THE SPECTRUM OF MICORBE HOST INTERACTIONS

Additional resource

In the accompanying Step, you read about the bacterium *Vibrio fischeri* which forms *a* mutualistic association with the Hawaiian bobtail squid (*Euprymna scolopes*). Let's look at two more examples.

Photorhabdus luminescens is another bioluminescent bacterial species with a fascinating life cycle. It lives within the gut of certain species of microscopic worms (nematodes) that live in the soil. The nematode uses its grinding jaws to chew through the tough exterior cuticle of an insect larva (eg a caterpillar) and vomits a small number of *Photorhabdus* cells into the insect bloodstream. *Photorhabdus* produces a range of different virulence factors including toxins. This prevents the caterpillar from fighting back with an immune response and releases nutrients which the bacteria feed on. Within 24-48 hours the caterpillar is a mushy sack filled with *Photorhabdus*. The dead caterpillar glows in the dark due to the bioluminescent bacteria. This may help warn potential animal predators not to eat the infected insect, keeping both the bacteria and the nematodes safe. The nematodes then replicate and feed on *Photorhabdus* (the nematodes are bacteriovores – bacteria eaters). Inside each nematode, a few bacterial cells escape digestion and stick to the intestine, eventually making their way to the nematode salivary glands. After a few weeks thousands of nematodes burst out of the dead caterpillar (Figure 1: Left) in search of a new insect host on which to unleash their bacterial weapons.

Figure 1: Left: Entomopathogenic nematodes emerging from a wax moth cadaver. © By USDA [Public domain].
Figure 2: Right, Transmission electron microscope (TEM) image of a Photorhabdus cell, packed full of crystalline protein inclusions © Dr Nicholas Waterfield.

Photorhabdus and their nematode partners work together to kill insects for food. From the nematode's perspective *Photorhabdus* is an **obligate mutualist,** but to insect hosts it is an **obligate pathogen**. In the electron microscope photograph we see *Photorhabdus* cells contain large protein crystals. There is evidence to suggest the bacteria make these as a food source for their nematode partners which eat them.

The bacterium *Rhizobium leguminosarum* is a **mutualist** that lives as a free-living form in the rhizosphere (the area surrounding plant roots) and also inside pea plant root cells within specialised organs called root nodules (Figures 2 and 3). The plant reduces the oxygen concentration within the root nodule so that the nitrogen-fixing enzyme nitrogenase can function. The bacteria fix atmospheric N_2 and provide ammonia (a usable nitrogen source) to the host plant. The plant fixes CO_2 via photosynthesis and provides sugars (**photosynthate**) to the bacteria to fuel nitrogen fixation – as you learned earlier in the course, this process requires a lot of energy. Leguminous plants like beans and peas can be used as biofertilisers to improve the nitrogen content of soil.

Figures 3 and 4: Root nodules ©UoR