Octopus suckers glow in the deep, dark sea

A red octopus that drifts through deep waters off the eastern United States shines in a novel way: Its suckers flash on and off.

Finding luminescence in any of the known octopus species surprised codiscoverer Edith A. Widder of Harbor Branch Oceanographic Institution in Fort Pierce, Fla. The seas where octopods live sparkle with constellations of bioluminescent fish, squid, crustaceans, and other creatures. Yet the only octopods previously found to luminesce belong to two or three species in which females develop bright rings around their mouths just before mating.

The light organs that Widder and her colleagues describe in *Stauroteuthis syrtensis* lie in a single row of raised buttons stretching down each arm. The bumps look like suckers that evolved the ability to glow, the researchers suggest in the March 11 NATURE.

Such a glimpse into the evolutionary history of a bioluminescent structure holds special interest because of its rarity, notes Widder. Tracing histories of light organs has proved difficult because "there's no fossil record for bioluminescence," she laments.

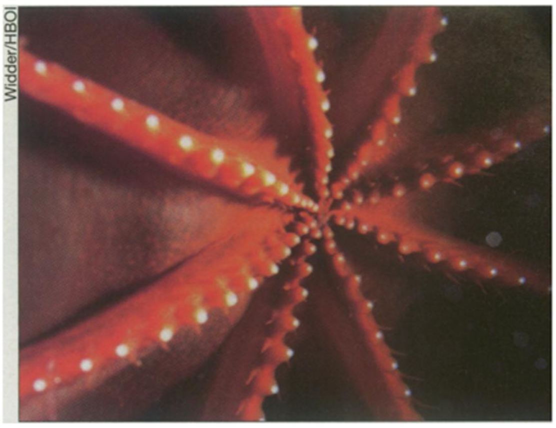
In 1997, Widder brought a live, footlong specimen from the Gulf of Maine back to a lab. When the researchers turned off the lights, the suckers glowed blue-green, emitting the most light at 470 nanometers, a wavelength that travels well underwater. "It's kind of a twinkling effect," Widder says.

Most octopods catch fish or other decent-size prey, but this octopus, oddly enough, had been eating mostly tiny crustaceans called copepods. "It's like a raccoon living on a diet of mosquitoes," Widder explains.

She saw no structures to filter copepods from the water, so she speculates that glowing suckers might lure them the way porch lights attract moths. Shallow-water copepods flock to light, but researchers know less about the deep-water counterparts. Glands around the octopus' mouth secrete mucus, which might snag bedazzled copepods for dinner.

Widder points out that many deep-sea creatures hunt with glowing lures. Light may be attractive in part because of the nutrient bonanza of luminescent fecal matter that drifts to the depths from creatures above. The abundance of light-generating microbes in the diet of upper-ocean animals gives this fecal rain its gentle glow.

For about 100 years, scientists have recognized *S. syrtensis* without realizing that it glows, notes cephalopod biologist Michael Vecchione, who heads a National Marine Fisheries Service lab in Washington, D.C. Despite the earlier reports of glow-in-the-dark octopus lipstick, the new find was startling.



Widder/HBOI

Suckers lining the arms of the deep-water octopus Stauroteuthis syrtensis *can twinkle blue-green in the dark.*

S. syrtensis "is in a completely different group," Vecchione says. It swims with fins and the webbing between its arms, while the other glowing octopods motor through the sea by squirting water jets.

Richard E. Young of the University of Hawaii at Manoa in Honolulu calls Widder's discovery "a spectacular find." As one of the authors of a report on mouth luminescence, he's long mused that more octopods ought to glow. The greatest hope for finding overlooked bioluminescence, he predicts, lies with the hard-to-observe, deep-water finned species. There, he says, "we haven't looked hard enough." —*S. Milius*

Breaking bonds reveals their strength

Sometimes the best way to understand something is to take it apart. Applying this principle at the molecular level, a team of German scientists has measured directly, for the first time, the strength of a single chemical bond—the kind that holds atoms together to form molecules such as proteins, sugars, and DNA. The researchers tugged on a molecule until the bond snapped.

For the nanometer-scale tug-of-war, the team selected a long, rope-like sugar molecule. The scientists anchored one end of the sugar chain to either a glass or a gold surface by means of covalent bonds, in which two atoms share electrons. They then attached the other end to the tip of a strain gauge and pulled the taut molecule until it separated from the surface.

"It's a very simple technique," says coauthor Michel Grandbois of the University of Munich. Until now, scientists have deduced a bond's strength from the amount of energy needed to make or break large numbers of bonds.

The new technique, reported in the March 12 SCIENCE, will be the basis for tables listing bond strengths in future chemistry books, predicts physicist Paul K. Hansma of the University of California, Santa Barbara. "With this fundamental understanding, there's room for more rational improvements of materials," he says. "It's amazing in some sense that material scientists have gotten as far as they have in improving the strength of materials" without being able to directly measure single molecular-bond strengths.

The tug-of-war relies on an atomic force microscope (SN: 10/24/98, p. 268). Like a diving board, its tiny cantilever tip responds to force. The tip deflects slightly as it pulls the stretched sugar molecule, and a laser measures this movement. When a covalent bond snaps, the sugar molecule goes slack, and the tip bounces back.

Catching just one long sugar molecule with the tip is like fly fishing, says study coauthor Hermann E. Gaub, also of the University of Munich. The researchers lower the tip onto the gold or glass base and then gently pull it back up. If a sugar molecule has "bitten," the strain gauge will register the molecule's resistance.

They can also tell whether they have caught more than one sugar molecule. As they pull on the sugar molecule, straightening out its chainlike structure, the researchers detect a characteristic abrupt change in force. With more than one long sugar chain, the force readings smear, says Gaub.

Along its looping length, each sugar molecule may bond to the gold or glass surface in several spots. Once the tip catches hold of the molecule, the researchers tug at it repeatedly until all the bonds have broken, like pulling ivy away from a wall, tendril by tendril. The covalent bonds that give way, the team suggests, are carbon-silicon bonds for the glass surface and sulfur-gold bonds for the gold surface.

One limitation of the study, says biophysicist Julio M. Fernandez of the Mayo Foundation in Rochester, Minn., is that the authors cannot prove they are measuring the rupture of covalent bonds. How the sugar chain attaches to the tip is mysterious, he says, and the force the researchers register could be the sugar molecule sticking and slipping along the strain gauge. But the study is a good start, he says.

"Little is known about molecules and force," says Fernandez. "Covalent bonds hold it all together, and it's important to know their strength." —*L. Helmuth*