Investigating New York City with DNA

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Summary: Student detectives investigate household items, find DNA everywhere.

Short message: “DNA is all around us.”

What did you do?

We investigated whether DNA testing can identify household items. We collected all types of specimens that we thought might contain DNA and took them for testing. We matched the sequences from our samples to those in the Barcode of Life Database. We focused on animal products because the barcode library for plants is not developed yet. We worked with scientists at Rockefeller University and American Museum of Natural History.

What is DNA barcoding?

DNA barcoding is a simple, standardized way of identifying species by DNA. It uses methods that can be carried out in any laboratory familiar with DNA work.

What did you find?

1. We got DNA from most things we tested. (DNA was found in 151/217 (70%) of the items)

2. We found DNA from 95 different animal species.

3. We could identify the DNA in all kinds of human and pet foods including raw, cooked, dried, and processed foods. For example, we obtained chicken DNA from dried soup mix, scrambled eggs, dry dog food, and chicken McNuggets, and we found beef DNA in cooked hamburger, beef jerky, bologna, yogurt, cheese, and even butter. One exception was canned foods; we got DNA from only 1 of 21 canned items.

> *Why not from canned foods?*
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> When foods are canned they are heated to high temperatures which breaks up the DNA into small pieces that are hard to detect.

4. We found 16% of food items we tested were mislabeled. For example, a specialty cheese labeled as being made from "sheep's milk" was made from ordinary cow's milk, and a delicacy labeled “dried shark” was Nile perch, a freshwater fish from Africa. “Venison” dog treats turned out to be beef. Fish were the most commonly mislabeled items.

Is food mislabeling important?

We think food mislabeling is important. First of all you should know whether you are getting what you pay for. Second, some people have allergies, or dietary restrictions about certain foods. Finally, knowing the species can be important for protecting the environment, such as fish that are protected or regulated. Knowing about the sources of foods for pets like cats and dogs is important too.

What else did you find?

1. We found DNA lasts a long time. For example, we found DNA in an ostrich feather duster sitting in a hardware store, an insect stored at room temperature for 6 months, an old hairbrush that hadn't been used for a year, and a dried food item purchased 8 years ago.

2. We could identify animals from what they leave behind in the environment. For example, we found DNA in a pigeon feather on the sidewalk, dried-out horse manure in Central Park, bat droppings, and a shed snakeskin.

3. We found the DNA library could identify most things we tested. Even when DNA barcodes did not match exactly, we could usually get a good idea of the type of organism from what other species it was closest to. Most of the specimens that did not match exactly were insects.

4. We found a genetically distinct cockroach that might be a new species or subspecies. Our specimens were identified by appearance as American cockroaches (*Periplaneta americana*). However, the DNA sequences of our specimens were different from those of other American cockroach specimens. They differed by about 4%. Differences within species are usually 1% or less. This might mean our specimens are a separate species or an isolated population within the species.

What is your most important result?

We think our most important result is that "DNA is all around us." This means that DNA testing a good way for students or anyone to explore and learn more about their environment, including in the city.

Who helped with your project?

Dr. Mark Stoeckle and Mr. Jesse Ausubel at Rockefeller University helped us with collecting samples and analyzing data. Dr. George Amato and colleagues at AMNH did DNA barcode testing of our samples.

What did you learn from identifying species?

Learning the species name was like finding a key that opened a new book. It's exciting to learn more once you know a species name. For example, "dried shredded squid" turned out to be

Jumbo flying squid (*Dosidicus gigas*). We looked up Jumbo flying squid and found it grows to 100 lbs, swims at depths up to two thousand feet, travels in large schools containing hundreds of indivduals, and hunts in cooperative packs like wolves. This gave us new thoughts about the oceans and about calamari salad!

Were there any surprises?

There were a lot of surprises. For one example, we tested "buffalo mozzerella" cheese and found it is made from milk of Water buffalos! We asked some adults who have ordered it on restaurant menus and they didn't know that.

Are there advantages to DNA identification compared to identifying by appearance?

First, we could name some organisms that usually only experts know. For example, a strange long-legged centipede from a classmate's house turned out to be a House centipede (*Scutigera coleoptera*), which is a species that came originally from Europe.

Second, we were able to name items that even an an expert couldn't identify, like the dried shredded squid. We could even identify species in highly processed foods, like dog biscuits.

Third, we got a picture of evolution by comparing DNA sequences. For example, we found vertebrates and invertebrates were on different branches, and coyotes and dogs had very similar DNA sequences. We also saw how individuals within a species can have very similar DNA barcodes. For example, we tested hair samples from 8 classmates (just one hair gave enough DNA for testing!) and found their sequences were identical or differed by just 1 site out of about 650. We used special software that is available for free on the web to do these comparisons.

Were all the DNAs from animals?

We collected a few non-animal specimens. We got DNA sequences from a fresh raspberry and from mold growing on a shower curtain.

Why can't you do barcoding for plants?

Scientists are working on a DNA barcode method for plants. The COI barcode region used for animals doesn't work well in plants. Plant COI sequences don't differ enough to tell species apart.

What did you learn about science?

We learned it is important to have accurate records and keep careful track of specimens! We had to pay careful attention at all steps with our evidence. First, we labeled each specimen clearly with a number, and recorded the information about when and where we got each specimen on a spreadsheet. Second, we took a digital picture of each specimen. Third, we delivered the labeled specimens and the spreadsheet to the museum and made sure we had back-up copies of the data and pictures. The scientists at the museum also tracked each specimen and

made sure the sequence results were linked to the specimen numbers. When we analyzed the sequences, we double-checked the results to be sure the search results matched our original spreadsheets.

How do you do DNA analysis?

The DNA testing was done by scientists at the American Museum of Natural History. The general method is to purify DNA from the specimen, then amplify the barcode region with what is called PCR or polymerase chain reaction, which is like "xeroxing" the gene to make a lot of copies of it, and then do DNA sequencing. Every week or so the researchers at AMNH emailed us new sequences from specimens we delivered. We also met with scientists to go over our results. The scientists at AMNH can give you more information.

What is a DNA barcode?

A DNA barcode is a short sequence from a standardized gene used for identifying species. The DNA barcode for animals is part of a mitochondrial gene called COI. You can find more information on websites related to DNA barcoding.

How do you use the barcode library?

Searching for matches in the database is just like using Google, except you enter the DNA barcode, which is like a word 650 "letters" long. You "copy and paste" the barcode sequence into the search box on the barcode database, and hit enter! The search engine then gives you the closest matches, their scientific names, and where they were found.

Who paid for the study?

The scientists at Rockefeller University and American Museum of Natural History donated their time and materials to the project.

What is the next step?

We hope other students will be interested in doing similar projects using DNA to explore their environment.