Remarkable Creatures

In a Shark’s Tooth, a New Family Tree

By SEAN B. CARROLL
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“Like a locomotive with a mouth full of butcher knives.”

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BITING The great white shark, with its serrated teeth, was thought to have evolved from the ancient megalodon. New clues suggest a different ancestor.

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That is how a shark expert, Matt Hooper, described Carcharodon megalodon to the police chief in Peter Benchley's novel "Jaws." He was referring to the 50-foot-long, 50-ton body and enormous six- to seven-inch-long teeth that made the extinct megalodon shark perhaps the most awesome predator that has ever roamed the seas.

Hooper had just gotten his first glimpse of the massive great white shark that was terrorizing the residents of Amity Island. Hooper explained that the Latin name for the great white was Carcharodon carcharias and that "the closest ancestor we can find for it" was megalodon. So maybe, he speculated, this creature wasn't merely a great white, but a surviving sea monster from an earlier era.

Hooper was toying with a simple and long-established idea: that the most feared predator in the ocean today, the great white shark, evolved from megalodon, the most fearsome predator of a few million years ago.

That is how the two species had been viewed, until recently, when new ways of looking at shark teeth, and new shark fossils from a Peruvian desert, convinced most experts that great whites are not descended from a megatoothed megashark. Rather, they evolved from a more moderate-size, smooth-toothed relative of mako sharks.

If true, then the mouth full of flesh-ripping razor blades that are the stuff of nightmares, and box-office blockbusters, are also a great example of one of the most interesting phenomena in the story of life, convergent evolution — the independent evolution of similar adaptations by different creatures.

The idea of a close relationship between great whites and megalodon started in 1835, when Louis Agassiz, a Swiss paleontologist and fish expert, formally named the giant species. The huge fossil teeth of megalodon had been known for centuries and were once believed to be the fossilized tongues of dragons. Agassiz, noting that great white shark teeth and the fossil megalodon teeth were both serrated, lumped megalodon into the same genus, Carcharodon, (from the Greek karcharos, meaning sharp or jagged, and odous, meaning tooth).

Agassiz was not, however, making an evolutionary judgment. In 1835, a young Charles Darwin was just then visiting the Galapagos Islands. There would be no theory of evolutionary descent for nearly 25 years. In fact, the brilliant Agassiz, who later became a professor at Harvard and the leading figure of natural history in the United States, forever resisted Darwin's revolutionary

ideas. Rejecting biological evolution, Agassiz defined species as a "thought of God." His classification scheme signified nothing about shark origins.

But over the next century, the idea that great whites evolved from megalodon took hold. Because shark skeletons are largely made of nonmineralized cartilage that isn't preserved in the fossil record, the principal evidence has come from their teeth. Shark teeth are heavily mineralized, preserve well, and sharks may shed thousands of them over their lifetime. Megalodon teeth are highly sought by collectors, so we have lots of their teeth.

Great white teeth reach a maximum size of about two and half inches. Scary enough, but adult megalodon teeth dwarf them. The most obvious characteristics the species' teeth have in common are their pointed shape and serrations. The points facilitate the puncturing of flesh and grasping of prey. The fine, regularly spaced serrations aid in cutting and ripping it into pieces.

Based primarily on these characteristics and some similarities in specific tooth shapes and roots, many experts supported the idea that great whites were, in effect, dwarf megalodons.

But a small minority had their doubts. It was noted that great white teeth also bore similarities to the teeth of an extinct mako shark, Isurus hastalis, some of which had weak serrations. An alternative proposal for great white origins was offered — that they evolved from an extinct group of mako sharks.

Many debates about interpretations of the appearances of structures in the fossil record boil down to the emphasis on different characters by different researchers, the great white origins debate included. It is often similar to a discussion at a family reunion of which child looks more like one parent or grandparent. It depends upon the feature and the viewer.

Such subjective arguments are hard to settle without more quantitative measures. Kevin Nyberg and Gregory Wray of Duke University and Charles Ciampaglio of Wright State University used new computer-assisted imaging and measurement methods to better assess the similarities and differences among great white, megalodon and extinct mako teeth. They determined that the extinct mako and great white teeth and roots were similar in shape and clearly distinct from megalodon.

Furthermore, high-resolution electron microscopy revealed that the shape and spacing of serrations of great white teeth were markedly different from those in megalodon teeth. The serrations that impressed Agassiz now appear to be just a superficial resemblance. The great white did not inherit its sharp cutting tools from megalodon.

Rather, it appears that great whites evolved from a less ferocious-looking ancestor and independently evolved sharp serrations. A remarkably well-preserved fossil of what a great white ancestor may have looked like was recently brought to light. The desert region of southwestern Peru is a graveyard of marine animals from the past 40 million years, including spectacularly preserved whales, dolphins, walruses, seals, turtles and sharks. It was there that Gordon Hubbell, a shark expert, collected the four-million-year-old fossil that had not only its jaws intact with 222

teeth, but also 45 vertebrae — both rarities for shark fossils and rare opportunities for shark experts.

The preservation of the teeth in their proper place, as opposed to being found scattered in sediments, allowed an unprecedented analysis of individual teeth and the pattern of tooth development in the shark. Similarities were found to both extinct mako sharks and living great whites, including weak serrations, suggesting that the Peruvian fossil might be a transitional form, a link between a smooth-toothed mako ancestor and the great white.

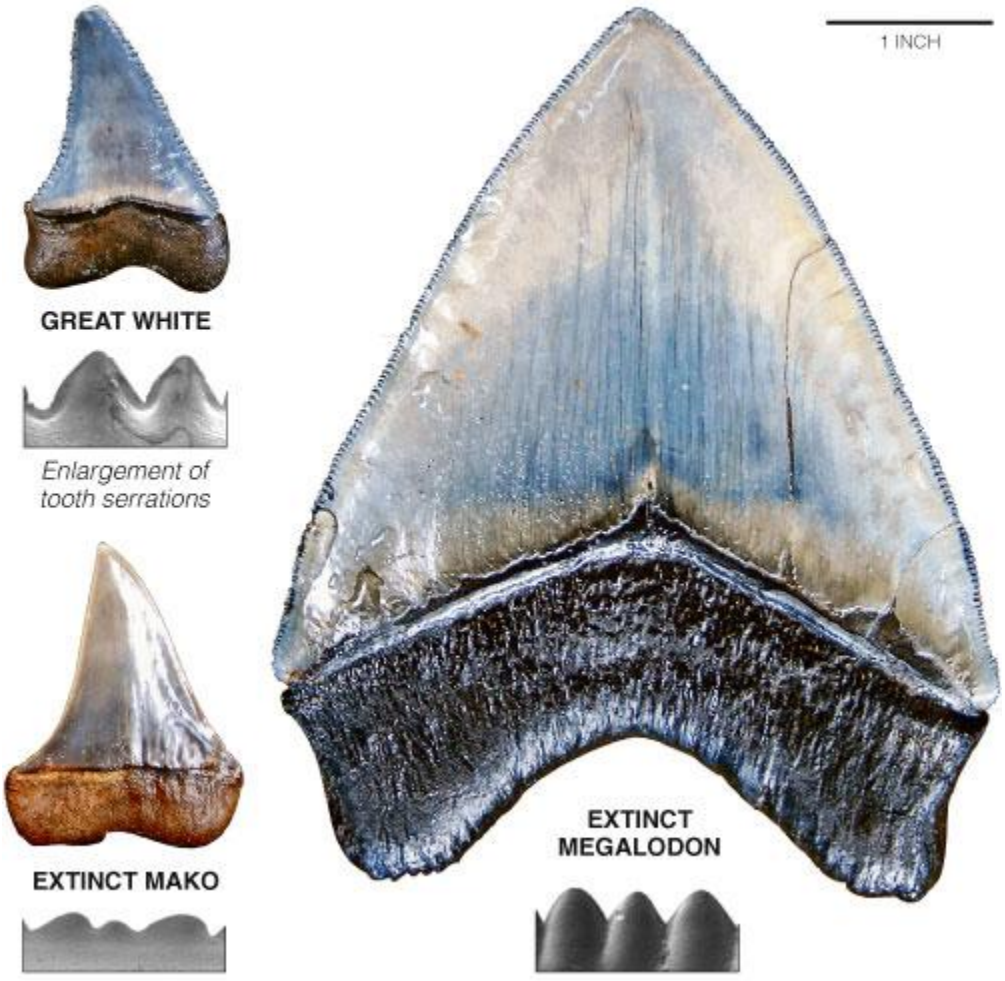
The serrations of great white teeth undoubtedly evolved to exploit expanding populations of marine mammals. That adaptation appears to have given the predators an advantage as they, like megalodon in its day, enjoy a broad oceanwide distribution. At least for now.

I say “for now” because great whites are declining along with most shark species, some of which have experienced alarming drops in their numbers in just the past two decades. Biologists are not sure what caused the once dominant megalodon to become extinct two million years ago, but there will be no debate about who is to blame if today’s top predator is gone tomorrow.

Sean B. Carroll is a molecular biologist and geneticist and the author of several books, most recently “Remarkable Creatures: Epic Adventures in the Search for the Origin of Species.” He will be writing a column of the same title for Science Times, more or less monthly, on the remarkable creatures that scientists study and the remarkable creatures that many scientists are (or were). He is an investigator of the Howard Hughes Medical Institute at the University of Wisconsin.

Dangerous Bite

New fossils and an analysis of tooth serrations suggest that great white sharks are not descended from megalodon, a huge shark with six- to- seven-inch-long teeth. Instead, great whites most likely evolved from a smaller, smooth-toothed relative of mako sharks.



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