National Museum of Natural History

ANNUAL REPORT 2005

NEW TOOLS FOR UNDERSTANDING NATURE

Smithsonian
National Museum of Natural History


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NEW TOOLS FOR UNDERSTANDING NATURE

MESSAGE FROM THE DIRECTOR

The 2005 Annual Report underscores the Museum's scientific accomplishments, which have helped define our role as a world leader among Natural History Museums. Our vision is to understand the natural world and our place in it, generating knowledge through our research and collections and sharing it with millions of Museum and web visitors each year. At the heart of this agenda is our collaboration with scientists and institutions from around the world.

The lead story, "Barcoding the Planet," reflects our research on DNA barcoding, a new technique that provides us with a unique genetic fingerprint for each species. Thanks to the support of the Alfred P. Sloan Foundation, we established the Consortium for the Barcode of Life (CBOL) in 2004, an alliance of specimen collection institutions, research organizations, government agencies and private sector partners involved in building specimen-based DNA barcoding resources. The use of barcoding in identifying and distinguishing species could revolutionize the way we do science.

In 2005 we published the third edition of Mammals Species of the World, a complete checklist and reference guide to the 5,416 known species. This includes 260 new species described during the last ten years, a fact that highlights the need to continue, if not broaden, our study of the natural world. With contributions from hundreds of scientists from around the world, the project emphasizes the collaborative quality of Museum science. We continue to take steps to provide greater access to such knowledge. An example is our award winning web site on North American Mammals, where teachers and students can find descriptions, images, and distribution ranges for more than 400 mammals native to the North American continent: http://www.mnh.si.edu/mammals/

Looking ahead, we have made major progress in the Ocean Science Initiative, an ambitious $75 million effort that will transform the way we approach marine science outreach. This is a collaborative initiative with the National Oceanic and Atmospheric Administration (NOAA) and other leading marine research and conservation organizations. The heart of the Ocean Science Initiative is a 23,000 square foot exhibition hall. Scheduled to open in 2008, the Ocean Hall will bring together our understanding of the geology, oceanography and biological diversity of our oceans, and explore the key role they play in our daily lives. The initiative will also include an ocean web portal designed as a gateway to the exhibition and our collections, as well as resources from key partner institutions.

In closing I would like to thank our collaborators, as well as our board, donors and supporters who helped make 2005 a banner year for the National Museum of Natural History.

Dr. Cristián Samper
DIRECTOR

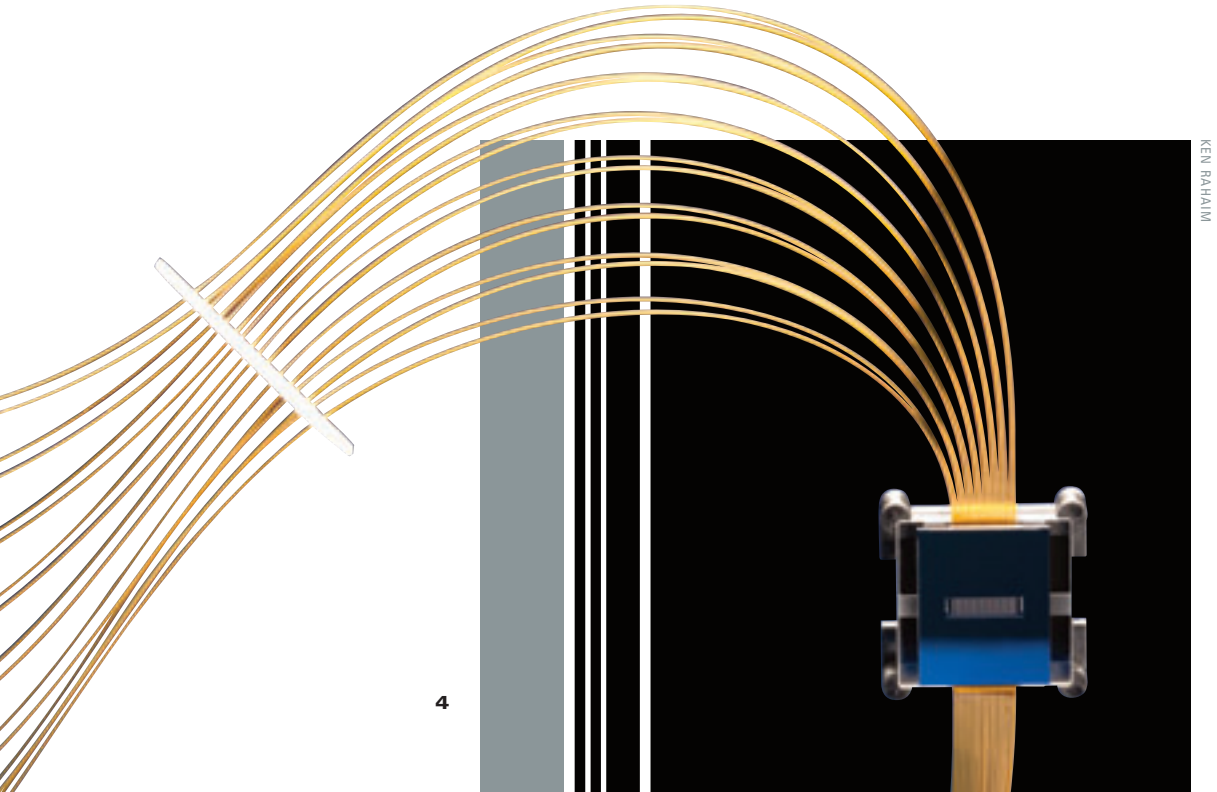
With involvement from Museum experts, an unprecedented international scientific effort on DNA barcoding was officially launched at a 2005 London conference. The Barcode of Life Initiative is using advanced DNA barcode technology to develop a system for rapidly and inexpensively identifying the approximately 1.7 million known flora and fauna species, and creating an electronic database for the estimated 10 million species across the planet. A DNA barcode is a short gene sequence, taken from a standard position in the genome, used to identify species.

KEN RAHAIM

DNA BARCODING

IDENTIFYING MORE THAN 10 MILLION PLANT AND ANIMAL SPECIES ON EARTH

Over the past 250 years, traditional methods of taxonomy – the discovery, description, and classification of different species – have been used to categorize only a percentage of the millions of species that may exist. Current techniques used to identify species require specialized knowledge and access to major museum collections.

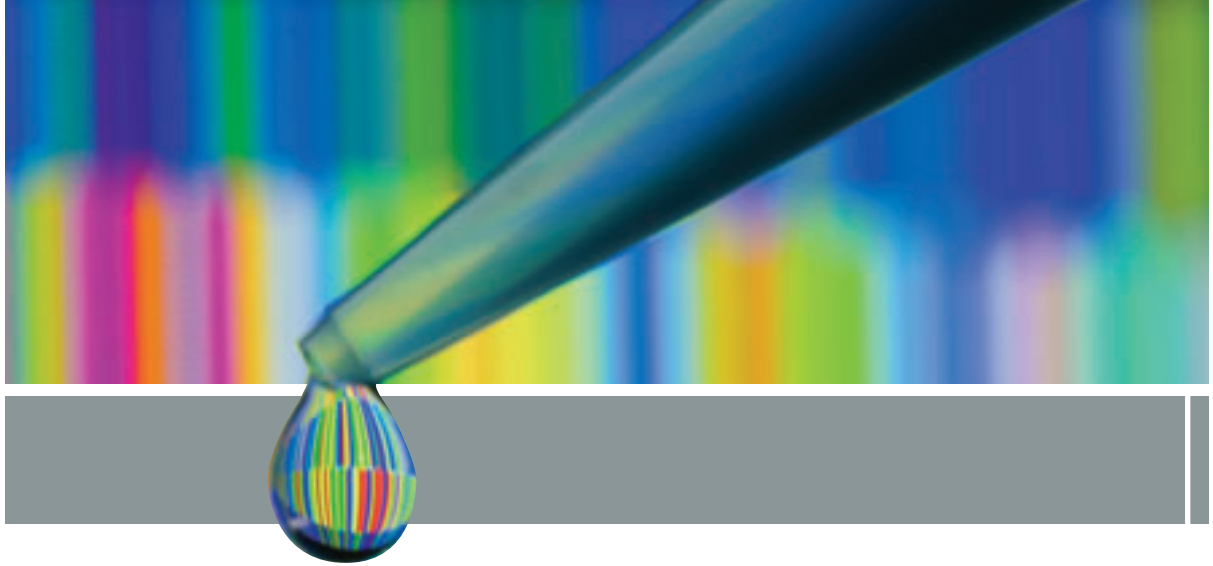


KEN RAHAIM

But with the emergence of efficient DNA sampling and sequencing methods, combined with advances in computing, a quick, accurate and globally accessible procedure for species identification is now possible. Building upon the existing taxonomic infrastructure, this new labeling system can revolutionize the world of biological collections – and create an invaluable public resource.

The initiative is being undertaken by a worldwide alliance including natural history museums, zoos, botanical gardens, research organizations and government agencies. The National Museum of Natural History hosts the organizing body – the Consortium on the Barcode of Life (CBOL) – whose goal is to promote the Barcode of Life Initiative. Dr. Scott Miller, Curator of Entomology and Associate Director for Science at the National Zoo, is the chairman of CBOL.

According to Dr. David Schindel, Executive Secretary for the Consortium, "by hosting CBOL, Dr. Miller and Museum Director Dr. Cristián Samper have added an important component to the Museum's mission, beyond research, collections, and education. They have made the Museum a global leader in efforts to stem the loss of biodiversity and in using taxonomy to solve real-world problems that face society."



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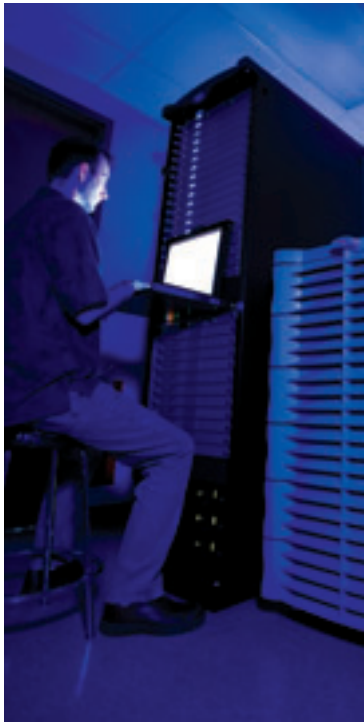


KEN RAHAIM

Inside the Museum's Laboratories of Analytical Biology (L.A.B.): An Epicenter for DNA Research

Lee Weigt, Manager of the Museum's Laboratories of Analytical Biology (L.A.B.), is proud of his robots. These remarkable, highly specialized tools have revolutionized his work – conducting molecular research for the Smithsonian. The L.A.B. is the center of where all the Museum's cutting-edge DNA research is taking place, using technology that propels the science in fascinating new directions.

"We plan to do the barcoding for hundreds of thousands of specimens," says Weigt. "This is where we build the DNA libraries." The L.A.B. capacity can currently handle 15,000 samples per month. In addition to increasing capacity to produce barcodes, the robots have increased quality and decreased the cost per sample.

To capture a DNA barcode, three types of robots conduct the bulk of the work at L.A.B. The first, an automated DNA extractor, can conduct 400 high-quality DNA extractions in just four hours. In contrast, it would take a scientist a full day to complete just 100 such extractions.

In a further step, a PCR (Polymerase Chain Reaction) robot rapidly and almost elegantly replicates a DNA fragment into millions of copies for scientists to work with. The chemical process is performed by the PCR robot with an impossibly small amount of volume – 800 samples could fit into a single drop of water.

The L.A.B.'s third robot, an automated DNA sequencer, separates the 600 bases of DNA so that they can be read. The data is then fed into powerful computer systems, where it will be analyzed and prepared for entry into a massive database.

But what does this sped-up sampling and pinpoint accuracy bring to the world? A revolution on several fronts, say scientists. "What human genome research can do for medicine, DNA barcoding can do for biology," says Weigt.

WHAT HUMAN GENOME RESEARCH CAN DO FOR MEDICINE,

DNA barcoding can do for biology.

DNA Barcoding and Bird Research

DNA barcoding has a wide variety of real-world applications, including identifying carriers of disease and agricultural pests and monitoring endangered species. One fascinating application currently under way concerns improving aviation safety.

The Feather Identification Lab at the Smithsonian, led by Museum ornithologist Dr. Carla Dove, is working in conjunction with the FAA and US Air Force on a five-year project to identify bird species involved in bird/aircraft collisions. DNA technology allows the collected sample to be as small as a bit of blood wiped on a paper towel.

"Knowing the type and weight of a bird that could possibly hit an aircraft is important when designing engines and windscreens," says Dr. Dove. "Also, when we know the exact species of bird we learn more about their habits, and we can modify habitats around airfields to help avoid bird/aircraft collisions."

The Museum is also participating in the All Birds Barcode Initiative (ABBI), a five-year, international effort to set up a database of DNA barcodes for the 10,000 known bird species around the world.

Seeing Plants in a Whole New Way

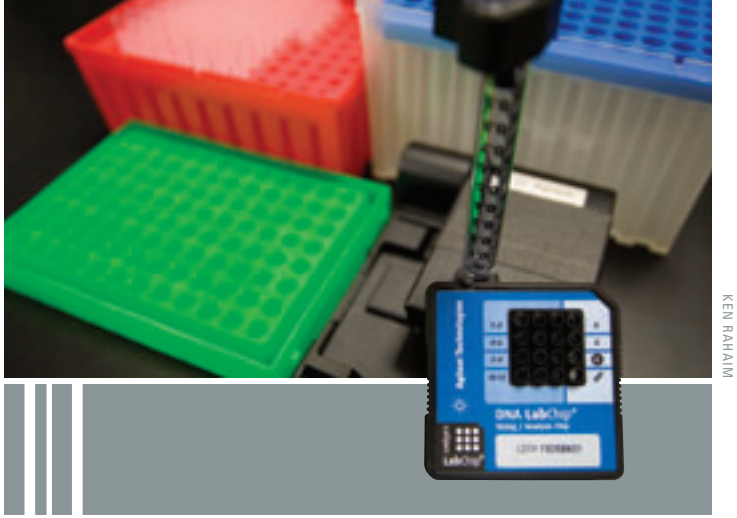
While use of DNA barcoding in animal study has been met with much success, efforts to apply the technology to plants are still in the preliminary stages. Dr. John Kress, Chairman of the Department of Botany, and colleagues are leading the way. Dr. Kress and his team have come up with a workable method of identifying a barcode for plants, and plans are under way to conduct a major pilot project in Costa Rica.

A collaboration between the Smithsonian, Missouri Botanical Garden and three Costa Rican biodiversity institutes, the project will generate barcodes for all vascular plants in that country – an estimated 8,000 species. "We're trying to make the flora of Costa Rica more accessible," says Dr. Kress. "Once we have the technology in place, when we walk through a forest or look through a window, we will be better able to identify everything that's out there."

More funding is crucial to continue. Dr. Kress views the project as a starting point for even wider efforts to barcode plants all over the globe.

Plants can now be identified by a short segment of DNA called a "barcode."

COURTESY OF KEN WURDACK



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Connections for the Future

By taking a sample of DNA from all known species on Earth and linking them to photographs, descriptions and scientific information, researchers are building the largest database of its kind. Scientists anticipate myriad applications that the new technology and information will yield, from enforcing food laws, to protecting wildlife to developing bio-defense systems.

Biotechnologists are even developing a portable device that will provide a rapid method for non-taxonomists to identify unknown specimens and then link to further information. Dr. Kress believes that, a few years down the road, even a 3rd-grade science student will be able to place a leaf or insect sample on a cell phone-size gadget, process the DNA, and link back on a public database to a wealth of information and photography about the species.

Will we see a day when every organism on Earth is known and categorized? Although species are being discovered all the time, new technology is making what was once thought an impossible task, conceivable. What is certain to Museum scientists is that on the way to that goal, answers to fundamental questions in ecology and evolution will surface. And most importantly, each new bit of information will help find ways to conserve and manage the many forms of life around us.

http://barcoding.si.edu/