. It says that so many years of hard work have paid off. It also carries a great sense of responsibility. I've been interviewed by the media, and some people consider me a role model. A huge responsibility comes with this award.

HO**:** What did President Obama say in his invocation?

Vázquez: President Obama said, "I see some women here. We need more. I see some African-American and Hispanic women. We need more of them."

HO**:** Why aren't there more women and more Latino women in the sciences?

Vázquez: Women are hard working, do very well in college, are interested in science, and then we lose them. Part of it stems from the natural time when women marry and have children and raise a family. In science, we need more family-friendly policies. We need graduate schools that support women with families. Women also need to become more assertive, and I don't mean aggressive. We need to train women science majors to be good public speakers and good managers. Latinos, in particular, need to believe they can do it and that anything is possible.

HO**:** Describe your personal life.

Vázquez: My husband Javier Asuraga also teaches mathematics at San Francisco State. We have two children: a 4-year-old boy and 9-year-old girl. I manage to juggle family and career. I do what I like and have a passion for my work. But at home, we try not talk too much about DNA topology.

HO**:** Five years from today, what would you like to have accomplished?

Vázquez: I'd like to have developed robust mathematical and computational tools to study the entanglement of DNA. I also aim to instill the love for math and science in children by bringing the excitement of the research to them.