Want the Truth? Slice the Tooth

CEMENTUM AGING

by Tana Wilson

What do elk teeth and tree stumps have in common? You can count the rings in both to age them accurately. Here's how it works and why it matters.

PHOTOS: JILLIAN WIGGERS

It may lack in skyscrapers and people, but Manhattan, Montana, is still on the global radar—at least when it comes to animal teeth. This town of 1,700 has postmarked an improbable number and variety of teeth, aging more than 100,000 from dozens of species of wildlife each year. Located right off I-90—its crisp and inviting front often ironically mistaken as a restaurant—is Matson's Laboratory, a privately-owned wildlife lab that specializes in aging animal teeth.

Matson's Lab has been processing wildlife teeth for almost half a century. In 1969, Gary Matson launched the original lab 180 miles to the west in Milltown, Montana, housed in a considerably less impressive facility.

"When we first started, we had a 28-foot mobile home that was converted into a lab," Matson says. "It was really pretty pathetic. The roof leaked… everything leaked."

At the time Matson was working on his master's in zoology at the University of Montana and initially created the lab to specialize in histology, preparing slides for the microscopic study of animal tissues. But soon a friend and fellow grad student named Merlin Shoesmith suggested he try cementum analysis using elk teeth. Back then it was a relatively new technique that a handful of researchers had used mainly for aging marine mammals. Shoesmith, though, was working in Yellowstone National Park with world-renowned wildlife biologist and UM professor John Craighead, studying elk on Specimen Ridge. Shoesmith began shipping Matson batches of elk teeth he'd collected from winterkills in the park. Cementum analysis immediately showed promise for aging elk. Matson soon tried it for aging black bears, too, and in the process found it could reveal other secrets as well.

It slowly became clear to him there could be a market for this service. All mammals deposit distinct annual layers of protein within their cementum, the calcified or mineralized tissue layer covering the root of the tooth located in the bony socket below

the gum line. Running an incisor through a blend of hydrochloric acid and formalin softens it into the consistency of a rubber eraser. That allowed Matson to use a precision microtome—a six-inch-long, razor-sharp blade—to shave a cross-section off the tooth, a slice so thin it's transparent. Put on a microscope slide and stained, this reveals the growth rings.

Matson started teaching himself how to count them, which can be far from easy. With practice and collaboration with biologists analyzing known-age teeth, his accuracy steadily improved. Thorough evaluations using larger known-age samples from Montana and Alaska provided further validation of the cementum aging method.

Seeing an opportunity to fill a real need with perhaps the ultimate niche business, he mailed out postcards to state wildlife departments all over the country. He was not overwhelmed by a tsunami of inquiries, but business began to pick up as word spread. Matson soon said goodbye to his trailer and built a lab in Milltown, just outside of Missoula, where he processed more than 2 million teeth over 40 years.

While the lab facilities have changed, the cementum age analysis method has remained constant, and practice and experience made it all the more effective over time. In 2014, Matson handed the microscope off to Carolyn Nistler, a fellow biologist from the Bozeman area and now owner of the lab.

"When Gary was getting ready to retire, he ran a small ad in *The Wildlife Professional* [the quarterly magazine published by the Wildlife Society]. It was really nondescript. It just said, 'Wildlife lab for sale in Missoula, Montana, call this number.'" Nistler picked up the phone. The purchase was finalized in 2014, and she relocated the lab to Manhattan. "It has been a really good fit for me to mold the biology with the business side of things," she says.

Matson's Lab has aged teeth from all 50 states and all seven continents. The majority of business comes from the United States and Canada, along with some European countries, especially Sweden and Finland.

While wildlife biologists supply the vast majority of the teeth, around five percent of those aged annually are sent in by hunters, including the new typical archery world record bull killed in Montana in September 2016. That bull aged in at just 6 years old, far younger than expected. As a rule, mature bulls produce their largest set of antlers between nine and 12 years of age, so to find a record bull this young is rare indeed. (For the full story, see "Prime Tine" on page 64.)

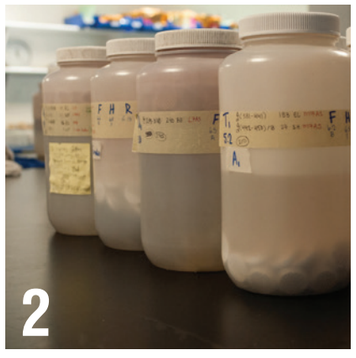
Nistler was excited to age the record bull last June and found that the tooth samples were as absolute as aging teeth can be when she examined the bull's primary incisor under the microscope.

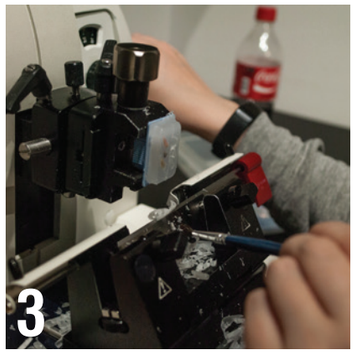
"Sometimes elk are really tricky and have multiple components, but we lucked out. This one

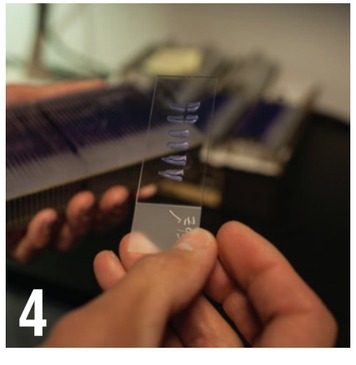
Gary Matson (left) launched his cementum-aging business in 1969 in a 28-foot trailer (top). In 2014, he handed the microscope off to Carolyn Nistler, a fellow biologist and hunter who relocated Matson's Laboratory to Manhattan, Montana—no trailer needed.

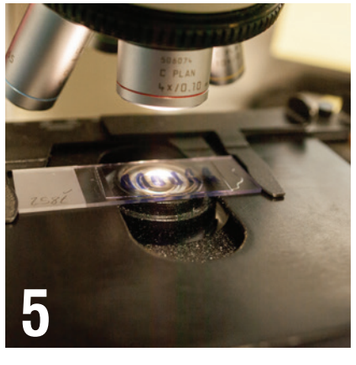
CLOCKWISE FROM TOP LEFT (THIS PAGE): COURTESY OF GARY MATSON / MICHAEL GALLACHER (*MISSOULIAN*) / COURTESY OF CAROLYN NISTLER

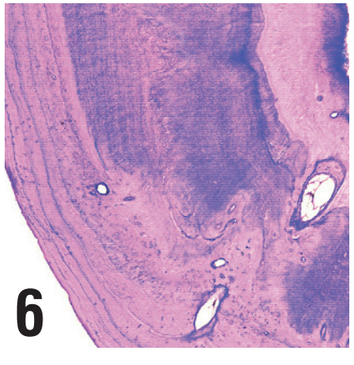
JAWBONING: The Montana Department of Fish and Game, as it was then known, pioneered the idea of aging elk by the wear patterns on their lower jaw in the 1950s. "Jaw boards" (left) are still fixtures at most game check stations across Montana, and biologists still learn how to rough-age elk and deer by the wear on their teeth. The hard-worn teeth from a 20-year-old cow elk (above) show the extreme end of what jaws can reveal.











CLOCKWISE FROM LEFT (THIS PAGE): RMEF / RMEF / JILLIAN WIGGERS (1-6)

SLICE OF LIFE: All mammals deposit layers of protein within their cementum, the calcified tissue covering the root of the tooth(1). Running an incisor through hydrochloric acid and formalin (2) softens it into the consistency of a rubber eraser. Using a precision microtome—a six-inch-long, razor-sharp blade—agers shave a cross-section off the tooth(3), a slice so thin it's transparent (4). Put on a microscope slide and stained(5), this reveals the growth rings (6).

was really clear."

If you do find yourself curious how old an animal is, there's a good chance Matson's Lab can tell you. It usually takes about three months to process and report on—not too much different than dropping a head or antlers off at a taxidermist.

The opportune time to extract a tooth is right after death. Once the tissue begins to stiffen, it's far harder to free it from the gum. If a tooth breaks at the gum line, it is impossible to use cementum to age it. The best extraction method is to slice down on each side of the two lower front teeth with a sharp knife. Then wiggle one back and forth until it can be pulled free.

For wildlife biologists, sending teeth to Matson's Lab is a dependable population monitoring tool. The oldest elk the lab has so far aged was an incredible 32 years of age, a cow elk from Pennsylvania. Jeremy Banfield, Pennsylvania state elk biologist, attributes that to high-quality habitat and tightly limited hunting opportunity since the first modern elk hunt there began in 2001. In addition to more than 3,000 teeth from black bears, Pennsylvania ships around 120 elk teeth to Matson's each year—one from each elk legally killed in the state's hunt, plus elk that die from other causes. When Banfield gets the results back from the lab, he doesn't want to see a large number in the senior age class. He says the primary reproductive years for cows are between 3 and 10, and a healthy herd is comprised mainly of fertile cows and their calves.

"We don't want to see old cows simply because they are consuming resources and not putting calves on the ground," Banfield says. "That sounds cruel, but that's population dynamics in a nutshell."

Matson's cementum age analyses are not only species-specific but are also based on a standardized tooth type. Lab technicians must also account for the anatomical differences between species. For instance, bighorn sheep have four pairs of incisors that erupt in four consecutive years. If a technician aged the first-year incisor as though it were the incisor erupting the fourth year, the age count would be off three years, so it's critical to identify the specific tooth type before counting cementum deposits.

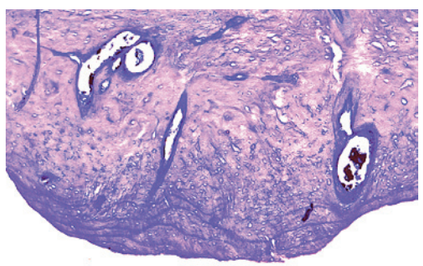
Nistler says mountain lions, otters and polar bears are among the more challenging species to accurately age. Instead of distinct annular patterns that are often found in elk, bobcats and black bears, the protein layers look more like a meandering stream than the ideal linear ring-shape.

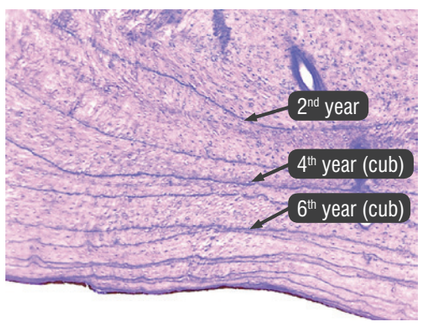
In the winter, when food tends to be scarce and low in nutrients for elk and other big game, they deposit dark, narrow growth bands. Then in spring and summer when resources are abundant, they deposit thick, light bands. The dark bands are what agers count to determine how old an animal is. For the most part, animals that are five or older are easier to age than those that are younger.

Some animals have very distinct layers of cementum that are like counting rings on a tree—but other species are more difficult. Nistler says mountain lions, river and sea otters and polar bears are among the more challenging species to accurately age. Instead of distinct annular patterns that are often found in elk, bobcats and black bears, the protein layers look more like a meandering stream than the ideal linear ring-shape.

Five-year-old river otter tooth section

Twelve-year-old black bear tooth section





CLOCKWISE FROM TOP LEFT: DAVID REIN / DARYLE HUNTER / COURTESY OF MATSON'S LABORATORY

Teeth often reflect an animal's health and habitat, which wasn't lost on one of the forefathers of elk conservation, biologist Olaus Murie. When he published *The Elk of North America* in 1951, he wrote:

"The teeth are a vital part of the anatomy of any mammal, and their importance to an herbivorous mammal cannot be overestimated. The condition of the teeth is often the deciding factor in the length of life of an herbivorous animal…and plays a big part in the winter mortality of certain age classes."

Cementum deposits are a lot like rock layers—if you look closely, you can infer what might have occurred in the past. For example, while aging female black bears, Matson, Nistler and lab manager Arthur Stephens can often pinpoint exact ages when a sow reared cubs.

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"Years where the lines get scrunched together are the years the sow had to rear the cubs and couldn't get as much nutrients for herself," Stephens says. "Once the cub is a year old, we see that sow is more self-sufficient, and the lines spread out more."

Bizarrely, they don't see that in any other bear species. Stephens has aged 1,300 polar bears—equivalent to roughly 5 percent of the current world population—and has never been able to differentiate between years with cubs and years without.

Cementum analysis typically does not work for fossilized species, but one Princeton University research student lucked out and has been able to send partially fossilized bats from the island of Madagascar to Manhattan, Montana. The bat specimens are between 100 and 200 years old and predate bushmeat hunting on the island when bats became a food source for people. Matson's Lab has been able to age most of the bat teeth because they were so well preserved below ground.

If something has become fossilized, by definition, its bone has lost the collagen and the soft parts, Nistler says. "When we decalcify the tooth, the boney part is gone, so all that is left is connective tissue [what they use to determine age]. Once that part has been lost to the chemistry of fossilization, there is nothing we can do."

Now and then, melting or calving glaciers spit out the frozen remains of animals such as woolly mammoths, and Nistler says there is no reason why Matson's couldn't age one the same way they age bison and other somewhat similar species. "We'd have to get bigger slides though," she says.

While Matson's Lab hasn't yet taken on a mammoth, no other cementum labs in the world age as many species or teeth. "We add a handful of new species each year," Nistler says. In 2017, the lab aged porpoises and caracals [bobcat-sized wildcats native to Africa and central Asia] for the first time. However, there is one animal that will never debut on the list: humans. The lab has been approached to age human teeth. Scientifically, there is no reason they couldn't, but Nistler says it's a no-go. "My passion is wildlife. I'm not trying to be a criminologist."

There are very few North American wildlife species that the lab hasn't processed. One exception: the order of animals perhaps best known for its fangs. No snake has yet crossed their microscopes, but both Nistler and Stephens are confident they could age one.

Even species with continuously growing incisors such as beavers can be aged using their molars, and Matson's Lab has processed quite a few over the years. One species that is impossible to age, though, is one that has no lack for teeth—at least 300 of them, in fact. Shark species defeat any and all attempts at using cementum for aging. As *Shark Week* buffs can attest, they continuously replace their teeth as they break off or wear down, making it impossible to use them for aging. In fact, sharks can go through 30,000 teeth in their lifetime.

If you walked into Matson's Lab today, you would see up to nine lab employees all trained in each of the steps that go into aging a single tooth. You would also see striking blue tiled floor. When Nistler picked out the tiles, she wanted to make sure they were a color that would allow a dropped tooth to stand out. Aging teeth is a curiously quiet process, the opposite of being at the dentist and listening to all the miniature power tools at work. If it wasn't for background music you would be able to hear a pin drop, or in this case, a tooth.

The folks who work at the lab have a unique skill set. After hiring on at the lab, new employees undergo training similar to an apprenticeship. Most have either a biology or histology (the study of the microscopic structure of tissues) degree, and they have to slice, stain and accurately age a lot of teeth to become an ager.

The lab has a set of blind-test slides—aged correctly by Matson, Nistler and Stephens—that are used to test rookie agers. The goal is for every trainee to accurately recognize and age teeth of the most common species, and for each to also find their forte with more specialized species. For instance, Stephens

is the go-to for aging polar bears, Nistler for seals. And Gary Matson, of course, is the guru of all. Once a technician's age results compare with Matson's with a precision of 85-95 percent—depending on the difficulty of the species—they are considered ready to work.

"When I first started doing cementum analysis in the late '60s, I thought this would be really easy. You just count—everybody can count," Matson says. "But the process requires experience and is something that's not easily duplicated."

Still, the method has long since proven itself. A peer-reviewed study led by Montana Fish, Wildlife and Parks biologists and published in the *Journal of Wildlife Management* in 2000 evaluated the accuracy of cementum aging by Matson's Lab for 111 known-age elk, 108 mule deer and 74 whitetails. It found accuracy rates of over 97 percent for elk, over 92 percent for mule deer and over 85 percent for whitetails. That blew visual tooth-wear aging out of the water (see "Jawboning" on page 59), which registered less than 63 percent accuracy for mule deer, 43 percent for whitetails and 16 to 50 percent for elk, depending on the animal's age.

This dependability has led biologists around the country to rely on Matson's Lab. Montana has aged wolves there since the first pack roamed back into the state from Canada in 1979. Matson's has similarly aged virtually every black bear killed by hunters in Pennsylvania, New Mexico, Maine, North Carolina and a large number from other states and provinces since the 1980s—fast approaching 700,000. Such a deep archive of data in each state reflects the fortunes of species on a broad scale.

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New Mexico Department of Game and Fish (NMGF) relies on Matson's cementum analysis as a primary indicator for both mountain lions and black bears, which also gives them a window into bear reproduction.

"We use the lab to track what ages most female bears first give birth to see if there are any changes or trends over time," says Elise Goldstein, NMGF Wildlife Management Division assistant chief. "Good healthy bears should have cubs beginning at a fairly young age, which can be tied to climate conditions and food availability. So, if your birthing age suddenly spikes and stays up, we will want to figure out what happened and why."

The data also helps them to set hunting seasons.

"If suddenly the average age of harvested bears in a certain area plummets and continues to stay low, we'll be like, 'Wow, what happened to all the mature bears?'" Goldstein says. "And we will look to see if there is has been a disease die-off, a big change in habitat, a drought—something that might lead us to shift our harvest management in response."

She says Matson's has been a stalwart partner in this effort for decades, which is a service that the lab is proud to deliver.

"The success of the lab has a lot to do with the loyalty and support we've had from our clients," Matson says. "We've tried to be a member of the wildlife biology community, rather than just a vendor. We want our results to be the best so that the wildlife management actions taken because of those results can be the best, too."

Tana Wilson is a University of Montana alumna from Libby, Montana, and former Bugle *intern. She recently traded Montana mountains for the foothills of South Carolina where she's pursuing a master's degree in parks and conservation area management at Clemson University.*

PHOTO: DIANE HIGDEM