Exploring with DNA in New York City

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Take a walk through your home. Think about the sterile, urban environment we have created for ourselves, an environment seemingly untouched by nature, and then think again. The chicken in your refrigerator, the leather chairs in your living room, and the feather duster in your closet have something in common. They all contain DNA. We imagine that objects must be purified and cleansed in order to pass into our world, and that evidence of their original source is all but erased. However, the blueprint for all carbon-based life, DNA, is far more resilient than we might have thought. Indeed, subjecting it to heat, cold, drying, and/or chemicals may be futile attempts to destroy this evidence of the natural world from which so many of our commodities are taken. In our seemingly sterile urban environment we are surrounded by DNA traces of multifarious life forms.

We began our investigation, named DNAHouse, in November 2008. Over the next four months we became detectives, looking at the things in our homes through the lens of biological matter. Strands of hair, dots of mold, and even our food became possible carriers of DNA. So after we realized that it was, indeed, omnipresent, one important question arose. How much abuse can this genetic material take before it becomes unintelligible or even unrecognizable? We began to look at products in stores with a skeptical eye. 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. No specific conditions proved able to destroy the DNA consistently. Whether frozen, cooked, dried, soaked, canned, bagged, and/or pickled, most of our specimens yielded DNA in a recognizable form. Not only was DNA able to withstand these stresses, but it also survived the passage of time: for example, a fragment of deer antler yielded DNA even after eight years of sitting at room temperature, in varying humidity.

Our investigation utilized DNA barcoding, a standardized, simplified approach to identifying species by DNA. The DNA barcode standard for animal species is the COI gene, which is located in the DNA of mitochondria, energy-producing cellular organelles that are passed down from mother to offspring. By standardizing on one or a few gene region(s), scientists aim to establish a DNA reference library for all animals and plants, and thereby enable simple, machine-based methods for identifying species, whether rare or well-known or as intact specimens or in in bits and pieces. So far scientists have collected DNA barcodes from over 500,000 individuals representing over 50,000 species and deposited the genetic sequences and associated specimen information in Barcode of Life Database (BOLD) (http://www.barcodinglife.org).

Not only was the COI DNA from our specimens recognizable in terms of nucleotide sequence, but what seemed to be a jumble of letters in fact contained an enormous amount of information. We matched the barcode sequence recovered from our specimens to BOLD online reference database, thus revealing their species identity. The information in the DNA was surprisingly deep. We found that in some cases even sequences as short as 20 nucleotides could be used to match to just one of the tens of thousands of species in the database. Naming by nucleotide sequence allowed us to see exactly which of these products were mislabeled. We found 16% of

food items 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, an inexpensive freshwater fish from Africa. “Venison” dog treats turned out to be beef. Fish were the most commonly mislabeled items. We do not know where or why the mislabeling occurred, but most cases appeared to involve substitution of a less expensive or less desirable item, suggesting the possibility of deliberate mislabeling for economic gain. We also think mislabeling is a serious problem because certain individuals have allergies or dietary restrictions regarding certain foods.

By comparing our sequences to the Barcode of Life Database (BOLD) we identified our specimens as 95 different animal species: 58 vertebrates and 27 invertebrates. Imagine that! Even within New York, traces of a great diversity of animals are all around us. Our identified species range from fly to fish. Once we were able to identify the species, a whole new world opened up to us. One snack, “dried shredded squid” turned out to be Jumbo flying squid (*Dosidicus gigas)*. The Jumbo flying squid grows to 100 pounds, swims at depths up to two thousand feet in the water and hunts in cooperative packs like wolves! By using the method of DNA identification, we overcame our lack of expertise in morphological identification. We identified a strange-looking long-legged centipede as the House centipede, an alien species that originated in Europe, and a squished fly found inside of a box of grapefruit shipped from Texas turned out to be the Oriental latrine fly, an invasive species now in the southern US. DNA testing enabled identifying bits and pieces, allowing authentication of cooked and processed foods, for example.

We discovered that a single bird feather or a single strand of human hair was sufficient to yield a DNA sequence. We were happy to report that our classmates came back as 100% human. Also, in analyzing our data using software found on the Web, we discovered our classmates’ DNA sequences differed only by 1 site out of 650. Because BOLD still lacks a complete database of life on earth, a few of our specimens did not have 100% matches. Many named species have not been placed into the DNA database and there are probably many species awaiting discovery. In exploring with DNA, we may have stumbled across a new species of cockroach. Some of our cockroach specimens, which were morphologically consistent with the American cockroach (a large 1-2 inch cockroach usually seen in the summer in NYC), repeatedly provided a genetically distinct barcode sequence that was 4% different than other American cockroaches. This could indicate a gap in the BOLD database, or even a new species.

We found DNA is a durable identifier, revealing diverse traces of life in what we thought was a barren urban environment. Like a powerful flashlight, DNA exposes hidden identities of living and once-living things. We look forward to more explorations!

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