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Professor genetically modifies mosquitoes in quest to protect humans

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Matthew DeGennaro is determined to stop the world's deadliest animal.

Accounting for as many as 725,000 deaths worldwide every year, mosquitoes transmit a variety of infectious diseases including malaria, dengue fever, yellow fever, West Nile virus and Zika. While there are thousands of species of mosquitoes, only a small number are known to transmit diseases. As fate would have it, the carriers of disease happen to be the species that prefer the taste of humans. The Aedes aegypti mosquito is among those, a spreader of yellow fever, dengue and Zika. DeGennaro spends his days surrounded by them, trying to better understand why they hunt people and how he might stop them from biting us.

The FIU biologist is the first scientist in the world to create a mutant mosquito—a feat he achieved in 2010 as a researcher at Rockefeller University in New York. While it sounds like a Marvel movie in the making, DeGennaro has no intention of unleashing a new type of mosquito on the world. His mutants serve a greater scientific purpose—they help him better understand what attracts mosquitoes to humans.

DEET, the most common active ingredient in insect repellant, is not enough to safeguard humans.

"Although DEET is safe and effective, we need new tools to prevent mosquitoes from biting us," DeGennaro said. "Understanding how

DEET works will help us develop a new generation of repellents."

Scientists still are not entirely clear as to how DEET works. They don't know if DEET alone repels the pests or if it mixes with human odors to confuse mosquitoes so that they lose their attraction to people. Because you can't exactly ask a mosquito, DeGennaro has gone the scientific route.

First-generation college student

DeGennaro was born in the Bronx and grew up in Rockland County, New York, to middle class parents. His father was an elevator mechanic and his mother worked as an administrative secretary. By the age of 15, DeGennaro had grown tired of high school and knew he was ready for something more challenging. So he enrolled at a liberal arts college in Massachusetts designed for high school students who want to start college early. There he earned an associate's degree in natural sciences before enrolling at Bard College in New York, where he double majored in the history and philosophy of science and gender studies.

He then headed west, working as a research scientist at the Oral AIDS Center at the University of California, San Francisco, where he studied Epstein-Barr Virus in HIV patients. Returning to New York a few years later, he was hired as a research scientist at Howard Hughes Medical Institute at Columbia University and later at the Skirball Institute of Biomolecular Medicine at New York University School of Medicine. Through these experiences, DeGennaro realized two things about himself—he didn't want to be a doctor and he was pretty good at being a scientist. So he enrolled at NYU to pursue a Ph.D. with Ruth Lehmann, one of the founders of developmental genetics.

Shortly after earning his Ph.D. in 2008, he landed a coveted postdoctoral research position in the Laboratory of Neurogenetics and Behavior at

The Rockefeller University in New York under the direction of Leslie Vosshall. It was a perfect match. DeGennaro was a geneticist looking to study neurobiology in an insect system. Vosshall is known internationally as the scientist who discovered the insect olfactory receptors. By the time DeGennaro arrived in her lab, she had decided to shift her focus from flies to mosquitoes.

"She asked me if I wanted to create the first mutant mosquito. That sounded interesting," DeGennaro said.

He accepted the challenge and got to work.

History in the making

Mosquitoes rely on their antennae to track down each meal. Along with heat and CO2 sensors, these tiny projections are equipped with 131 odor receptors. These receptors enable mosquitoes to isolate different odors in the air and pick up the most desirable scent to them—unsuspecting humans. That much was known in 2008. But scientists knew little else. To uncover the secrets of the mosquito, DeGennaro and Vosshall turned to the fruit fly. Research had already determined odor receptors in fruit flies are all linked to a single gene. Without that gene, the flies can't detect odors in the air. The scientists hypothesized that the mosquito's odor receptors might rely on a similar gene. In less than two years of joining Vosshall's lab, DeGennaro successfully "tweaked" the targeted gene in an Aedes aegypti mosquito, essentially turning it off.

When the researchers exposed the modified mosquito to human scent, the mutant had lost interest. The mutant also became resistant to DEET. With that single genetic modification, DeGennaro successfully influenced the mosquito's behavior.

When he arrived at FIU in 2014, he continued his work with mutants

and joined the research team in the Biomolecular Sciences Institute in the College of Arts, Sciences & Education. In an institute where much of the work focuses on the treatment of diseases, DeGennaro's research stands out. Instead of finding cures for patients, he is trying to stop diseases before they ever get to people.

"Mosquito-borne diseases are serious global health problems with high relevance to South Florida," said Yuk Ching Tse-Dinh, a biochemist and director of the Institute, which is housed in the college's School of Integrated Science and Humanity. "Dr. DeGennaro's work may provide novel approaches for controlling the spread of these diseases."

DeGennaro joins FIU researcher Fernando Noriega and others at the university who are exploring the world's insects, and in particular, the mosquito. DeGennaro's fast-growing lab includes 12 undergraduate students, three graduate students and a postdoctoral researcher. The team genetically modifies mosquitoes to influence their behavior, trying to isolate what parts of a mosquito's genetic makeup makes it thirst for human blood. He says if his team can identify which genes lead mosquitoes to people, scientists should be able to refine and improve upon current repellants and mosquito controls. Because of the important role biodiversity plays on the planet, DeGennaro doesn't want to rid the world of mosquitoes. After all, it's only a select few species of mosquitoes that are giving the thousands of others a bad name. He just wants to stop them from zeroing in on people. With that goal in mind, DeGennaro is also working with fellow FIU professor Jamie Theobald to understand how the sense of sight figures into the hunt.

The Zika outbreak

DeGennaro's efforts have garnered international attention in recent months as an outbreak of Zika has gripped much of South America. Brazil, which will host the 2016 Summer Olympics in August, has been

the hardest hit. Zika has been linked to an increase in cases of babies born with microcephaly, a condition that results in abnormally small heads and underdeveloped brains. In adults, Zika is not fatal. Zika's symptoms can include rash, joint pains, pinkeye and fever, and tend to subside within a week or two.

Zika is transmitted through the bite of the Aedes aegypti mosquito, which is prevalent in warm, humid climates, such as South Florida. More than 1,100 cases of Zika have been reported throughout the United States, including Florida. The World Health Organization estimates that the Zika virus will reach every country in the Western Hemisphere before the end of 2016, infecting nearly 4 million people. Last year, more than 1 billion international travelers were logged, according to Carolin Lusby, an assistant professor of tourism, research methods and leadership in FIU's Chaplin School of Hospitality & Tourism Management.

"With so much people flow, there is always risk for diseases to travel around the world," Lusby said.

Currently, there is no treatment for Zika and no vaccine. This reality makes DeGennaro's work all the more critical. The first and currently the only line of defense is preventing an infected mosquito from biting you in the first place. DeGennaro would argue that preventing the bite of a mosquito should be a priority to combat all mosquito-borne diseases.

His work is pushing science toward a new generation of repellants and mosquito controls that could usher in a new era of disease prevention.

"If we can stop mosquitoes from finding us, we can save 725,000 lives a year," DeGennaro said. "The key is understanding mosquito behavior."