An illuminating partnership for squid

The squid *Euprymna scolopes*, a denizen of the shallow waters surrounding the Hawaiian archipelago, provides a shining example—literally—of symbiosis in action. The cephalopod's symbiotic partners are the bioluminescent bacteria *Vibrio fischeri*.


Thomas Kleindinst/WHOI

The Hawaiian squid Euprymna scolopes.

These bacteria colonize a specialized cavity called the light organ, located on the squid's underside, and allow the animal to emit a diffuse glow toward the seafloor. The result appears to be counterillumination, which eliminates telltale shadows, thus enabling a variety of fishes and cephalopods to move and hunt undetected at night.

With the aid of its microbial tenants, *E. scolopes* may "camouflage itself against the moonlight and starlight," explains Margaret McFall-Ngai of the University of Hawaii in Honolulu. In return, she says, the animals seem to offer the bacteria comfortable homes.

Several researchers discussed aspects of this squid-bacteria collaboration at last week's Symbiosis 96! meeting in Bar Harbor, Maine. For example, McFall-Ngai's group, which recently moved from the University of Southern California (USC) in Los Angeles, studies changes brought about in the light organ when *V. fischeri* appears.

At hatching, notes McFall-Ngai, the squid are free of bacteria. The immature light organs have cells with cilia, or threadlike extensions, that propel bacteria from the surrounding water into the light organ. Once colonized, the light organ undergoes dramatic changes in shape that allow it to function as a bacterial hotel and squid night-light.

McFall-Ngai's group has found that the ciliated cells die off within days after the bacteria arrive. McFall-Ngai and her colleague Jamie S. Foster have now shown that this cell death does not stem from a direct assault by the bacteria. Instead, the microbes seem to signal the ciliated cells to undergo apoptosis, a kind of cellular suicide. The investigators plan to determine the nature of that signal and why it doesn't affect the cells to which the bacteria are attached.

Edward G. Ruby, another USC scientist who is moving to Honolulu, heads a group studying how the squid control their bioluminescence, which follows a daily rhythm. "During the daytime, they become considerably dimmer," he says.

The squid turn down their wattage in part by limiting the amount of oxygen that reaches the light organ. The bacteria need oxygen to produce light. Moreover, "about 90 percent of the bacteria are expelled each morning," says Ruby. That strategy may seed the water with bacteria for new hatchlings, he notes.

Both separately and in collaboration with a group led by Paul V. Dunlap of the Woods Hole (Mass.) Oceanographic Institution (WHOI), Ruby's team has identified mutant strains of *V. fischeri* that have trouble initially colonizing the squid, establishing a normal-sized community in the light organ, or persisting in the animal. The scientists are now searching for the mutated genes that cause those bacterial difficulties.

Researchers from WHOI and the Marine Biological Laboratory in Woods Hole are struggling to generate laboratory colonies of *E. scolopes*. The researchers have found that they can transport squid from Hawaii to aquariums at Woods Hole with relative ease and that the animals will lay eggs that hatch. Yet no matter what the scientists fed them, the hatchlings died. "We were trying to present them with small prey in great abundance," notes Dunlap.

Michael F. Claes of Northeastern University in Boston then pointed out that juvenile squid naturally feast on adult shrimp, even those much bigger than themselves. On that diet, Dunlap reports, two-thirds of the captive hatchlings live to the age where they can reproduce.

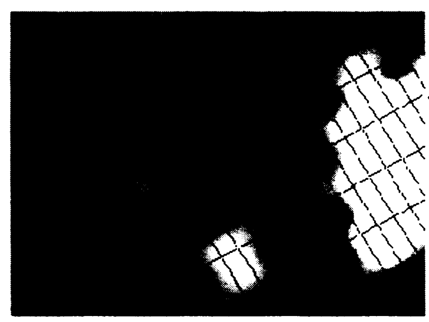
The eggs produced by these squid do not seem to be of the same quality as those of the first generation in captivity. They have a poor fertilization rate, and those that hatch produce squid that have trouble surviving. More research on rearing squid is needed before a stable laboratory colony of *E. scolopes* can be maintained, says Dunlap.

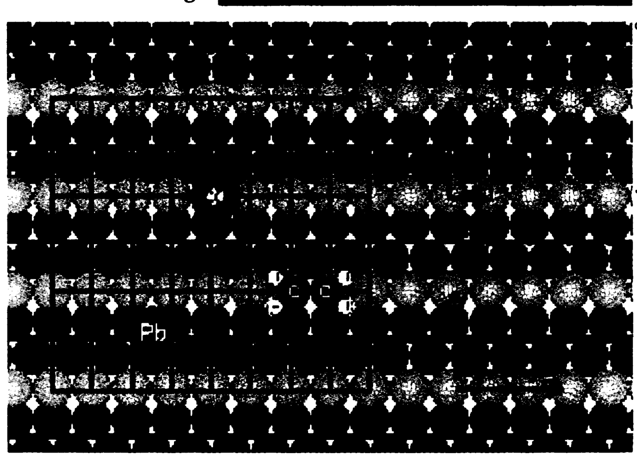
Once laboratory squid are plentiful, the alliance between *E. scolopes* and *V. fischeri* should serve as a research model for other animal-bacteria symbioses, including those that occur inside humans, says McFall-Ngai. —*J. Travis*

Registering visitors to metal surfaces

The place a foreign atom or molecule occupies on a surface can have an important effect on chemical processes. Now, researchers have a new tool for determining whether such a visitor sits on top of the substrate atoms or in the crevices between them.

Gerhard Meyer and his colleagues at the Free University of Berlin use the needle tip of a scanning tunneling microscope to position a copper (Cu) atom alongside several carbon monoxide (CO) molecules on a copper surface (upper image). The copper atom settles on the surface in a well-understood way, enabling the researchers to determine its position accurately. The scientists then use the array of surface atoms to define a reference grid and precisely locate the CO molecules.





Gerhard Meyer, Karl-Heinz Rieder, and Ludwig Bartels/Free University of Berlin

The position of a single CO molecule, in turn, establishes a reference for locating other atoms or molecules. The lower illustration shows how a lead (Pb) atom and an ethylene molecule (C_2H_4) might nestle among the orderly surface rows of copper. The darkest shaded spheres signify the deepest copper atoms. The researchers describe their technique in the Sept. 2 PHYSICAL REVIEW LETTERS. —I. Peterson