The journey into a squid isn’t an easy one. But the bioluminescent marine microbe *Vibrio fischeri* is up for the challenge. Usually a free-living bacterium, *V. fischeri* has evolved a part-time symbiotic relationship with the Hawaiian bobtail squid (*Euprymna scolopes*). The latter stands to gain from the microbe’s bioluminescence to disguise its silhouette against a moonlit backdrop from predators lurking below. *V. fischeri*, meanwhile, can benefit from a safe place to feed, grow, and divide—something the squid offers in the tiny nutrient-filled crypts of a specialized structure called the light organ.

For the bacteria, getting to these crypts is a multistep affair, and fraught with peril, explains Spencer Nyholm, a biologist at the University of Connecticut and an expert on symbioses. To find its future host, *V. fischeri* has to swim up a trail of “mucus goo” secreted by baby squid upon leaving their eggs, while avoiding being killed by the goo’s abundant antimicrobial compounds. If it reaches the animal’s surface, the microbe next faces what’s known as the gauntlet. “There’s this little ciliated pore that’s like the door to the light organ, and there’s six of these doors on each squid—three on each side,” Nyholm explains. Each bacterium must navigate through one of the pores, dodging the beating cilia, and then swim along a duct pumped full of toxic compounds known as reactive oxygen species. Survivors pass through an antechamber and then have to squeeze through a microscopic bottleneck guarding the crypts themselves, Nyholm says. Only a handful of bacterial cells ever make it.

The complexity of this journey and of the light organ itself reflects the extraordinary intimacy of the relationship between these two organisms, which have been evolving together for millions of years. The obstacle course makes sure it’s only the specialized, flagellated, stress-resistant *V. fischeri*—and not any of the other billions of marine bacteria floating around the squid—that make it to the food-filled crypts. Once the hardiest *V. fischeri* individuals arrive and start forming a colony, the light organ becomes a communication center between them and their host, producing and receiving vast numbers of signaling molecules and metabolites—the functions of which researchers are still uncovering.

Nyholm and other biologists refer to the light organ as a “symbiotic organ” for its specialized role in housing and talking with the squid’s luminescent guests. And squid aren’t the only animals to have such structures. Nyholm also studies deep-sea anglerfish, which use bacteria-powered light organs dangling over their heads to attract food and mates in the sunlight-deprived depths. Various other animal and plant species have also evolved their own specialized structures to take advantage of completely different microbial functions: the production of particular antimicrobial compounds, say, or the ability to metabolize hard-to-digest food.

While many of these symbiotic organs have traditionally been studied as peculiarities of particular species, some researchers are now pushing to consider them collectively, as extreme examples of what happens when multicellular organisms develop intricate relationships with the microbes around them. In all of these cases, “you create this emergent organ that would only exist in the context of the interaction,” says Joel Sachs, an evolutionary biologist at the University of California, Riverside (UCR) who studies bacteria-housing root nodules that endow many plant species with the ability to fix nitrogen. “Once that occurs, it reshapes the evolution of both the host and the symbiont. And that’s the commonality where I think it makes sense to join these crazy, diverse systems and start to compare them side by side to see these similar dynamics.”

**LET THERE BE LIGHT**

**Host:** Hawaiian bobtail squid (*Euprymna scolopes*)

**Symbiont:** *Vibrio fischeri*

The Hawaiian bobtail squid gets *Vibrio fischeri* into its light organ by means of chemical signals and a complicated obstacle course that blocks out other bacteria. Once established in the squid’s organ, bacterial symbionts are fed by their cephalopod host, while the microbes luminesce—a trait the squid uses to disguise its silhouette from predators beneath it in the water.