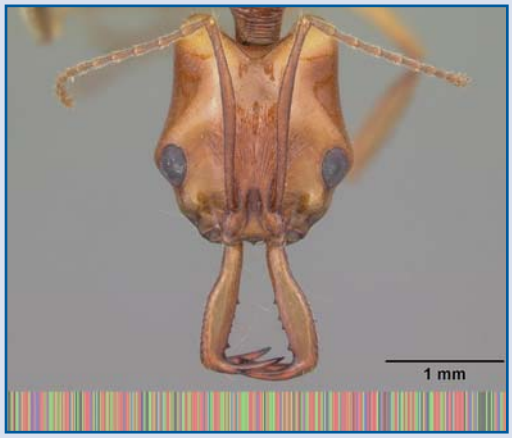
Research
UNIVERSITY of GUELPH
Focus on
DNA Barcoding



Decoding nature

Genetic barcodes are on track to identify the world's species

All stories by Christine Eisler

The year is 2017. Prof. Paul Hebert is trekking through a Costa Rican rainforest when he notices what appears to be a toucan perched in the above canopy. To confirm the rare sighting of this endangered, nearly extinct species, he feeds a fallen feather into a handheld scanner for analysis. Moments later, the pocket-sized machine positively identifies this finding, and provides a photo and description of the bird.

That's where Hebert, of the Department of Integrative Biology at the University of Guelph, says DNA barcoding is headed.

DNA barcoding is a technology using gene sequences to differentiate animals, similar to the way retail stores rely on short, standardized barcodes to differentiate the hundreds of thousands of items they sell.

This technology can help reduce species identification time from days to, ultimately, minutes, based on a database of established DNA barcodes. Time is essential when identifying products crossing international borders, tracing undesirable plant or animal material in processed foods, discovering new species, or identifying the animals that caused a bite, sting or poisoning.

"DNA barcoding promises a future where everyone will have rapid access to the names and biological attributes of all species on the planet," says Hebert. "This is important for the conservation of life as well as managing species with negative impacts on human health and economic systems."

Prof. Paul Hebert founded DNA barcoding, a technique which can identify animal species using a small fragment of DNA.

Species such as *Anochetus goodmani* (ant, top left photo) and *Rana clamitans* (green frog) have been DNA barcoded and are included in a database that can be referenced for future species identifications.

Hebert is the founder of DNA barcoding. In 2003, he was the first to propose using a short portion of a gene called cytochrome *c* oxidase 1 (CO1) to identify the world's animal species. He recognized that the CO1 gene was a short, standardized DNA sequence contained in all animals, yet the actual sequence could differentiate species.

Currently, this technology is being used in the University of Guelph-based barcoding initiative to genetically index the 1.7 million species already described via other taxonomic means, as well as identify the estimated 10 million species that still need classifying. •

Raising the bar

High-throughput facility boosts volume of species identified

Canada's DNA barcoding efforts have gained momentum with the newly opened Biodiversity Institute of Ontario (BIO) facility at the University of Guelph.

The new facility, a $4.2-million, 15,000-square-foot building, opens opportunities for heightened research productivity. It will help fast track DNA barcoding technology's introduction to public use for applications such as border control or pest management.

BIO is home to the Canadian Centre for DNA Barcoding (CCDB). This centre develops laboratory protocols and maintains the Barcode of Life Data System, an online data management system which is central to the global barcoding community for maintaining barcode records and being a resource to diagnose unknown animals.

CCDB also serves as core facility and headquarters for researchers in the Canadian Barcode of Life Network, enabling them to gather and share ideas and information to advance DNA barcoding research.

"Our location in BIO has allowed us to concentrate our resources to become a high-throughput facility for DNA barcode analysis and production," says Alex Smith, BIO research program co-ordinator.

In the past, DNA barcoding research was based out of a single laboratory at the University of Guelph. This location was capable of processing up to 75,000 samples for barcoding each year.

But now, BIO's launch dramatically raises that capacity. Heightened production in all aspects of barcode research and new equipment at the facility will result in an anticipated output of 500,000 barcode analyses per year. And improved efficiencies are expected to reduce barcoding costs in the new facility.

"The productivity levels that we are now able to reach should help ensure that the global effort to barcode all animal species will continue to be based in Guelph," says Smith.

Funding for the BIO building and barcoding research is provided in part by Genome Canada through the Ontario Genomics Institute. Additional funding for BIO comes from the Canada Foundation for Innovation and the Ontario Innovation Trust. Barcoding research is sponsored through the Gordon and Betty Moore Foundation, the Natural Sciences and Engineering Research Council, the Ontario Research Fund and various federal and private sector organizations. •

Funding for DNA Barcoding at the University of Guelph
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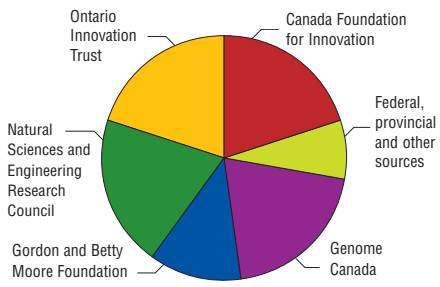

Canada Foundation for Innovation	$5 million
Federal, provincial and other sources	$2 million
Genome Canada	$5 million
Gordon and Betty Moore Foundation	$3 million
Natural Sciences and Engineering Research Council	$5 million
Ontario Innovation Trust	$5 million
Total	**$25 million**

Alex Smith, BIO research program co-ordinator (left), and biology professor Bob Hanner say DNA barcoding technology is steadily progressing because of heightened research activity at Guelph.

What's behind the barcode

Developing a method to identify every living species on Earth is no easy order, but University of Guelph researchers have found a way to do it. With a small fragment of DNA from a portion of a single gene, they can characterize nearly any animal species on earth.

Prof. Paul Hebert, Department of Integrative Biology, and his colleagues, including Prof. Bob Hanner, are working with a gene called cytochrome *c* oxidase 1 (CO1), to distinguish one species from another. CO1 is found in the mitochondria – the powerhouses of cells in living creatures. CO1 plays a pivotal role in providing energy to the cell.

The advantage of using CO1 for identification is that it's short enough to be quickly and inexpensively sequenced, yet long enough to set apart variations among species. (Use of the CO1 gene is a straight forward method to help identify animal species, but does not apply to all life. Further research at the Canadian Centre for DNA Barcoding and the Canadian Barcode of Life Network is focused on isolating standardized genes that will identify plant species.)

"This gene allows for rapid and accurate identification," says Hanner. "It has proven success in species discovery and identification from many divergent animal groups, from ants to birds."

There are five main steps involved in obtaining CO1 DNA sequences.

First, a specimen must be collected, and identified by a taxonomist.

Then, a tissue sample is obtained from the specimen and digested to make the DNA accessible so it can be isolated and extracted.

The DNA is then amplified (copied) in a specialized chemical environment using a process called polymerase chain reaction, which makes copies of the specific gene fragment for sequencing.

Once amplified, the DNA is sequenced to generate a barcode.

Finally, the barcode is entered into the Barcode of Life Data System (BOLD), which manages the growing number of barcode sequences. It is an online system to help researchers from across Canada and around the world to collect, manage and analyze DNA barcodes.

Each entry organized in BOLD has information such as the animal's taxonomic name, its picture, GPS co-ordinates for where it has been found, and its barcode sequence.

This information is accessible through BOLD to anyone in the world and will have many applications, including environmental monitoring, food safety and medicine. For example, DNA barcoding will be used to identify the larvae of invasive pests, discover new species, identify the species that caused a bite, sting or poisoning, monitor biomaterials crossing international borders and verify plant or animal ingredients in foods. •

Guelph researchers such as Katy Hind are working with a gene called cytochrome *c* oxidase 1, which is found in the cells of all animals, to distinguish one species from another.

Canada: A world leader in DNA barcoding technology

From humble beginnings in a small laboratory, to establishing the Canadian Centre for DNA Barcoding and the Biodiversity Institute of Ontario, the University of Guelph's DNA barcoding research program has experienced a massive evolution since its inception in 2003.

The progress has propelled Canada to a position of leadership and innovation in using DNA barcoding technology. Guelph researchers lead the Canadian Barcode of Life Network and play a significant role in a number of international barcoding efforts, including campaigns to barcode fish, birds, butterflies and moths.

Canada has been at the forefront in collecting DNA and developing tools to manage the barcoding data. The Barcode of Life Data System (BOLD) was created at Guelph as a means to organize, analyse and query all DNA barcodes. BOLD has been universally adopted by all major international barcoding campaigns, helping to build a reference library of barcodes in one central location.

Through the determined efforts of highly skilled researchers and support from diverse organizations and specimen collections, Canada is making key contributions to a biological research program that will have economic, social and environmental applications, both nationally and internationally. •

For more information

Canadian Centre for DNA Barcoding
www.dnabarcoding.ca

Canadian Barcode of Life Network
www.bolnet.ca

Barcode of Life Data System
www.barcodinglife.org

Biodiversity Institute of Ontario
www.biodiversity.ca

The DNA barcoding team: propelling Guelph to a position of leadership and innovation.

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