DNA Barcoding Investigations Bring Biology to Life

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When Sophia Cuprillnilson walked into her undergraduate genetics class in the fall of 2008, little did she realize that her perception of biology would be transformed forever. "I thought I was going to be learning about Mendel and peas," she said. Instead, Cuprillnilson and her classmates became DNA detectives, sent out in pairs to collect samples of fish from local restaurants. Back in the lab at Nova Southeastern University's Farquhar College of Arts and Sciences in Florida, they extracted DNA, created primers, and analyzed the sequences to determine whether consumers were really getting the species described on the menu.

Their professor was Mahmood Shivji, who is also director of the Guy Harvey Research Institute at the university's Oceanographic Center, in Dania Beach, Florida. In early 2007, he led an investigation into fish labeling at restaurants and found significant substitutions. He decided to continue the investigation with his genetics class that fall. "It was much more exciting than using the typical genetics lab teaching organisms, *Drosophila,* or onions," Shivji said. "The students didn't know the outcome of the investigation, and the instructors didn't know it either, which is very atypical for an undergraduate lab."

He didn't have to change his syllabus very much to incorporate the real-world investigation because it already included the protocols for DNA extraction and creating primers for DNA amplification. "I was very pleased to see that the students really got into it," Shivji said. "Plus, it accomplished all of the education goals for the course and was fun for me too. And I suspect the students absorbed much more this way than if we had simply followed a standard laboratory textbook exercise."

The students' enthusiasm stemmed from the fact that there was a real-world connection to what they were learning. "We're always in our textbooks and notebooks," Cuprillnilson says. "We mostly just care about the next exam and what's going to be on it, but [Shivji] connected our outside life with our school life." The course not only changed her perceptions, it also changed her career path. Cuprillnilson originally had an interest in surgical procedures, but after taking genetics during her junior year, she realized that "surgery is rather medieval compared to what I was learning." She became fascinated by the elegance and sophistication of using DNA-based tools and technologies in preventive medicine applications.

Other biologists recognize the power of DNA barcoding not just to teach biology through connections to the real world but also to immerse students in the exciting process of science. As an investigator in the Program for the Human Environment at Rockefeller University in New York, Mark Stoeckle became involved in extracurricular science projects because of his daughter's inquisitiveness. After hearing him talk about his work, his daughter asked about applying the technology to identify the fish served in sushi. A year later, with Stoeckle as their adviser, she and a friend completed "sushigate."

The experience was so rewarding that Stoeckle decided to invite two other students from his daughter's school to collaborate on another project. Brenda Tan and Matthew Cost, then juniors at Trinity School, heard Stoeckle's presentation at a school assembly and volunteered to become DNA investigators. "He told us we'd be exploring New York City through the lens of DNA," said Cost. "I thought it would be fun and a neat way to learn something new." Tan originally thought the project would be an extension of what Stoeckle had done with his daughter, but she was pleasantly surprised to learn it would be a novel investigation. According to Tan, "Dr. Stoeckle asked us what we were interested in and valued our opinion." The result was the DNAHouse project (*http://phe.rockefeller.edu/barcode/dnahouse.html*).

The DNAHouse investigators collected specimens, such as a feather duster and a dead cockroach. They photographed, cataloged, and sent each item to the American Museum of Natural History for DNA extraction and sequencing. Then Tan and Cost entered the sequences into GenBank and Barcode of Life databases to find species matches. Cost was surprised to find that, regardless of the original condition of the specimen, they found DNA in so many things. Tan's favorite discovery was a genetically distinct cockroach that could be a new subspecies.

In contrast to other school endeavors, the DNAHouse project was a true discovery experience for the students. "Instead of following a strict lab protocol, we based our next step on our collected samples," said Tan, adding, "I felt like a true scientist." Stoeckle encourages other high school and undergraduate instructors to try this approach, especially because the technology is cheaper and more accessible than ever. "This is the future of science," Stoeckle says. "DNA is an exploratory tool that many people can use to learn something that no one else knows, finding out things that even experts don't know."

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