# Interdomain Interactions: Dissecting Animal–Bacterial Symbioses

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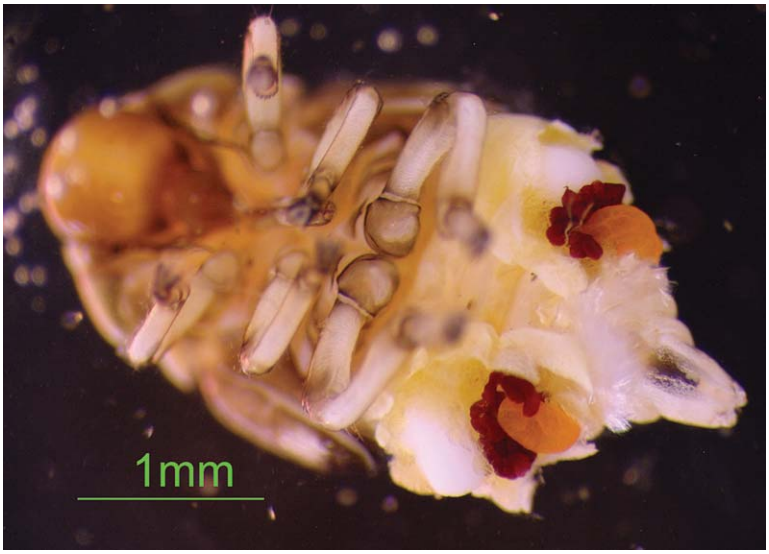


*Immature individual of the spittlebug* Clastoptera arizonana*, showing the brightly colored bacteriomes on each side of the abdomen. Two different symbionts live in this insect:* Candidatus Sulcia muelleri *and an unnamed species of* ß-proteobacteria*. Photograph: Phat Tran.*

For the first billion years of life on Earth, prokaryotes had the place to themselves. By the time the first eukaryotes and then, finally, multicellular organisms arose and diversified, prokaryotic bacteria and archaebacteria had invaded almost every nook of the planet and invented nearly every known metabolic pathway.

"All the animal body plans evolved in a microbe-rich marine environment," says developmental biologist Margaret McFall-Ngai of the University of Wisconsin–Madison. "It's very likely that it was a very common thing to associate with microorganisms."

Selective pressure from other organisms has come not only from creatures evolving alongside them but, in many cases, from inside of them. Virtually all animals are thought to have some type of symbiotic prokaryote living inside them, although these relationships can span a vast continuum from fleeting to requisite and from beneficial to pathogenic.

Prokaryotes can influence host biology and evolution in incredibly diverse ways. Luminescent bacteria form light organs in many species of fish, possibly for different evolutionary reasons. Bacteria called *Wolbachia* are reproductive parasites in insects but obligate mutualists in nematodes. Beetles' symbionts secrete a toxin that wards off wolf spiders, and several insects have symbionts that confer resistance to extreme heat.

Some symbiotic bacteria colonize host epithelial tissue, such as the mammalian intestine and termite hindgut, while others have actually invaded host cells and live almost as organelles. A few animals, including deep-sea shrimp and nematodes that live in coastal sediments, possess permanent bacterial coats on the outside of their bodies.

The site of colonization in the host tends to correlate—although not absolutely—with how the symbiont is transmitted from generation to generation. Intracellular symbionts are frequently passed vertically from mother to offspring through the egg cell, while bacteria that live outside host cells are usually picked up from the environment by each new generation of animals. In some animal species, adults participate directly in the microbial colonization of juveniles: Adult termite workers feed their feces to newly hatched juveniles, presumably to ensure the juveniles' hindguts are exposed to the correct consortia of bacteria.

A host's reliance on its symbionts also spans a wide spectrum, from pathogens that the host's body actively tries to eliminate to obligate symbionts, without which the host dies. Insects that feed exclusively on restricted diets, such as plant sap, blood, or wood, often receive essen-