Saber Teeth

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Carnivores of all kinds have always been of interest to me. Arguably it is a much more difficult lifestyle to hunt and kill another animal than it is to browse or graze on non-mobile plants. Carnivorous animals have evolved to stalk and kill their prey in many, many varied ways. Just think of the speed of a frog's tongue or the speed of a cheetah, the stealth and camouflage of an octopus, or the intelligence of some birds. These are only a few examples of modern carnivores; the variety of carnivores through time is broader and even more fascinating.

Convergent evolution is the reappearance of the same solution to a biological problem across unrelated groups of animals. This has happened many times throughout Earth's history. The similar body shapes of sharks, fish, ichthyosaurs (a group of swimming reptiles) and dolphins is a great example of unrelated groups of animals all converging on a similar body plan that is very efficient at moving through the water column. Flight is another great example of convergent evolution. Powered flight has evolved separately in insects, birds, reptiles and mammals. The ability to fly has many advantages and may give those animals access to additional resources or offer them the ability to more easily escape predators. The (now extinct) Tasmanian wolf of Australia and the North American wolf shared many traits, the North American armadillo and the African pangolin also share many traits, these and many other examples of convergence can be found throughout Earth's history of life.

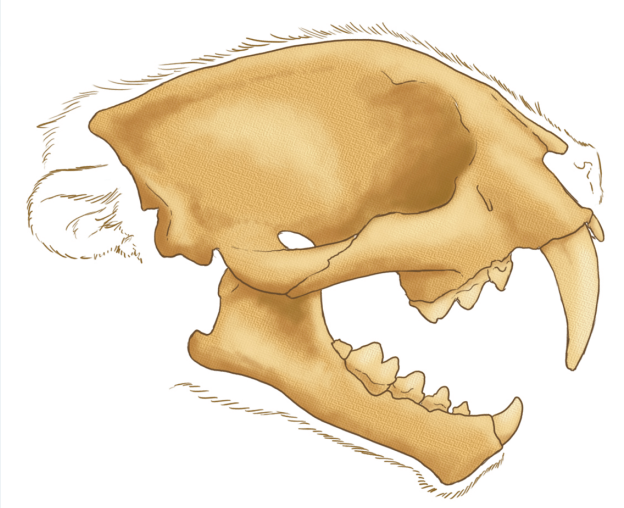

Figure 1. The scimitar-toothed cat-like animal *Dinictis*. Drawing by Becky Barnes.

A lesser known example of convergent evolution is the appearance of saber-teeth in different groups of carnivorous animals. Even though most have heard of *Smilodon*, the saber-tooth cat which can be found in the La Brea Tar Pits in California, few realize that *Smilodon* is only the last iteration of saber-teeth in the fossil record. Carnivorous mammals with large sabers have appeared four times across unrelated groups of carnivorous mammals over the last 60 million years (or so) of Earth's history.

Types of Saber-teeth

Not only were there four different groups of mammals that evolved saber-teeth separately, there are also two different kinds of saber-teeth. There are the dirk-toothed forms, and the scimitar-toothed forms. The scimitar-toothed animals tended to be more lightly built with coarsely serrated and somewhat elongated canines (fig. 1) (Martin, 1998a). The dirk-toothed animals tended to be more powerfully built with long, finely serrated, dagger-like canines which sometimes included a large flange on the lower jaw (fig. 2) (Martin, 1998a).

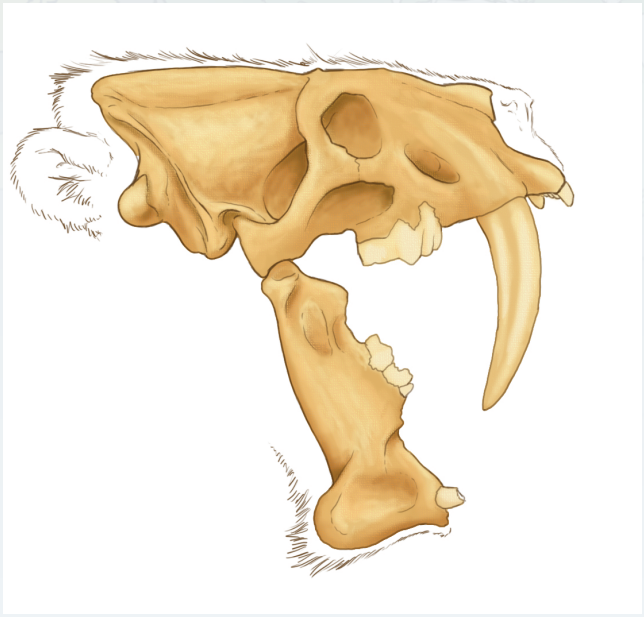

Figure 2. The dirk-toothed cat-like animal *Barbourofelis*. Note the large flange protecting the saber on the lower jaw. Drawing by Becky Barnes.

There are many modern animals with very large upper teeth, for example elephants, wild boar, and the Chinese water deer, but these teeth are not necessarily adapted for hunting. In fact not all of these animals have modified their canine teeth as saber-tooth cats have. For example, the tusks of elephants are actually modified incisors, not canines. These "saber-teeth" have also appeared in other groups of animals throughout Earth's history (Krebs, 1998; Rougier et al., 2011), but only the carnivorous felids (true cats) and felid-like animals will be discussed herein.

The first group of carnivorous mammals to evolve saber-teeth was an ancient group called the creodonts. This diverse group

of felid-like animals ranged from housecat-size up to lion-sized (Gunnell, 1998). They first appeared about 60 million years ago and the last member of the group disappeared around 30 million years ago (Gunnell, 1998). Although only a few members of this group evolved saber-teeth, their presence within the group is well documented: an animal called *Hyaenodon* was a saber-toothed member (fig. 3). Members of this group are separated from other mammals owing to many morphological features, one of which is the arrangement and shape of all their teeth, not just those with sabers.

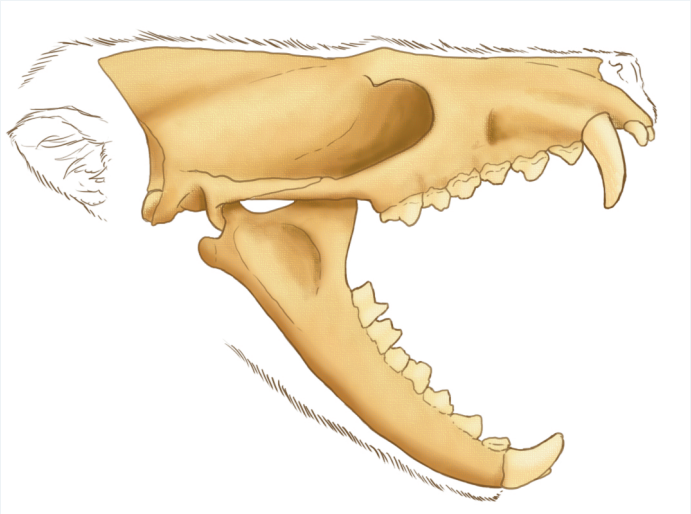

Figure 3. The creodont cat-like animal *Hyaenodon*. Drawing by Becky Barnes.

The second group of carnivorous mammals to evolve saber-teeth was the Nimravidae. This group was very cat-like in appearance, but were not true cats. Besides many other differences in the skull and teeth, nimravids had a much smaller brain case than felids (Martin, 1998a). Of the seven genera that lived in North America all but one are considered saber-toothed (Martin, 1998a). They are often called false sabertooths, and thrived in North America and Eurasia between 35 and 25 million years ago, although one genus (*Barbourofelis*) (fig. 2) appeared in North America five million years ago (Martin, 1998a). An animal called *Dinictis* (fig. 1) was a saber-toothed member of this group.

The third group of carnivorous mammals to evolve saber-teeth was the South American carnivorous marsupials called borhyaenids. The genus *Thylacosmilus* evolved from this group during the Pliocene-Pleistocene (less than five million years ago). Even though it was not a very large animal (leopard sized), *Thylacosmilus* had some of the largest sabers compared to body size. In all mammals with teeth, there is an exposed crown portion of the tooth and a hidden root portion of the tooth. Some mammals have very short roots and some have very long roots, the same is true for saber-tooth animals and their sabers. The sabers of *Thylacosmilus* are contained in bony sheaths on the top of the skull. These sheaths open at the palate where all teeth protrude from the jaw and continue up and back along the top of the skull and end well behind the orbit or eye socket (fig. 4). No other group of saber-tooth animals had sheaths this large. These sabers also originated from an extended pulp cavity, suggesting that they were ever growing throughout the animal's life (Riggs, 1934).

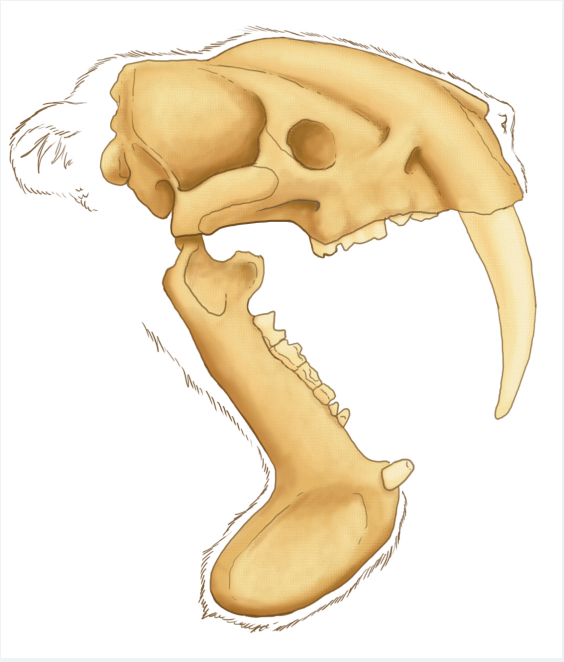

Figure 4. The marsupial saber-tooth *Thylacosmilus*. Drawing by Becky Barnes.

The fourth group of carnivorous mammals to evolve saber-teeth was the modern cat family or Felidae. Arguably the most well-known saber-tooth cat of all, *Smilodon*, is from this group (fig. 5). Like a few of the other saber-tooth cats, *Smilodon* was heavily built (Martin, 1998b). One could think of *Smilodon* as being similar to an animal with the body of a bear and the head of a cat with razor sharp knives protruding below its jaw; a formidable animal to be sure. *Smilodon* was the last fossil felid to have saber-teeth, going extinct at the end of the Pleistocene, a mere 10,000 years ago. It is possible that *Smilodon* interacted with or even preyed on early humans, but no evidence has ever been found to prove such a claim. A very large proportion of the animals being recovered from the LaBrea Tar Pits are carnivores, specifically the wolf *Canis dirus* and the saber-tooth cat *Smilodon fatalis* (Stock, 1930). This unusual proportion is believed to be the result of these large carnivores feeding on other animals mired in the tar with the carnivores then becoming stuck themselves.

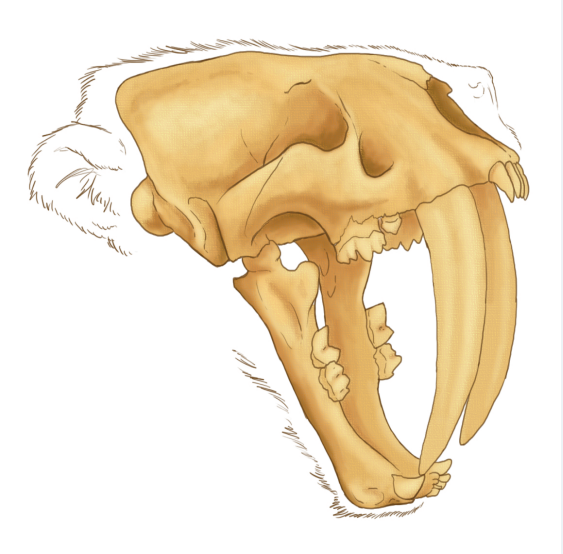

Figure 5. The saber-tooth cat *Smilodon*. Drawing by Becky Barnes.

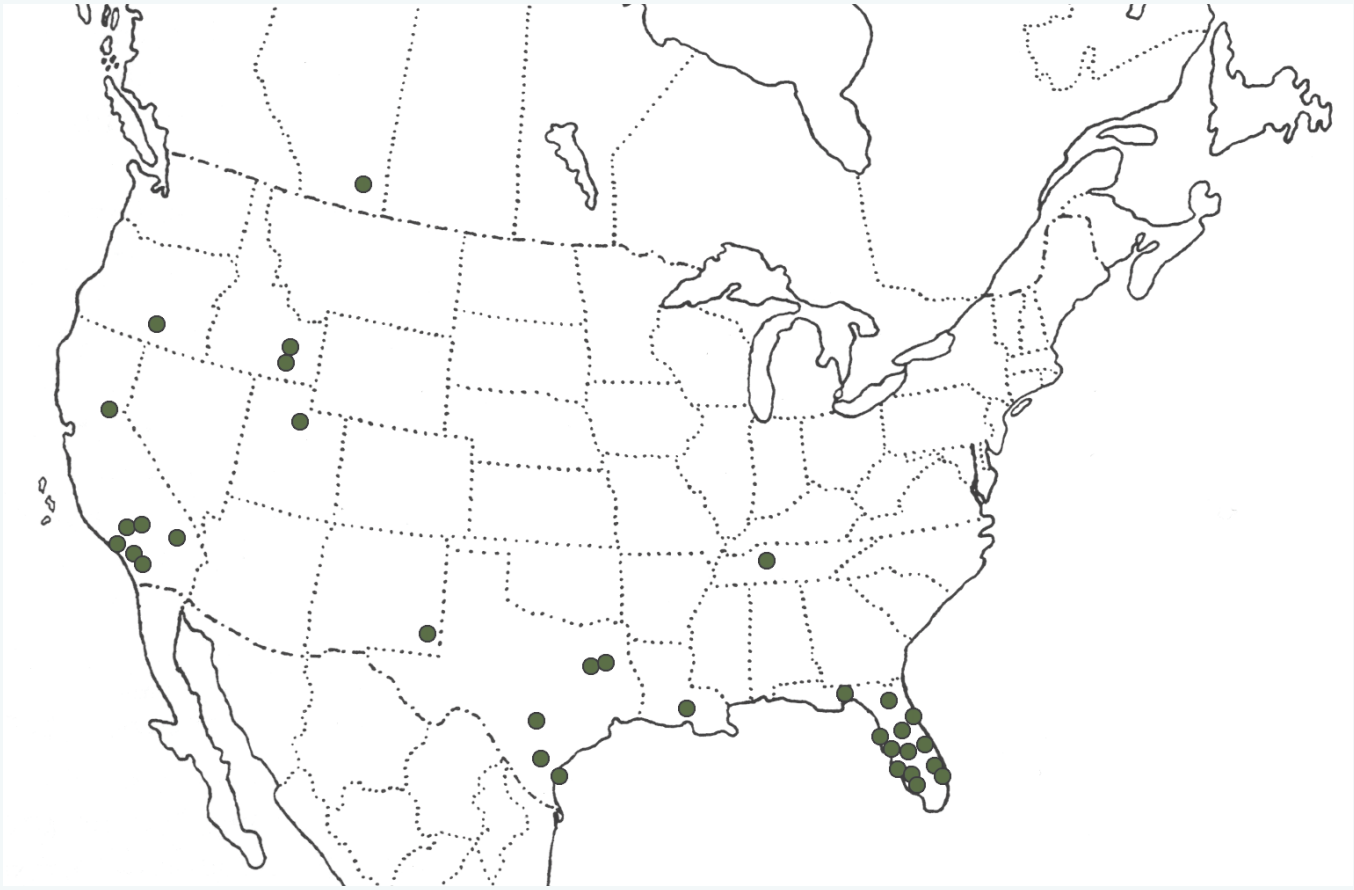

Figure 6. Distribution map of *Smilodon* (green dots) across the United States and Canada. Modified from Kurten and Anderson, 1980.

Saber-tooth function: Stabbing vs. Slicing

The actual function of these saber-teeth is still debated today. It really comes down to a very simple argument: Were the sabers used for stabbing or were they used for slicing?

First of all, if these sabers were used for stabbing, could these animals open their mouths wide enough to be able to use them effectively, and could they even see what they were biting? This comes from the hypothesis that the arrangement of the bones and muscles of the skull would not allow the animal to open its mouth wide enough to bite anything. Since the tips of the sabers are so far beneath the lower jaw, and therefore well below the line of sight of the animal, the animal would not be able to see what was going into its mouth at the time of the bite. Although compelling, this argument has been proven false a number of times throughout the study of this question (Matthew, 1910; Bohlin, 1940). These animals could indeed open their mouths wide enough to use them in a stabbing motion, although the fact remains that they most likely could not see exactly what they were biting into.

The stabbing camp hypothesizes that these saber-teeth were used more like butcher knives or daggers and were stabbed into the throat, cutting through all the soft tissue leading to an almost instant death. The very robust, bulky, almost tank-like appearance of some of the skeletons of these saber-tooth animals is used as evidence that these animals (*Smilodon* for example) were capable of subduing a potentially thrashing animal during the killing bite, thus saving the sabers from being broken.

The slicing camp hypothesizes that the saber-teeth were used as slicing weapons. They would slice their prey at the throat or in the soft underbelly and wait for them to bleed out, retreating away from a thrashing, kicking or fighting animal. After their prey has stopped thrashing they could begin feeding since the animal is weakened and cannot fight back. This camp states that even if these animals could open their mouths wide enough to grasp prey between their canines, these canines would be too fragile to use for stabbing. The risk that the prey might thrash and break the sabers would be too great.

So which of these hypotheses is correct? The truth of their use may actually lie somewhere in between. It is possible that some of the more lightly built scimitar-toothed forms were slicers, and the more heavily built dirk-toothed forms were stabbers. This makes a great deal of sense. If you are lightly built you would most likely not have the strength to subdue an animal while it thrashes about. Your strategy would therefore be to inflict a sizeable wound and wait for the animal to become weakened before dispatching it. However, if you are more powerfully built you could grapple with an animal while it thrashes with much less risk of breaking your teeth while doing so, dispatching the animal much more quickly and more readily ensuring a meal. Whichever style was used, there is no debating that the large saber-teeth were beneficial to the animals that wielded them. These large sabers would not have evolved so many times if they were detrimental.

Saber-tooth cats in ND

North Dakota has been host to two of the four kinds of saber-tooth animals. Remains of the creodonts, specifically *Hyaenodon* have

Figure 7. Comparison of the clouded leopard (left) and leopard (right). Note the size of the upper and lower canines on each.

been found in the Little Badlands of southwestern North Dakota. The Little Badlands have also produced remains of nimravids, specifically *Dinictis*. Please see Hoganson and Person (2011) for evidence that *Hyaenodon* and *Dinictis* not only overlapped in time and space, but interacted with each other. The group of saber-tooth animals to which *Thylacosmilus* belongs is purely South American so obviously no remains of that group have been found in North Dakota. Lastly, the felids have produced a number of saber-tooth cats but none have been found in North Dakota. This seems to be a bit odd, considering remains of *Smilodon* have been found in Canada and as far east as Tennessee and Florida (fig. 6). This could be the result of biogeography, that is, *Smilodon* may not have lived in this part of the country. It could also just be the result of a geological phenomenon and remains of the animal may still yet be found at various localities across the state.

Modern saber-tooths?

The last fossil carnivorous animal to possess very large sabers was *Smilodon fatalis*, who went extinct at the end of the Rancholabrean age (approximately 10,000 years ago) most likely due to the disappearance of their prey. However, another felid and not-so-distant cousin of *Smilodon* exists today and has surprisingly large canines. The clouded leopard (*Neofelis nebulosa*) of southern Asia is a very secretive cat of which very little is known. The upper canines of this cat protrude below its lower jaw, compared to its close living relative, the leopard (*Panthera pardus*), whose upper canines do not (fig. 7).

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