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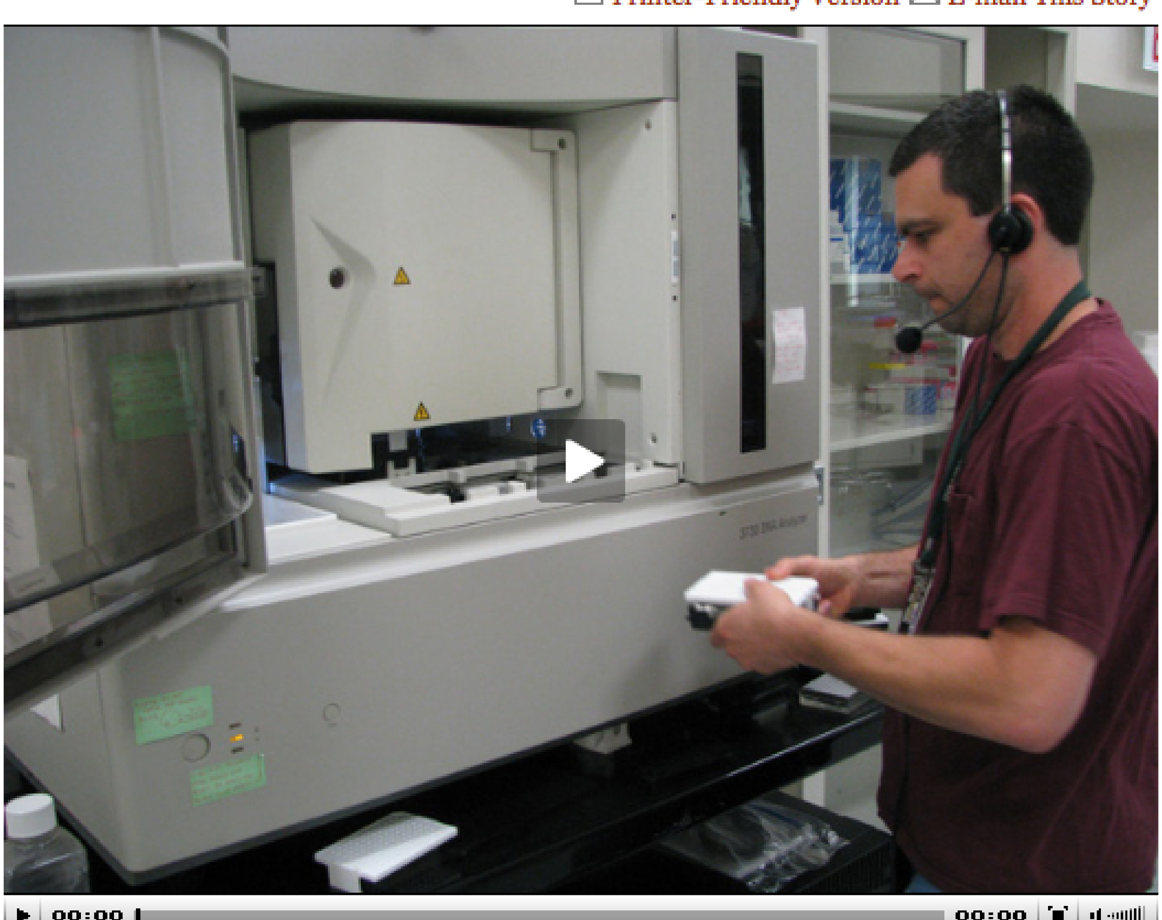


Chris Sweeney and Town Travis/Medill

Researchers at the new DNA Discovery Center at the Field Museum contribute to trees of life by extracting and analyzing DNA.

Trees of life rooted in the Field's DNA lab

BY CHRISTOPHER B SWEENEY AND TOWN TRAVIS
JUNE 04, 2008

If a researcher is mapping out a tree of life for just 30 species, the number of possible arrangements is more than the number of stars in the known universe, said Mark Westneat, curator of zoology at the Field Museum of Natural History.

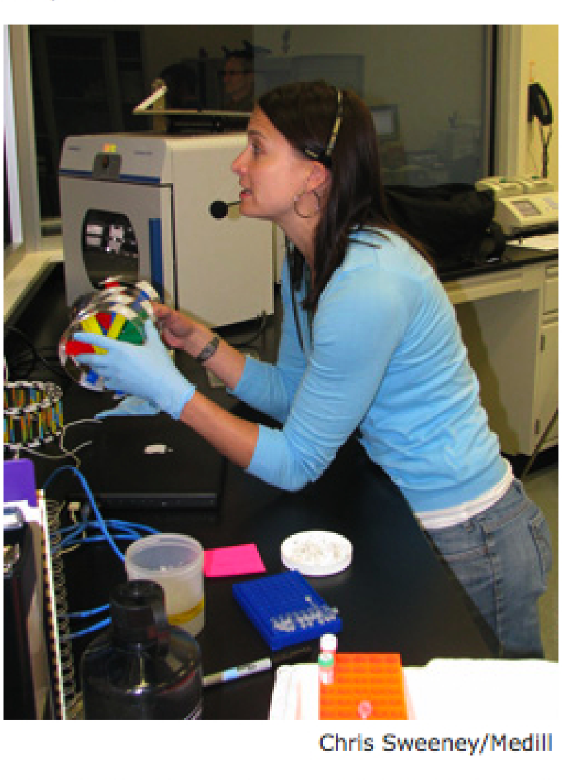
Town Travis/Medill

Researchers at the Field Museum collect samples such as this lemon shark in order to extract and analyze DNA.

"For 100 species there are 10 to the 184th power of possible trees, and that's greater than the estimated number of atoms in the known universe which is about 10 to the 80th power," he said.

The Field Museum's DNA Discovery Center -- the public face of the Pritzker Laboratory for Molecular Systematics and Evolution -- recently opened for exhibition at the museum.

The ideal goal of science is to have DNA samples from every creature on earth but the immediate goal is to collect and preserve samples from as many species as possible. Plants and animals that become extinct in the future will still "live" here.



Chris Sweeney/Medill

Researcher Erica Zahnle fields questions from the public about DNA during an hour-long Q&A session at the Field Museum of Natural History.

This is one of the only DNA extraction labs in the country where scientists work on multiple samples at the same time -- rather than focusing on a single species.

The approach allows them to contribute more details to trees of life about all species through online databases such as the Tree of Life Web Project and GenBank.

It's an ongoing project with no end in sight as new life forms continue to be found around the globe.

Chris Sweeney/Medill

DNA lab manager Kevin Feldheim prepares samples for the 3730 DNA analyzer, a machine that rapidly sequences DNA at the Field Museum.

"We're adding to the tree of life that will hopefully determine the relationship of all life on earth, ultimately. Our lab is just a very small part of that whole project," said Kevin Feldheim, manager of the Pritzker Lab. "Here we have students working on lichens from Antarctica, fish from the deep sea, sharks from the Bahamas, mushrooms from the Indiana dunes. So we really have a wide variety of taxa that are studied in this lab. That's really unique compared to most other labs across the country."

Chris Sweeney/Medill

Erica Zahnle works on bacteria samples in the DNA lab at the Field Museum.

Although the DNA Discovery Center is unique in its approach, other institutions also research evolutionary ecology and trees of life. Even though many of us are accustomed to thinking of one unified tree, from researchers' perspective there are many separate trees reaching across the ages.

Feldheim collaborates with people from the University of Chicago, the University of Illinois at Chicago, the Morton Arboretum and McGill University in Canada.

"When working out the tree of life, you have so much quantitative data and you're trying to figure out what tree of life a specimen supports," said Paul Sereno, famed dinosaur hunter and paleontologist at the University of Chicago. "We go out and study fossils, for example -- we're looking at how many fingers this specimen has and figuring out how to code the information."

Contrary to popular belief, DNA extraction labs such as the one at the Field Museum can't harvest dinosaur DNA.

"DNA from things that are extinct gets a little tricky. The oldest claimed DNA extraction is from a plant that's 400,000 years old," Feldheim said. "So we're not like Jurassic Park. The problem is, once something is that old and fossilized, the DNA just doesn't exist anymore."

"Jurassic Park premises that a mosquito took blood and the DNA was [preserved] in amber. But insects in amber are [fossilized] rock most of the time," said Westneat. "There are sub-fossils that have bits of hair or bone that haven't been turned into rock. It's theoretically possible to amplify DNA if a portion of it has been preserved."

German and U.S. scientists claimed to have extracted DNA from Neanderthals in 1997, according to the scientific journal Cell. Although scientists have attempted to map the genome from Neanderthals, the results are controversial and may have been contaminated by modern human DNA, according to a 2007 article in Science Daily.

"A lot of us don't believe that Neanderthal DNA was amplified. It is controversial," Westneat said. Most of the time the scientists end up sequencing their own DNA, he said. "Even if a tiny bit of scalp dandruff falls into the specimen, they'll end up amplifying themselves."

Three primary difficulties exist when working with ancient DNA. First, with ancient samples, there is plenty of time for lots of environmental change that facilitates DNA degradation. That prevents researchers from obtaining long, informative stretches of DNA.

The second obstacle is the intrusion of chemical compounds, which can cause post-mortem damage to DNA sequences.

"By virtue of being buried, there are lots of chemical compounds in the soil which bind to DNA and inhibit our ability to sequence it," said Dennis O'Rourke, professor of anthropology at the University of Utah, home to one of the country's ancient DNA labs. Such labs deal with DNA that is at least 100 years old and frequently much older.

The third and biggest concern is modern contamination, O'Rourke said. "We try to run as clean a lab as absolutely possible. It's impossible to always prevent that contamination. It is a constant serious concern in all ancient DNA analyses."

According to O'Rourke, approximately 100,000 years is as far back as scientists can extract usable DNA samples. The oldest sample at the University of Utah lab is 10,000 years old, which O'Rourke pointed out was just a single sample and therefore not very informative. However, O'Rourke's lab mostly works on material between 800 and 1,000 years old.

Researchers at the Field Museum work with more recent specimens most of the time.

Related Links

- The Field Museum
- DNA Discovery Center
- Tree of Life Project
- GenBank

How scientists reap DNA

- **Collection** - Gather tissue samples or dried plant samples outside the lab
- **Extraction** -"If you've ever worked in a kitchen and baked a cake, you can do what we do, because it's really following recipes." - Kevin Feldheim, manager of the DNA lab at the Field Museum of Natural History.
  (The process differs based on what sample you work with. For example, plant samples are more difficult and require more chemical treatment.)
  - Cut up the sample with a razor blade in lots of small pieces
  - Put the pieces in a solution containing the enzyme Proteinase K that chews up proteins, SDS [sodium dodecyl sulfate], a soap found in most shampoos, and Tris, an organic compound that maintains a neutral pH. Overnight, in a hybridization oven, the solution breaks cellular membranes and releases proteins and organelles and the DNA into the solution
  - Next day, add table salt to the solution and mix it up, causing the proteins to leach out of the solution. This leaves only the DNA.
  - Put the solution into a new tube and add alcohol, which separates the DNA from the solution.
- **Amplification** - Copy the DNA using the Polymerase Chain Reaction (PCR) technique.
- **Sequencing** - Read the As, Ts, Gs and Cs of DNA using the 3730 machine, which relies on a laser and fluorescent dyes to decipher the DNA blueprint
- **Analysis** - See how individuals differ from each other on many levels and contribute to trees of life

(Source: Kevin Feldheim and Erica Zahnle, Field Museum DNA research staff)

Q&A with Kevin Feldheim, manager of the DNA lab at the Field Museum

Medill Reports: What is the difference between the DNA Discovery Center and the Pritzker Laboratory?

Kevin Feldheim: The DNA Discovery Center is actually the public face of this facility. It is the exhibition part. That includes DNA basics -- the shape of DNA, where it's found. The Pritzker Lab itself has been in existence for many, many years, behind the scenes. The Pritzker family was kind enough to give us an endowment. A lot of the things that we purchase in the lab are from that endowment and the Pritzker Lab was so-named.

MR: What is the goal of the lab?

KF: We have many, many projects going on in the lab. Since I've been here, we've trained 184 users from 31 different countries. We're doing a multitude of things. We're looking at relationships -- but across many levels. I'm looking at relatedness between individuals. We have people looking at relatedness between populations, between species, between families -- all the way up to between different phyla. What we're doing in the lab is adding to the tree of life, essentially, and looking at the relationships of all species on earth.

MR: What is the tree of life?

KF: The National Science Foundation started these programs called "Assembling the Tree of Life." There are many different very large grants that were awarded. We have a couple here in the Pritzker lab. Shannon Hackett has the bird tree of life. They're examining every lineage of birds and seeing how they're related. A lot of what they're finding changes what was based on morphology many years ago. Things that we thought were closely related, when we look at the DNA, they're not closely related at all.

MR: How do you preserve your research for the future?

KF: We have a cryogenics facility where we have four large liquid nitrogen tanks. Those tanks keep our Petri samples extremely cold. A lot of our curators and other science department staff will go out into the field and collect something -- a bird liver or a shark fin or some part of the animal or plant or mushroom or whatever that they're studying -- and we'll bring it back here and put it in a vial. Those vials are then stored in our cryogenics facility. We can always go back to those samples, so if someone wants to study birds 20 years from now, they can come to our liquid nitrogen tanks, get out the samples of those particular birds and extract the DNA.

"Probably 50 or 60 years old is the oldest that we've tried to extract from here in the lab," Feldheim said. "The DNA with [ancient] samples is highly degraded. People just tend to avoid it if at all possible."

But older DNA comes in handy for research and scientific comparison.

"Isabel Caballero from UIC [University of Illinois at Chicago] is studying peregrine falcons in the Chicago region. She's looking at population variability throughout all falcons worldwide and looking at a local mating system in Chicago," Feldheim said. "One thing she's interested in is how the current genetic variation compares to historic genetic variation. She's actually gone back into some of the samples collected in the early 1900s and extracted DNA from toe pads from the specimens that we have in the museum collections."

DNA research contributing to trees of life has greatly evolved since Darwin drew his first sketch. New technologies allow vast amounts of DNA to be analyzed simultaneously.

"Right now we are at a junction between rapid genetics and rapid computation that's enabling us to answer these big questions about life," Westneat said.

"There is a lot of interest and funding for sequencing genes in a wide range of species because, with powerful computational approaches, we can rapidly take that data and understand what the pattern of relatedness is," Westneat said. "The computer programs will take the data and give me the best supported tree of life in a couple of days."

In addition to contributing to trees of life, DNA extraction labs such as the one at the Field Museum play an active role in conservation and in protecting endangered species.

"We're identifying new species or threatened species and, ultimately, we can take that information to governments and hopefully work on preventative measures to protect species that are endangered," said Erica Zahnle, a DNA educator and researcher at the Field Museum.

For instance, Demian Chapman, director of shark research at the Pew Institute for Ocean Science at the University of Miami, puts DNA research to work for shark conservation.

"One of the major threats to shark populations is shark fin soup," Chapman said. "It's hard to tell what species of shark is actually making up the soup. Some species, such as great whites, are protected and some aren't. I developed a DNA test that can tell you whether a soup or a fin comes from a protected shark."

As new species are discovered, researchers will continue to add to and reshape trees of life. DNA is the root for that project and provides the blueprint for our existence.