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Knight in slimy armour

FRANK FENNEMA/FOTOLIA

Liz Sheffield explains how the slime from hagfish and their ability to escape from tight spots might come to our rescue for a range of applications

Hagfish live in great numbers at the bottom of the sea. They are hugely valuable members of food chains as they devour carcasses. This returns valuable nutrients to the marine ecosystem — but seldom as a result of predation. Although attackers may be attracted by the soft, seemingly unprotected hagfish, they are quickly repelled when the hagfish release copious amounts of slime. As seen here — **www.bbc.co.uk/news/magazine-21966514** — a shark attack presents no problem to the hagfish, as its slime does not dissolve in water. Instead it rapidly clogs the shark's gills, threatening to suffocate the predator. Recent research has revealed not only how the slime works for the fish, but also how it could be useful to us.

Slime structure

At the February Annual Meeting of The Society of Rheology, a researcher explained that he had used a rheometer (an instrument that measures the responses of fluids to forces) to measure how hagfish slime stretched and flowed under different conditions. The properties of this protein-based gel remained similar over a wide range of concentrations in water. This means that even when the concentration changes dramatically, the structure and properties of the gel do not.

Such properties make hagfish slime ideal for assembling under what are known as 'uncontrolled conditions'. Examples of such conditions include slow leaks from oil drilling equipment underwater, which can prove disastrous for marine ecosystems. The gel could plug or slow such leaks, and could also provide cells in culture with the scaffolds they need to make three-dimensional tissues and organs.

Spineless Houdini

You saw in the BBC movie that despite the shark biting down during the attack, the hagfish was not harmed. We have only recently understood why this is. Fish typically have a relatively rigid backbone (spine), and 'wear' their skin tight, like Spandex. But hagfish lack a spine and have loose skin. They do have a rod that

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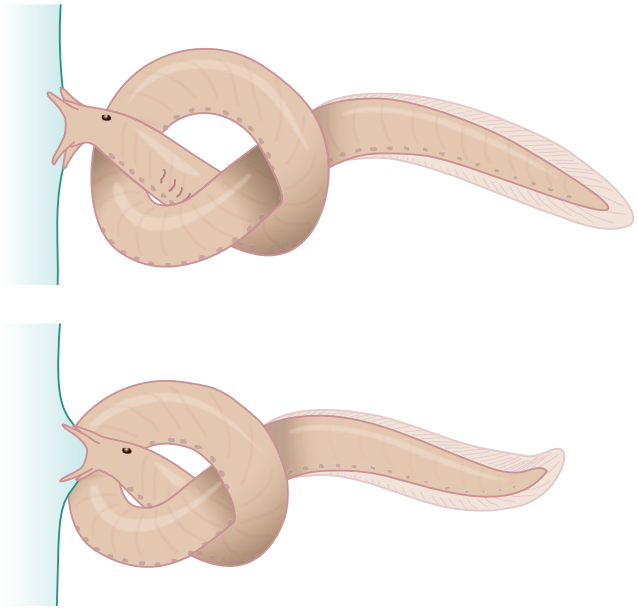

Figure 1 Hagfish starting to feed

runs along their backs but it is made of cartilage, so it is flexible. This means they are literally able to tie themselves in knots. They often do this when starting to feed on a carcass (see Figure 1). They lack jaws, so to tear open skin, they latch on with their tongues, which are studded with rows of sharp teeth (see photo on page 1). This acts rather like one half of a jaw — the knot in their body braced against it serves as the other half, against which to push in order to tear an opening.

Hagfish skin is only loosely connected to the muscles and organs inside. Just under the skin is a blood-filled cavity with plenty of room to spare — so when a predator bites down, the organs inside the hagfish slip out of harm's way. This means that hagfish can squeeze through very tiny spaces — including slits half their body width. They do this by angling their heads through the opening, and wriggling their bodies back and forth. They then form a loop with the part already past the opening. This gives them the leverage to get the rest of their bodies through. Key to the success of this move is the fluid-filled cavity under the loose skin. Blood gets pushed towards the tail as the hagfish squeezes through the slit. This movement can lead to dramatic swelling of the tail, which finally gets pulled through.

These Houdini manoeuvres could prove useful for engineers. The way hagfish squeeze through constricted spaces could have applications in running wires and cables through existing buildings and in search and rescue. This new understanding of how small-brained animals perform such complex tasks — including knotting — may one day help engineer flexible robots that can do the same.

Activities

Taking inspiration from nature to solve human problems is biomimicry. You can find other examples, including Velcro, here:
www.youtube.com/watch?v=JnBkbaFsZOY

and if you get inspired, why not get together with some friends and enter the biomimicry challenge?
http://challenge.biomimicry.org/

Weblinks

PhysOrg, 14 February 2017, Researchers explain the unique properties of hagfish slime:
https://tinyurl.com/jgbadhy

Live Science 31 January 2017, Slimy defense: hagfish-inspired slime could protect Navy warships:
https://tinyurl.com/z7jh5wl

Science, 6 January, 2017, How the slimy hagfish ties itself up in knots — and survives shark attacks (incudes movie of knot-tying):
https://tinyurl.com/zrp3ymn

BBC, 8 September 2016, The strange reason why hagfish tie themselves in knots:
https://tinyurl.com/zzlmpa5