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Sea horse's square tail could inspire future armored robots

By AMINA KHAN
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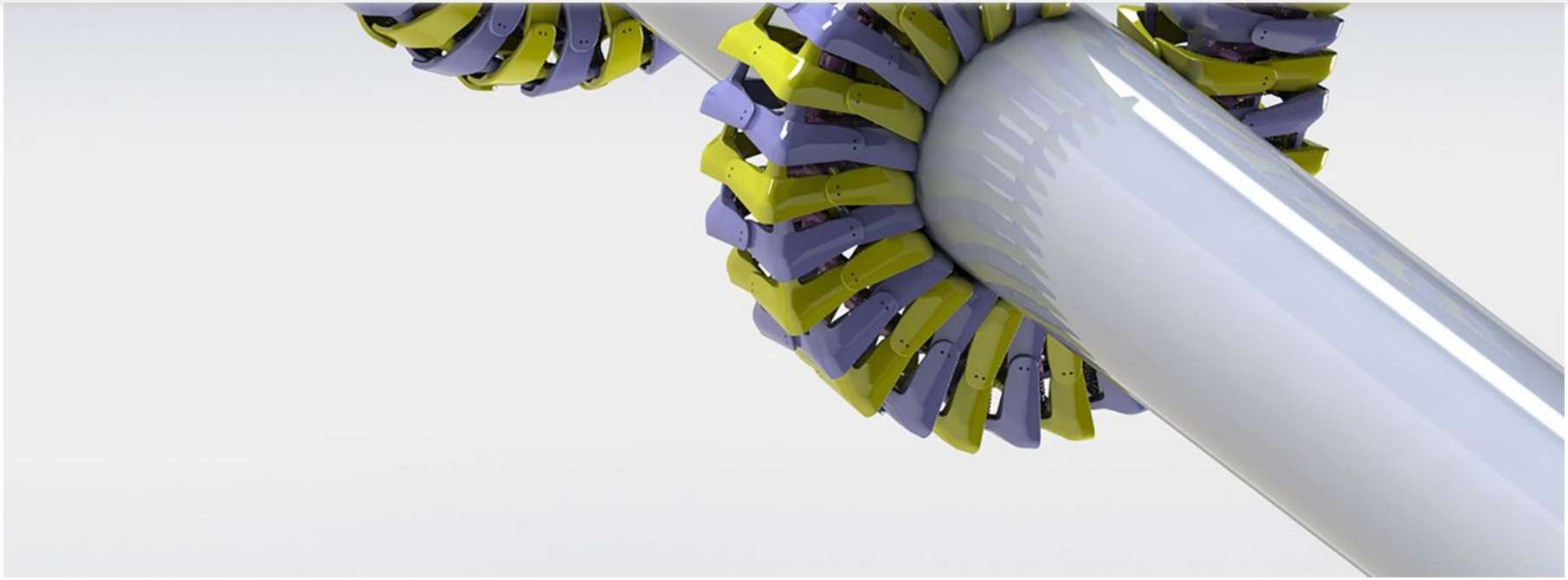

The sea horse's square tail may be odd, but it could inspire new advances in robotics, scientists say. (Michael Porter / Clemson University)

With an equine head and a prehensile tail, the sea horse seems as odd as it is adorable -- but these strange little creatures are tougher than they look. Scientists studying the animal's square-shaped tail have discovered that it's better able to withstand attack than a smooth, round tail would be.

The findings, described in the journal Science, could help researchers build more flexible and durable robots in the future.

That tail, which is used for grasping objects, is made of about 36 squarish segments with a boxy cross section rather

than the more common cylindrical form, such as an arm or a leg or a tree branch. That's already weird, but it seems even stranger to see on a water-dwelling animal, where you would think that the smoothest, most streamlined shape would win out.

"When living organisms deviate from the norm, there's usually a good biomechanical reason: a clue to some specific problem that needs to be solved," Miriam Ashley-Ross of Wake Forest University in North Carolina, who was not involved in the paper, pointed out in a commentary.

Lead author Michael Porter began wondering about sea horses' tails while studying the material that makes up their skeletons at UC San Diego. He had also started working on a project to build a steerable catheter, and at first his design had a square cross section. But when he tried to make it round (in order to be inserted into veins), the device didn't work nearly as well as its square predecessor.

"The square one just felt better. It felt like it basically fit together better and just performed more robustly, whereas the round one just didn't really hold its shape well and just didn't seem to fit together as well," said Porter, who is now a mechanical engineer at Clemson University in South Carolina. "So that's what led to this idea of 'Huh, I wonder if the square actually had some advantages over the circle, and how can we actually prove that it has those advantages?' "

The sea horse's body is protected by tough, overlapping L-shaped plates beneath its skin whose corners form the square of the cross section. These plates are stacked all the way down the sea horse's tail (although they get smaller toward the tip). The researchers 3-D-printed larger-than-life models of the sea horse's vertebral columns and armored plates and strung them together with springs and elastic to emulate the natural connections between those plates.

Then, they designed another set of plates -- but instead of being square, these were rounded. In place of the L-shaped corner plates that overlapped to form the boxy cross section, they built crescent-shaped plates that

shaped corner plates that overlapped to form the boxy cross section, they built crescent-shaped plates that overlapped to form a circle. Now they could see whether square or rounded worked better.

The researchers took these plates and compressed them -- creating the kind of force a sea horse would feel if teeth or a beak were trying to crunch into its tail. The square plates easily squeezed inward while still retaining their shape, because they could slide over one another. The round ones could not without trying to poke into each other and warping the overall shape.

The scientists also twisted the long chain of plates and found that the squares were better able to resist and could also bounce back to their original shape. The string of circular plates, meanwhile, ended up remaining distorted even after they stopped twisting. Being able to resist twisting and bounce back from deformation is important to protect the sea horse's fragile spinal cord.

"From the sea horse's perspective, if you overtwist its tail you could damage some of its internal organs," Porter said.

With their flat sides, the square tails were also better at gripping objects -- although the researchers believe that the tail evolved mainly for protection and that this grasping ability probably arose later.

Engineers are increasingly working in soft robotics, but those mechanisms are often weak and easy to break. Traditional rigid elements, meanwhile, don't allow the type of flexibility and responsiveness that you see in living beings. The findings of the sea horse study could help scientists build more flexible robots that are strong but less prone to breaking in the future, Porter said, mentioning robotic tentacles, sturdy mechanical arms and military body armor.

"In situations where the sharp corners are not a drawback, a flexible armor based on the sea horse tail may prove

advantageous, bending smoothly while still affording protection to structures within -- proving that it's not always a bad thing to be 'square,' " Ashley-Ross wrote.

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Amina Khan

Amina Khan is a science writer covering a broad range of topics, from Mars rovers to linguistics to bio-inspired engineering — but she's perhaps best known for her repeated and brutal attacks on the office snack table. She surfs and snowboards in her spare time.

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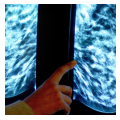

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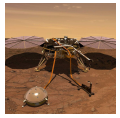

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