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DNA in the City

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Students Brenda Tan and Matt Cost, together with barcoding experts, are available for advance interviews. High-resolution photos are available for media use at http://phe.rockefeller.edu/barcode/dnahouse.html

Student Sleuths Using DNA Reveal Zoo of 95 Species in NYC Homes; Reveal Potential New Cockroach Species and New Evidence of Food Fraud

Two New York City high school students exploring their homes using the latest high-tech DNA analysis techniques were astonished to discover a veritable zoo of 95 animal species surrounding them, in everything from fridges to furniture, from sidewalks to shipping boxes, and from feather dusters to floor corners.

Guided by DNA "barcoding" experts at The Rockefeller University and the American Museum of Natural History, Grade 12 students Brenda Tan and Matt Cost of Trinity School, Manhattan, also revealed a lot of apparent consumer fraud in progress, finding that the labels of 11 of 66 food products purchased at local markets misrepresented the actual contents.

The January edition of BioScience magazine will report on their "DNA House" project, detailed as well online at http://phe.rockefeller.edu/barcode/dnahouse.html.

Among other things, Tan and Cost also found an invasive species of insect in a box of grapefruit from Texas. And the duo might get to coin a Latin name for what could be a

new species or subspecies of New York cockroach revealed by DNA barcoding.

The work builds on the 2008 “sushi-gate” findings of two other Trinity School students, Kate Stoeckle and Louisa Strauss, who found one-quarter of fish they bought at markets and restaurants in Manhattan were mislabeled. Some labels hid endangered fish species but most misrepresented cheap fish species like tilapia, sold as expensive species like tuna. Now second-year university students, Kate and Louisa will address the 2010 Annual Meeting of the American Association for the Advancement of Science.

Buyer beware – but how?

The new barcoding study by Tan and Cost uncovered additional examples and types of “mislabeled” food products:

- An expensive specialty “sheep's milk” cheese made in fact from cow's milk;
- “Venison” dog treats made of beef;
- “Sturgeon caviar” that was really Mississippi paddlefish;
- A delicacy called “dried shark,” which proved to be freshwater Nile perch from Africa;
- A label of “frozen Yellow catfish” on Walking catfish, an invasive species;
- “Dried olidus” (smelt) that proved to be Japanese anchovy, an unrelated fish;
- “Caribbean Red snapper” that turned out to be Malabar blood snapper, a fish from Southeast Asia.

While not publicly identifing the products or retailers involved, the students do offer opinions.

“You should get what you pay for,” says Cost, 18. “We don’t know where it occurs, but most of the mislabeling involves substitution of something less expensive or desirable, which suggests it’s done for profit. Also, mislabeling exposes people with an intolerance or allergy to certain foods, or misleads people with dietary restrictions. Many Hindus might be upset to discover that they had purchased a product labeled as ‘sheep’ that was in fact made from cows.”

“Truth on labels – especially when it comes to food – needs to be beyond doubt absolutely. Fraudulent labeling has led to puffer fish poisoning cases in the US.”

“Knowing the sources of foods for pets like cats and dogs is important too,” adds Tan,

17. “And species identification can help protect the environment. Species that have protected status aren’t supposed to be sold.

“But how are consumers supposed to protect themselves? Someday DNA barcoding may be a cool smartphone app. Until then, we think government agencies should start using these early versions of species identification tools to police the market, and the sooner the better.”

“This report signals to food and health authorities worldwide how simple and easy it is today to check and certify the origins of products in the market, crack down on fraudsters, and protect both the health of consumers and depleted species,” says Mark Stoeckle, a member of the adjunct faculty in the Program for the Human Environment at The Rockefeller University.“Several reports have appeared in the past year and a half about DNA barcode technology exposing mislabeled fish. Now Brenda and Matt have shown that many other food products are likewise misrepresented to buyers. We suspect it won’t be long before we see the first criminal charges laid based on DNA barcoding evidence.”

The US Food and Drug Administration (FDA), which is responsible for ensuring the safety and accurate labeling of America’s food supply, recently described the particular challenges posed by the many species of seafood and the high percentage of imported products, often processed to a point where traditional morphologic species determination is not possible.

“New methods that allow accurate and rapid species identifications are critical for both food borne illness investigations and for the prevention of deceptive practices, such as those where species are intentionally mislabeled to circumvent import restrictions or for resale as species of higher value,” according to a November FDA paper.

DNA barcoding technology identifies and distinguishes known and unknown species quickly, cheaply, easily and accurately based on a snippet of genetic code. The agency is working with experts at various institutions to build a vouchered library of seafood species standards, which will include barcodes.

Other animals in the zoo at home

"We may think we live in a sterile, urban environment seemingly untouched by nature," says Cost. "We imagine objects are purified and cleansed in order to pass into our personal world with evidence of their original source all but erased. But DNA is amazingly resilient to damage through all the processing to which it is subjected. We got usable DNA from 151 of 217 of the items tested – including dried soup mix, dog biscuits, beef jerky, butter, a feather lying on the sidewalk, a dried bit of horse manure from Central Park, even a feather duster."

Other animals the students found they were living with include:

- Genetically distinct cockroaches that might be a new species or subspecies. The specimens collected looked to be ordinary American cockroaches (*Periplaneta americana*) but their DNA differed by about 4% from the reference sequence (differences within species are usually 1% or less).
  "This might mean our specimens are a separate species or an isolated population within the species," says Tan.

- A strange-looking long-legged House centipede – an alien species that originated in Europe, and

- An Oriental latrine fly – an invasive species now in the southern US. It was found inside a box of grapefruit shipped from Texas.

"The superintendent of the apartment building was surprised when we wanted to save rather than squash the cockroach," says Tan.

"Learning the species name was like finding a key that opened a new book," she adds. "It's exciting to learn still more after 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 2,000 feet, travels in large schools containing hundreds of individuals, and hunts in cooperative packs like wolves. This gave us new thoughts about the oceans and about calamari salad!"

“There were a lot of surprises,” adds Cost. “We tested ‘buffalo mozzarella’ cheese and found it is made from the milk of Water buffalos! We asked some adults who have ordered it on restaurant menus and they didn’t know that.”

DNA is resilient

The pair started the DNA House project in November 2008. Over the next four months the students became detectives, looking at the things in and around their homes through the lens of biological matter.

The students even collected a single strand of hair from eight classmates and “we were happy to report that they all came back as 100 percent human,” says Tan.

A single bird feather was sufficient to yield a DNA sequence.

“New Yorkers think bird-droppings on the window sill are bad, but we saw an opportunity for science,” she adds. “Strands of hair, dots of mold, and even our food became possible carriers of DNA. So after we realized that DNA was, indeed, omnipresent, an important question arose: How much abuse can this genetic material take before it becomes unintelligible or even unrecognizable?”

“Could we find decipherable DNA in a piece of cooked meat? A piece of cheese? A highly processed dog treat? What we found was astonishing. Few specific conditions proved able to destroy the DNA consistently.”

Subjecting it to cold, drying, or chemicals seems to have little impact on DNA survival.

“Whether frozen, fermented, dried, or pickled, most of our specimens yielded DNA in a recognizable form,” says Cost. “I did not used to think I was eating intact DNA when I was eating yogurt.

“DNA also survived the passage of time. For example, a fragment of deer antler yielded DNA even after eight years of sitting in a room with varying temperature and humidity.”

The one exception of endurance was canned foods, processed at such high temperatures in the process that DNA broke into pieces, making contents identification often impossible.

Translating many samples into names

In total, the students sent 217 specimens to the American Museum of Natural History for analysis. Some 70 percent – 151 – contained readable DNA for the standard "barcode" region now used to identify animal species.

When the museum scientists reported a DNA sequence back to the students, they simply pasted it electronically, like a 650-letter word, into a search engine (www.barcodinglife.org) that translates the species name almost instantly. The translation rests on a Rosetta Stone called BOLD.

The Barcode of Life Database (BOLD) is maintained by the Biodiversity Institute of Ontario at the University of Guelph, Canada, where DNA barcoding was pioneered. So far, scientists the world over have DNA barcoded over 750,000 individual specimens representing over 65,000 species. Their ultimate goal is a reference library of barcodes for all animals and plants on Earth.

Of the 95 different animal species identified by Brenda and Matt, 60 were vertebrates and 35 invertebrates. They placed the vertebrates and invertebrates on different branches of the evolutionary tree to see their genetic relationships (deer and cattle, for example).

Assisting the students were Stoeckle; Jesse Ausubel, director of Rockefeller's Program for the Human Environment and the Alfred P. Sloan Foundation; George Amato at American Museum of Natural History, and associates Sergios Orestis-Kolokotronis, Matt Leslie, and Cecilia Bartholomew; and Alison DiStefano, Jan Kang, and Frances Cary at Trinity School.

"High school students showed why DNA is the stuff of heredity: It's tough enough to survive in Manhattan," says Ausubel.

"I am delighted that Trinity continues to fulfill its mission to 'challenge the minds' and 'fire the imaginations' of our students while ensuring that they are engaging in 'the larger communities of city, nation, and world of which we are a part,'" says John C. Allman, Head of School at Trinity. "Their discoveries in the use of DNA testing demonstrate the creative thinking that will serve them well throughout their lives. Such work shows that

students are not only the future, as is often said, but are the present as well. Congratulations to Brenda and Matt for their good work and thank you Drs. DiStefano, Kang, and Cary for being such wonderful Trinity teachers and mentors."

Tan and Cost plan to pursue biology and music respectively at university next fall.

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About The Rockefeller University: www.rockefeller.edu/about.php

About Trinity School: Founded in 1709 as a charity school for the parish of Trinity Church, Wall Street, Trinity School is the oldest continuously operating educational institution in New York City. Celebrating its 300th year in 2008-2009, the School is deeply committed to the conversation between student and teacher, to rigorous and passionate intellectual inquiry, and to engaging fully in the city, nation, and world of which we are a part. www.trinityschoolnyc.org

About the American Museum of Natural History: http://congen.amnh.org/people.html

Useful links:

- Barcode of Life Database / International Barcode of Life project: www.barcodinglife.org
- Consortium for the Barcode of Life: barcoding.si.edu
- Barcoding marine species: www.marinebarcoding.org
- Barcoding blog: http://phe.rockefeller.edu/barcode/blog
- Ten Reasons for Barcoding Life: http://phe.rockefeller.edu/barcode/docs/TenReasonsBarcoding.pdf

Encyclopedia of Life pages for species in this release:
Tilapia: www.eol.org/pages/12679
Tuna: www.eol.org/pages/223943
Sheep: www.eol.org/pages/39510
Cow: www.eol.org/pages/328699
Deer: www.eol.org/pages/34545
Sturgeon: www.eol.org/pages/8302
Mississippi paddlefish www.eol.org/pages/208600
Nile perch: www.eol.org/pages/204767
Yellow catfish: www.eol.org/pages/613220
Walking catfish: www.eol.org/pages/203710
Olidus: www.eol.org/pages/224435
Japanese anchovy: www.eol.org/pages/207206
Caribbean red snapper: www.eol.org/pages/356305
American cockroach: www.eol.org/pages/1076920
House centipede: www.eol.org/pages/1033083
Oriental latrine fly: www.eol.org/pages/730221
Jumbo flying squid: www.eol.org/pages/403181
Water buffalo: www.eol.org/pages/311907