Nature's Cutest Symbiosis: The Bobtail Squid

hhmi BioInteractive

Animated Short Transcript

[Music playing]

Ed Yong: Hello. Yes, it's me. Right here. Being able to turn invisible or at the very least being incredibly well camouflaged is incredibly useful. Especially if I was a spy. I'm not a spy. For me, it would be really fun to be able to disappear from view on a whim. But for this creature, being able to disappear is a matter of life and death.

This is the Hawaiian bobtail squid. It's no bigger than a walnut, but it's full of personality. I'm rather taken by it. I think it's spectacularly beautiful. But for many of the creatures in the ocean, the squid could best be described as delicious. So the squid has evolved a host of strategies to hide from hungry predators. It can cover itself with sand. It can change its color to blend into its surroundings. It can eject an ink blob to cover its escape. But at night, it has to head up into the water column to hunt. And here it is especially vulnerable. So it uses an amazing trick. It can disappear by glowing. If you look at the little creature's underside you will see a pair of structures called the light organ. These project light, shining down below the animal which matches the moonlight and starlight welling down from above. So any predator looking up at the squid from below can't make out its silhouette.

This behavior is called "counterillumination," and it's quite handy if you're trying to avoid being eaten.

Margaret McFall-Ngai: They're very tasty.

Ed Yong: That's Margaret McFall-Ngai, a zoologist at the University of Hawaii.

Margaret McFall-Ngai: I've actually never had a bobtail squid from Hawaii, but I have had a bobtail squid in the Mediterranean.

Ed Yong: And when she's not occasionally snacking on bobtail squid, she's studying them. She finds them fascinating because these animals can't actually produce any light on their own. Not a single photon. Instead, the light comes from *Vibrio fischeri*, a bacterium that lives inside the light organ. Without these bacteria …

Margaret McFall-Ngai: … the animal would be picked off by a predator.

Ed Yong: But what do the bacteria get out of it?

Ned Ruby: They get a supply of food, and they are not out in the water with the potential of some protozoan coming along and eating them.

Ed Yong: That's Ned Ruby, he is Margaret's partner in work and in life. He focuses on the bacteria, while she concentrates on the squid. And the two of them, much like the creatures they study, live in what could best be described as a symbiosis.

Ned Ruby: Very simply from the Greek "symbiosis" which is …

Margaret McFall-Ngai: … the living together of two dissimilar organisms.

Ned Ruby: To live together …

Margaret McFall-Ngai: Persistent living together …

Ned Ruby: … for long periods of their, of their, lifetime.

Ed Yong: They've been working together for around thirty years, and in that time, they have turned the squid, and its bacteria, into icons of symbiosis.

Margaret McFall-Ngai: The bobtail squid is a great study subject because it's just one bacterium and one host animal.

Ed Yong: And, the squid is born without its microbial buddy, allowing Margaret and Ned to conduct a simple but powerful experiment. They raised two sets of bobtail squid. One, with their symbiotic bacteria. And one without. And then they compared the two. And what did you find when you raised the squid without their bacteria?

Ned Ruby: The animal is perfectly happy and healthy.

Margaret McFall-Ngai: Except, um …

Ed Yong: Except?

Margaret McFall-Ngai: In the absence of *Vibrio fischeri*, they don't develop light organs and don't make light.

Ed Yong: Huh, so the squid need *Vibrio fischeri* in order to develop the light organ.

Margaret McFall-Ngai: Exactly, Ed. When the juvenile squid is born, there is a structure …

Ned Ruby: This nascent light organ, we call it, because it hasn't yet begun to produce light.

Margaret McFall-Ngai: Once the bacteria get in, they say to the animal I'm here. I'm gonna direct you in the sculpting of that structure …

Ned Ruby: … into this very complex, multitissue structure …

Margaret McFall-Ngai: … that will function in counterillumination effectively.

Ed Yong: This is a profound discovery. It means that microbes help to sculpt some animal bodies.

Margaret McFall-Ngai: Yes.

Ned Ruby: That's exactly what happens.

Ed Yong: If you watch a fertilized egg under a microscope – human, squid, any will do – you will see it divide into two, and then four, and then eight. It folds, bulges, and contorts. Body parts start to form. An embryo grows. This whole sequence seems self-contained, barreling along like a complicated computer program. But the squid tells us that development in many animals is not always a monologue. It can be a conversation between different species. The squid for example is surrounded by countless species of microbes floating out in the open ocean. But somehow it only lets *Vibrio fischeri* into the juvenile light organ. And Margaret and Ned have shown exactly how this exclusivity works.

Margaret McFall-Ngai: One of the things that the juvenile light organ has that the adult light organ does not have is a set of appendages on its surface, and on those appendages are very, very active cilia which are like hairs.

Ed Yong: The hairs create currents that draw in particles of bacterial size and no bigger.

Margaret McFall-Ngai: That's when chemistry comes in. The animal has put into the environment a bunch of molecules, a cocktail to which only *Vibrio fischeri* seems to be able to adapt.

Ned Ruby: When the bacterium comes in contact with the tissues of the squid, it's getting some signals to tell it where to go. Where to enter this animal's body.

Margaret McFall-Ngai: They go up a long duct into an antechamber, and then on average a single microbe squeezes through a bottleneck on the other side of the antechamber.

Ned Ruby: The bacteria begin to grow up into hundreds of thousands of cells.

Margaret McFall-Ngai: … and they signal to the host, you can go on to mature the light organ. The light organ changes shape. It changes chemistry.

Ned Ruby: It needs to develop other tissues around the outside of this organ.

Ed Yong: Like an iris, so it can adjust its brightness and fine-tune its camouflage. That is how the light organ forms, and having been colonized by the right bacteria it won't be colonized again. These partners are now set for life. It's become clear that many animals from fish to mice rely on microbes to build their bodies. And it seems likely that we humans also grow up under the influence of our microbial partners.

Margaret McFall-Ngai: I'm an animal biologist. I would love to be able to say that the microbial world is not at the center of everything. But it is!

Ed Yong: So, which bacteria do I need to host in order to become invisible? Margaret?

Margaret McFall-Ngai: Goodbye, Ed!

Ned Ruby: Goodbye, Ed!

Ed Yong: The bobtail squid is far from the only animal with microbial superpowers, and some of the others are featured in our "Microbe Minutes." For example, the pufferfish uses a neurotoxin made by microbes to defend itself against predators. If you know about other cool animal-microbe interactions, let me know in the comments.

END OF EPISODE