

AURORA

Lifestyles of the modern and ancient

By Jeff Richardson

UAF UNIVERSITY OF
ALASKA
FAIRBANKS

Above: A woolly mammoth tusk is split lengthwise in a lab at the Alaska Stable Isotope Facility. The tusk is one of many remains of extinct animals that researchers at the lab have studied using isotope science. UAF photos by JR Ancheta.

It's a phrase that comes with a touch of bombast, at least by the standards of a research lab: "Board of Truth."

The words are scrawled prominently on top of a whiteboard at the Alaska Stable Isotope Facility. They share space with about a dozen animal magnets placed along a roughly drawn graph on the board, showing ratios of carbon and nitrogen isotopes in each.

Polar bears and grizzly bears are in the upper right corner of the board, in vaguely the same area as some of their favorite prey, seals and salmon. Herbivores like moose and

caribou, which subsist on wild, terrestrial plant diets, are closer to the bottom left corner.

A clump of colored magnets occupies the area in between, representing students, researchers and employees who work in the lab.



Matthew Wooller, director of the Alaska Stable Isotope Facility, points to a magnet that shows how his isotopic signature compares to various Alaska animals. Using isotopes, researchers can determine what someone has consumed and where they've lived.

"There's me," said ASIF Director Matthew Wooller, pointing to a blue magnet that's just offset from the rest. Wooller is a vegetarian, resulting in a slightly different isotope signature than more omnivorous humans.

"You've heard the phrase 'You are what you eat?'" Wooller asks. "That's what this is."

That phrase isn't always meant literally, but in this case it comes close. ASIF, located in the Duckering Building at the

University of Alaska Fairbanks, is built to analyze some of the common elements, such as carbon, nitrogen and oxygen, that exist in every living thing. By studying samples of hair, flesh, bones and blood, Wooller and his team can create an outline of their life story – what they've eaten, where they've lived, and sometimes even when they existed.

“Isotopes don't lie”

If someone drinks water from Alaska, the chemical composition of their body is different than their cousin who drinks water in Ohio. A person who regularly enjoys a slice of carrot cake for lunch will have a different isotopic signature than someone who snacks on raw carrots. Depending on where they've lived and what they've consumed, the same chemical clues exist in a polar bear, a dandelion or a mosquito.

When it comes to isotope science, the “Board of Truth” is just that.

“Isotopes don't lie,” Wooller said. “That's not saying that people always do, but they're sometimes not great at recording or remembering what they eat and what they do. Isotopes are good at that.”



Matthew Wooller, director of the Alaska Stable Isotope Facility, and Patrick Druckenmiller, director of the University of Alaska Museum of the North, go through the museum's collection of mammoth tusks. Isotope analysis offers a way to better understand the lives of the long-extinct mammals.

That inherent honesty has given ASIF a role in a remarkable variety of research projects. Although it's one of many isotope labs, both in the U.S. and internationally, ASIF's location has given it an instrumental role in Arctic research.

In recent years Wooller has participated in major studies about extinct woolly mammoths, the range of prehistoric Bering Sea ice and the lives of Alaska's earliest human inhabitants, just to name a few.

"It's remarkable," said Patrick Druckenmiller, the director of the University of Alaska Museum of the North. "It allows you to study animals and do things in ways that we were never able to do before."

Pursuing 'a big detective story'

The varied equipment that fills the labs at ASIF – test tubes, lasers, spectrometers and computers – works together for a common purpose. Elements like carbon and nitrogen come in "light" and "heavy" forms, and isotope labs work to determine how much of each is in the specimens it tests.



Top: UAF graduate student Michelle Trifari uses a mass spectrometer at the Alaska Stable Isotope Facility. Bottom: ASIF Deputy Director Karen Spaleta prepares a sample for testing.

Various organic samples brought to the lab are converted to a gas by dissolving them in acid or burning them. Using mass spectrometers that are configured to specific

elements, electromagnets act on that ionized gas and separate the heavy and light versions of those elements. A computer can then calculate the ratio of each.

Those ratios are the key to isotope science, providing a signature or “chemical fingerprint” that is specific to various plants, animals and geographic locations.

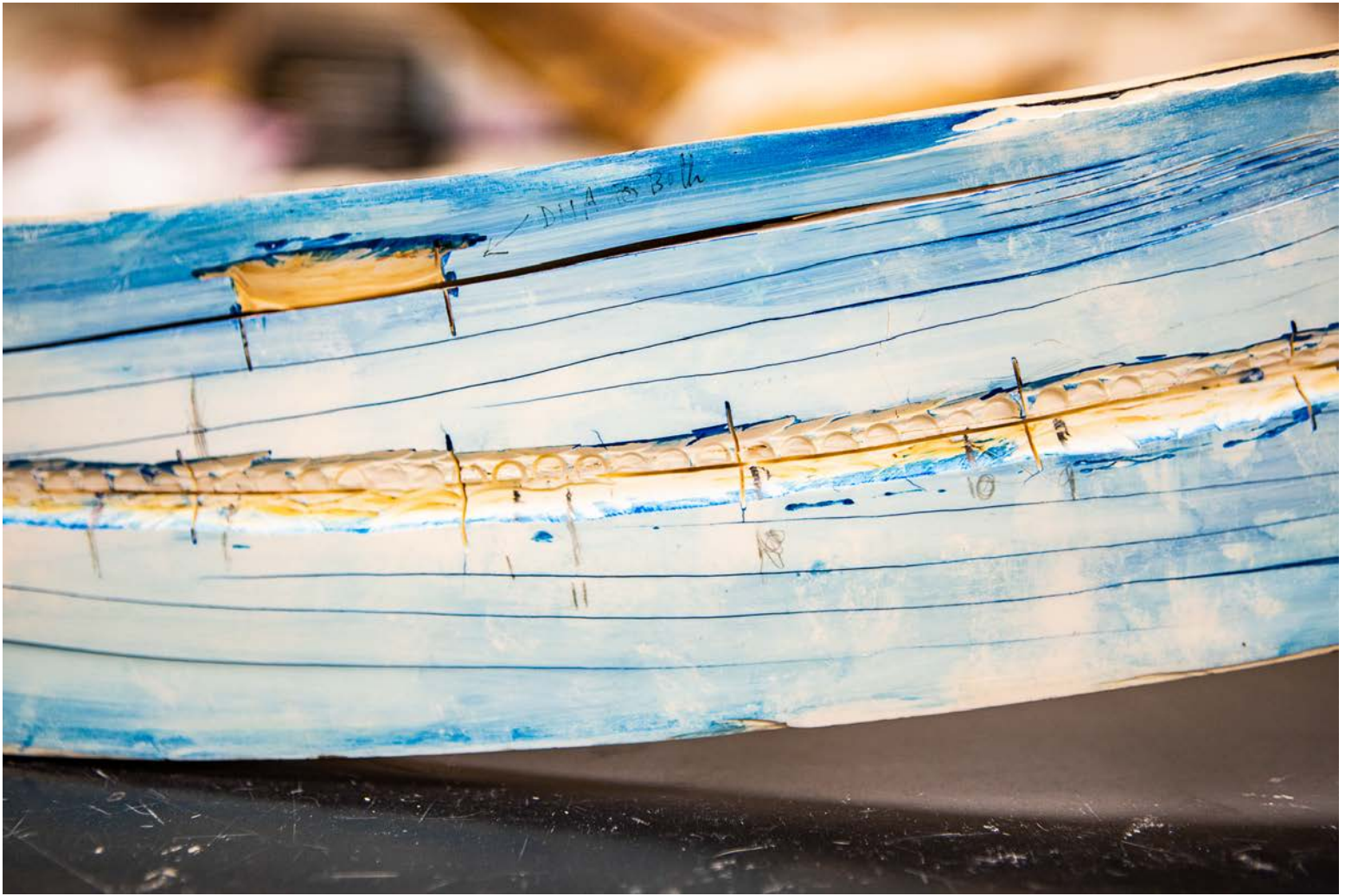
For example, two isotopes of the element oxygen – oxygen-16 and oxygen-18 – can exist in different ratios in plants and water depending on where they’re located. By analyzing a hair sample from a moose, scientists can determine what it’s eaten and where it has been in a general region based on the isotope ratios of elements like oxygen, carbon and nitrogen. The ratios of heavier elements, like strontium, are useful for providing signatures that can help identify distinct locations, like a stream or mountain.

One of ASIF’s most well-known projects was a partnership with Alaska law enforcement agencies in 2007 to determine if locally seized marijuana, before it was legalized, had been grown in Alaska or imported from outside the state. Wooller and his collaborators are now using a similar approach to isotopically “fingerprint” illicit opioids to help understand and trafficking networks inside and outside Alaska.

ASIF operates without university funding and covers its costs by working on contracts for UA, national and international researchers. In recent years some of Wooller's favorite research projects have helped solve mysteries from prehistoric times.

"My own personal scientific passion involves applying analyses of isotopes to questions surrounding past systems," Wooller said. "What caused mammoths, steppe horses, steppe bison, American lions, hyenas, camels to not be here today? It's a big detective story and it's gone on for a really long time."

ASIF contributed to a 2016 study that analyzed the life of a remnant population of woolly mammoths on St. Paul Island, north of Alaska's Aleutian Islands. By studying the contents of a sediment core from the island, isotopes not only determined that St. Paul mammoths had survived until approximately 5,600 years ago, but also showed that a shortage of fresh water likely led to their demise.



By studying isotopes in a cross-section of a mammoth tusk, researchers are working to learn more about the lives of the extinct mammal. Portions of the tusk are stained blue to reveal growth structures in the tusk, which grew like rings in a tree as a mammoth aged. The holes along the center of the tusk show where samples were removed for isotopic testing.

Last year, ASIF was part of a research team that studied a mummified wolf pup that was more than 57,000 years old. The specimen was discovered at a gold mine in Canada's Yukon. Isotope analysis of hair samples and tooth enamel determined that much of its mother's diet came from aquatic sources, likely a seasonal salmon run on the Klondike River.

Isotopes also helped illuminate the life of a human who lived on Alaska's Seward Peninsula about 9,000 years ago.

Using only a tooth, researchers made the surprising discovery that ancient inhabitants of the region subsisted mostly on a terrestrial diet, despite their proximity to the ocean.

“We often have these tiny bits of material from long ago and we’re trying to squeeze every bit of information out of them to tell a more complete story,” said National Park Service archaeologist Jeff Rasic, who worked with Wooller on the project. “With stable isotopes you can deal with the smallest fragments, and the person’s entire diet is in that sample.”

Wooller started work at the UAF isotope lab in 2002, taking over for lab founding director **Don Schell '64, '71** after his retirement. One of Wooller’s first projects at ASIF used his fascination with isotopes to create a particularly geeky show of long-distance love. As a present to his then-fiancée, Diane O’Brien, he decided it would be interesting to chart their isotopic signatures during their engagement.

O’Brien, who is now a professor and interim director at UAF’s Institute of Arctic Biology, was working at Wellesley College in Massachusetts at the time. Wooller was spending his first year in Fairbanks.



Audrey Rowe '18, a UAF Ph.D. student working at the Alaska Stable Isotope Facility, prepares test tubes for sampling.

Wooller collected his beard trimmings. O'Brien saved her fingernails. Analysis of those specimens literally showed how being separated by a country affected their chemical makeup.

"It was mainly for fun, but we studied ourselves," Wooller said. "I presented it at a conference as a Valentine's Day card for Diane."

Since both Wooller and O'Brien had been consuming variations of the same American mass-produced foods,

their diets were fairly similar. Many of the isotopic contrasts came from their drinking water, highlighting the differences between their water sources in Alaska and Massachusetts.

At the suggestion of several colleagues, that data became a peer-reviewed paper in an academic journal, showing the importance that location has on chemical signatures and for forensic science.

“I think people find it very, very captivating,” Wooller said of isotope science. “It can hook them in, big time.”

Captivated by the power of isotopes

The broad potential of isotope research is particularly clear at the UA Museum of the North, where Wooller and Druckenmiller, a paleontologist, spent a March afternoon wading through a space formally known as the Collection Range.

“The Coolest Room in Alaska is what I call it,” Druckenmiller said.



Photo caption: A vast collection of mammoth fossils, including a jawbone with teeth, are stored in the Collection Range at the UA Museum of the North.

A bowl marked “walrus teeth” sits on a small table, and sure enough, it’s full of massive, jagged molars. Bird skeletons, trays of insects, caribou skulls – just about any random piece of an Alaska species seems to be around somewhere. Wooller and Druckenmiller were there for the mammoths, shuffling through more than 100 gigantic tusks stashed above the high shelves in the middle of the room.

Wooller gestured to one split lengthwise, exposing a layered cross-section. “I don’t think there are many museum directors who would let you do something like that,” he said.

That may be true. But Druckenmiller is among a number of scientists who, even though they don’t have a background in isotope science, have developed an appreciation for the discipline.

Researchers have typically relied on radiocarbon dating and the DNA preserved in animal remains to determine their age, gender and how ancient animals were related. Samples throughout the Collection Range could tell much richer stories through their isotopes, and Druckenmiller said mammoth tusks provide a perfect example.

“If I wanted to design an animal for study, a mammoth would be the perfect one,” Druckenmiller said. “You have a tusk like Dixie cups stacked end-to-end on top of each other. Because of these cool isotopic techniques, we can look at that and tell what it’s done. It’s like an animal that was writing a diary throughout its life.”

Wooller, Druckenmiller and their colleagues are studying the range and migratory patterns of ancient mammoths, using those split tusks to tell the story. In the past they’ve

also collaborated on studies that look at the lives of Alaska's ancient bison, caribou, fish and people.

Wooller, who is affiliated with UAF's College of Fisheries and Ocean Sciences and Institute of Northern Engineering, said a variety of students, scientists and outside researchers value ASIF.

Michelle Trifari, a CFOS graduate student from New Jersey, is tracking marine food webs of the Aleutians. Instead of digging through the contents of fish stomachs, she has a record of their diet stowed in their tissues.

"This was totally out of my realm, completely new to me," she said. "But seeing what a powerful tool isotopes can be for a number of things, it's just incredible."

Ben Barst, a scientist at UAF's Water and Environmental Research Center, had a similar story. He began working at ASIF in 2018 as a post-doctoral researcher, finding its possibilities intriguing for studying the effects of environmental contaminants on wildlife.

"When you think about the levels we're talking about, the very fine ratios, the ability to measure it and what you can learn from it is mind-blowing," he said.

ASIF has blossomed during Wooller's nearly two-decade tenure, growing from two mass spectrometers to five. The most recent pieces of equipment, acquired with funding from the National Science Foundation and the M.J. Murdock Charitable Trust, expanded ASIF's capacity to analyze heavy elements and specific compounds that can help identify geographic locations and diets.

As ASIF works on an ever-broader range of projects, Wooller said, even he is amazed at the range of possibilities that isotope research offers.

"They're so versatile. You can apply them to almost everything – everything on the planet is made of isotopes," he said. "It's a very flexible tool. It's very adaptable. As a scientist, that's the wonderful thing about this science."



The video below discusses research on a 57,000-year-old mummified wolf pup discovered in Canada's Yukon and how

work done at UAF's Alaska Stable Isotope Facility helped scientists better understand its brief life.



<https://www.youtube.com/watch?v=1QDKHnJkabM>