Scientists find that squid beak is both hard and soft, a material that engineers want to copy

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How did nature make the squid's beak super hard and sharp — allowing it, without harm to its soft body — to capture its prey? The question has captivated those interested in creating new materials that mimic biological materials. The results are published in this week's issue of the journal *Science*.

The sharp beak of the Humboldt squid is one of the hardest and stiffest organic materials known. Engineers, biologists, and marine scientists at the University of California, Santa Barbara, have joined forces to discover how the soft, gelatinous squid can operate its knife-like beak without tearing itself to pieces.

UC Santa Barbara is a mecca for this type of interdisciplinary study, and draws scientists and engineers from all over the world to grapple with questions that cross a wide range of science and engineering disciplines.

The key to the squid beak lies in the gradations of stiffness. The tip is extremely stiff, yet the base is 100 times more compliant, allowing it to blend with surrounding tissue. However, this only works when the base of the beak is wet. After it dries out, the base becomes similarly stiff as the already desiccated beak tip.

Humboldt squids, or Dosidicus gigas, are about three feet wide and can injure a fish with one swift motion. According to the article, … "a squid beak can sever the nerve cord to paralyze prey for later leisurely dining."

"Squids can be aggressive, whimsical, suddenly mean, and they are always hungry," said Herb Waite, co-author and professor of biology at UC Santa Barbara. "You wouldn't want to be diving next to one. A dozen of them could eat you, or really hurt you a lot." The creatures are very fast and swim by jet propulsion.

Besides humans, squid's main predator is the sperm whale, and these animals frequently show the scars of battle, with skin marred by the squid's sharp suckers. Waite noted that squid muscle is available in locally made sandwiches, often called "calamari steak sandwiches."

Waite finds the squid beak compelling and he interested postdoctoral researcher and first author Ali Miserez in joining the study. Miserez is affiliated with UCSB's Department of Materials, the Department of Molecular, Cellular, and Developmental Biology (MCDB), and the Marine Science Institute.

"I'd always been skeptical of whether there is any real advantage to 'functionally graded' materials, but the squid beak turned me into a believer," said co-author Frank Zok, professor and associate chair of the Department of Materials at UC Santa Barbara.

"Here you have a 'cutting tool' that's extremely hard and stiff at its tip and is attached to a material — the muscular buccal mass — that has the consistency of Jell-o," said Zok.

"You can imagine the problems you'd encounter if you attached a knife blade to a block of Jell-o and tried to use that blade for cutting. The blade would cut through the Jell-o at least as much as the targeted object. In the case of the squid beak, nature takes care of the problem by changing the beak composition progressively, rather than abruptly, so that its tip can pierce prey without harming the squid in the process. It's a truly fascinating design!"

Zok explained that most engineered structures are made of combinations of very different materials such as ceramics, metals and plastics. Joining them together requires either some sort of mechanical attachment like a rivet, a nut and bolt, or an adhesive such as epoxy. But these approaches have limitations.

"If we could reproduce the property gradients that we find in squid beak, it would open new possibilities for joining materials," explained Zok. "For example, if you graded an adhesive to make its properties match one material on one side and the other material on the other side, you could potentially form a much more robust bond," he said. "This could really revolutionize the way engineers think about attaching materials together."

According to Waite, the researchers were helped by the fact that squid seem to be moving north from areas where they have been traditionally concentrated, for example deep waters off the coast of Acapulco, Mexico. Recently however Humboldt squid have been found in numbers in Southern California waters. Dozens of dead squid have recently washed up on campus beaches, providing the researchers with more beaks to study.

Source: University of California - Santa Barbara

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