Beyond Mendel: Student DNA Barcoding Project introduces next-generation microbiology to classrooms

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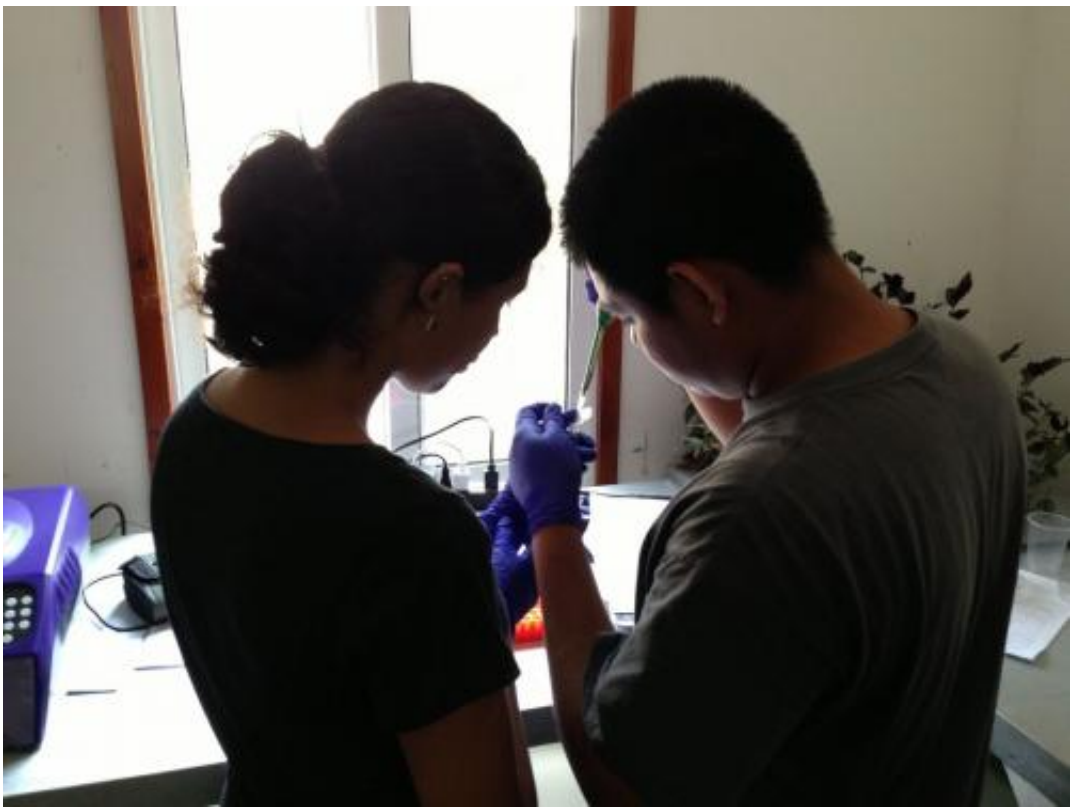

Students in Dangriga, Belize perform DNA extraction, one step in the DNA barcoding process. The students are identifying the species of fish filets bought at a local market to determine if the filets were mislabeled. Credit: Marissa Bellino, Biodiversity Center of Belize

On a cloudless day in Dangriga, a coastal city in southern Belize, a group of students are hard at work. One wall of their sun-strewn lab is lined with the usual gear of modern genetics: thermocycler, gel electrophoresis system, micropipets, test tubes. Swathed in purple gloves, they measure samples, mix gels and fill pipets with the utmost concentration.

A usual class this is not.

It is part of the Student DNA Barcoding Project, a flexible curriculum that uses student-generated research to teach about biodiversity, ecology and molecular biology. The project, which began in New York City and has now spread to Belize, is detailed in a paper in this week's issue of *Science*.

"We wanted to create an experience, inquiry-based, and introduce students to molecular biology skills they could potentially use as undergraduates," said Stephen Harris, who authored the paper with Marissa Bellino. Harris is a National Science Foundation (NSF) Graduate Research Fellow, studying evolutionary biology at the City University of New York (CUNY). Bellino is a New York City high school teacher and a student in CUNY's Urban Education PhD program.

The two met and developed the project through NSF's GK-12 program at CUNY. GK-12 paired doctoral candidates with K-12 science teachers. The graduate students were required to teach 15 hours each week in the K-12 classroom, integrating their research with the school's science teaching. More than 300 projects—reaching over 10,000 graduate students and 700,000 K-12 students—were supported through GK-12. The program ended in 2011.

GK-12 offered students a new perspective on studying science and gave doctoral students new skills—such as communication and time management—that come through teaching, said Sonia Ortega, program

director of NSF's Division of Graduate Education. The particular partnership between Bellino and Harris was successful because "they really took the opportunity to do something unique and meaningful," Ortega said. "They really went after it."

Not only did Bellino and Harris craft a yearlong curriculum—one that spurs students to make their own research questions, experiment and read scientific literature—they also secured funding to build a molecular lab in their Manhattan school.

Many schools send students into professional science labs, but the extra time and resources it requires means those students are often from private or top-tier public schools, Harris said.

Belizean students collecting insects in Dangriga, a city on the country's southern coast. Sampling local biodiversity--which includes collecting and classifying species in the local ecosystem--is the first part of the Student DNA Barcoding Project curriculum. Credit: Marissa Bellino, Biodiversity Center of Belize

Instead, he and Bellino wondered what would happed if they could build a lab within the school and bring the scientists to the students in a safe environment, where students could work every day at their own pace.

DNA barcoding, a relatively recent innovation, uses a fragment of DNA from a standard part of the genome to identify species. The DNA clip is short enough to be sequenced quickly, yet long enough to tease out variations among species. Barcoding is an apt term, since the process is similar to scanning a UPC code at the grocery. It distinguishes your pears from your potato chips, and your salt and vinegar potato chips from your barbeque ones.

From the beginning, the Barcoding Project was designed to be "very inquiry based and driven by student interest," Bellino said. Placing onus on the students—what do you want to study?—gave them ownership of the science. "A lot of responsibility was on them and their ability to ask the questions and come up with the design."

Students explored biodiversity in Manhattan parks. One became passionate about beetles, collecting them, learning their taxonomy. Another installed beehives on the school's roof to study colony collapse disorder. She monitored the bees, searched for viruses in their RNA, and received a full scholarship to continue her work at Cornell University.

All of the student research is uploaded onto The Barcode of Life Data Systems, an online database used by the international scientific community.

Bellino and Harris first took the Barcoding Project to Belize in 2012, partnering with The Petters Research Institute, a nonprofit that promotes science, technology, engineering and mathematics in the country.

That first year, they did ecological sampling, collecting and classifying

insects. Barcoding was added in 2012, thanks to a traveling DNA lab—two suitcase-sized boxes, now stored in Harris's apartment.

University students performing DNA extraction at a Biodiversity Center of Belize workshop. DNA extraction is one step in the process of DNA barcoding. A relatively recent innovation, DNA barcoding uses a fragment of DNA to identify a species. These students were trying to identify fish species. Credit: Marissa Bellino, Biodiversity Center of Belize

Dangriga is thousands of miles from New York City. Yet "similarities between the students were incredible," Harris said. Both cities are urban environments, where young kids don't have much connection to the natural landscape. This project can help change that, Harris said, by teaching students the importance of protecting biological diversity.

Next year, the Belize component—officially called the Biodiversity Center of Belize—will include a conservation camp at the country's zoo. Students will use DNA barcoding to determine the sex of some of the zoo's scarlet macaws, and zoo staff will be trained in lab techniques.

Now that the Student DNA Barcoding Project has been successfully used outside New York, Bellino and Harris hope it will spread to other U.S. schools. The curriculum is available on the GK-12 website, and is attached to the Science article.

"Science is about sharing, and so is education," Bellino said. "Anyone who wants to take it and model it and run with it would be amazing."

She measures success of the project in small victories: a student entering a science competition for the first time, the anticipation and the nerves before they nail their presentation.

"When they are doing the research, they can't see what's happening necessarily," she said. It's not until those moments when students step back and reflect that they realize "I've done so much and this is mine and I know this better than anyone else in this room."

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