biologist and evolutionary biologist at McMaster University. Currie studies symbioses in attine ants, which culture fungus gardens for food, similar to how humans grow crops. These ants depend on antibiotic-producing bacteria to protect their gardens from a fungus-attacking pathogen, and they host these bacteria in highly specialized cuticular structures such as crypts that are scattered across their exoskeletons. Using micro-examinations of nearly 70 attine ant species—both living and extinct—Currie and his colleagues found evidence that almost identical symbionts are transmitted directly among individuals in a population, eliminating some of the risk associated with environmental contamination. (While the beewolves have their brood cell secretions, the ants propagate microbes largely through physical contact between adult ants.) This sort of inheritance can have important consequences for bacterial evolution, notes Kaltenpoth. His group showed recently that beewolf symbionts are undergoing a reduction in genome size and complexity, consistent with their protected existence and reliance on hosts for transmission.

Some hosts with symbiotic organs instead filter their prospective partners from the environment using physical barriers, chemical attractants, or selective antibiotics. Plants with root nodules, for example, secrete compounds such as flavonoids when nitrates are scarce in the soil, helping to activate signaling pathways in nitrogen-fixing bacteria that then communicate back to the plant and kickstart a symbiosis. The baby bobtail squid, meanwhile, uses its combo of mucus and an obstacle course to specifically acquire V. fischeri.

These indirect modes of acquiring symbionts also affect the ecology and evolution of bacteria, which must be able to handle the journey to, and life in, the host organ, in addition to their regular environment in the ocean or soil. Clotilde Bongrand, a microbiologist at the University of Florida, has studied how different strains of V. fischeri compete with one another to access and colonize the squid light organ. Her research with Edward Ruby of the University of Hawai‘i at Mānoa has found that there are “dominant strains” of V. fischeri that “have a tendency to reach [the crypt] earlier,” Bongrand tells The Scientist. In lab experiments with squid, these strains seem to block out any competitors, she notes. In the field, however, she’s observed squid colonized by multiple strains—something that could happen if nondominant strains have a significant head start on the obstacle course and reach the light organ crypts first.

Getting bacteria into the symbiotic organ is only the initial stage of the partnership, of course. The real relationship begins once the microbes, settled into their new home, start doing the job they were hired for—or not, as the case may be. This much longer part of the symbiosis provides rich possibilities for host-symbiont conflict, Sachs notes, and thus can have major effects on the evolution of both parties.

**Keeping the peace**

However hard a host tries to attract the symbiont it wants, there’s always a risk that the microbes won’t hold up their side of the bargain. Bacteria reproduce much faster than the host they live in, and any strain that manages to hold onto its house without doing the costly work the host wants is likely to gain an advantage over its hardworking peers. Consequently, many multicellular organisms with symbiotic organs have evolved mechanisms to monitor and punish microbial cheaters.

Sachs’s lab has explored this phenomenon as it relates to plant nodules, which typically store their bacterial symbionts in specialized compartments within root cells. He and his colleagues have found that nodules that house cheaters—bacteria that don’t fix nitrogen into ammonia or related compounds for the plant—launch an offensive to kill off these cells. In the process, intracel-