Deceptively simple: Minute marine animals live in a sophisticated symbiosis with bacteria

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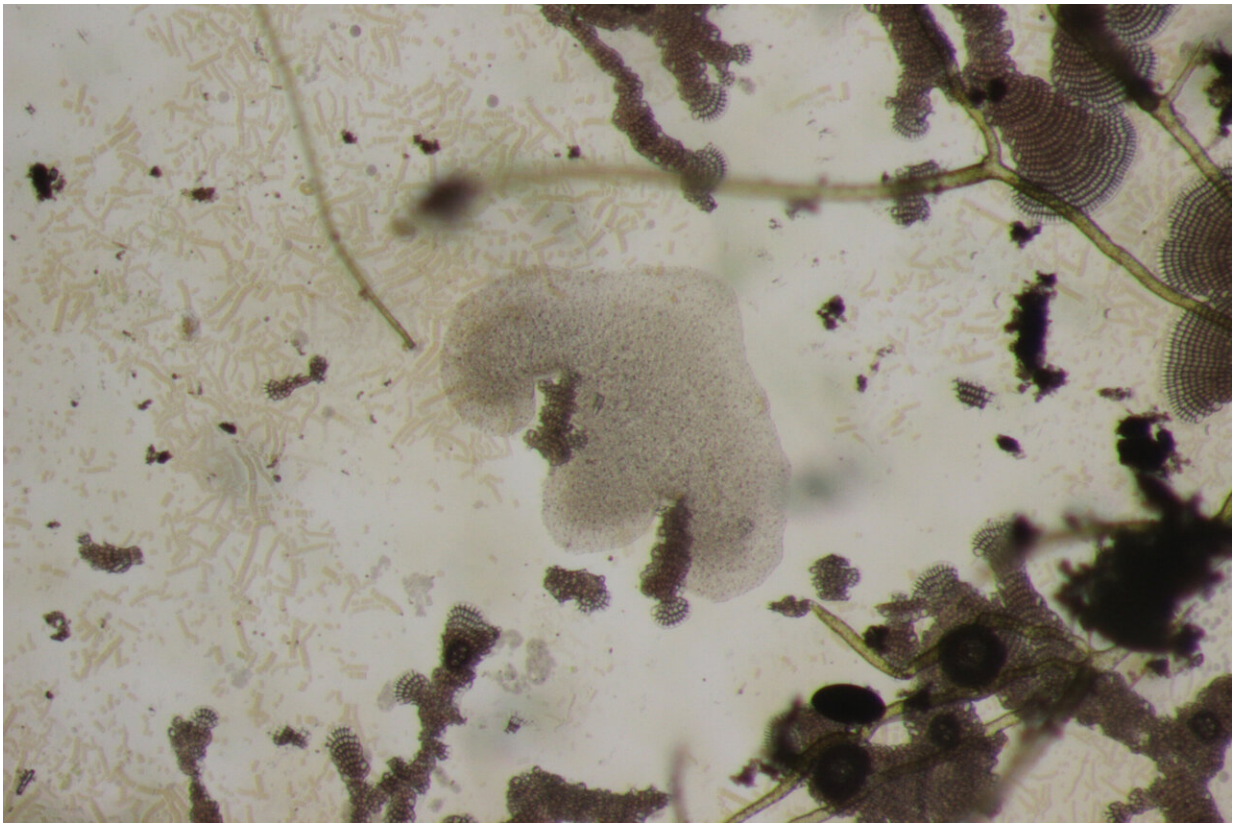

Trichoplax eating. Credit: Michael Hadfield / University of Hawaii

Trichoplax is one of the simplest animals, resembling a shapeless blob. Scientists from the Max Planck Institute for Marine Microbiology in Bremen, Germany, the University of Hawaii and North Carolina State

University have now discovered that *Trichoplax* is not as simple as it looks. It lives in a remarkably sophisticated symbiosis with highly unusual bacteria.

Senior author Nicole Dubilier says *Trichoplax* reminds her of a potato chip. It lives in warm coastal waters around the world, where it grazes on microscopic algae that cover sand and rocks. Although most aquarists may not know it, *Trichoplax* can also be found in almost any saltwater aquarium with corals.

Trichoplax, together with sponges and jellyfish, belongs to one of the most basal lineages of the animal kingdom. Until the 70s, it was not even clear if *Trichoplax* is a fully grown animal or just the juvenile stage of a jellyfish. Only about a half-millimetre in diameter, these animals lack mouths and organs of any kind, and are made up of only six different kinds of cells. Its simplicity makes it a popular model organism for biologists.

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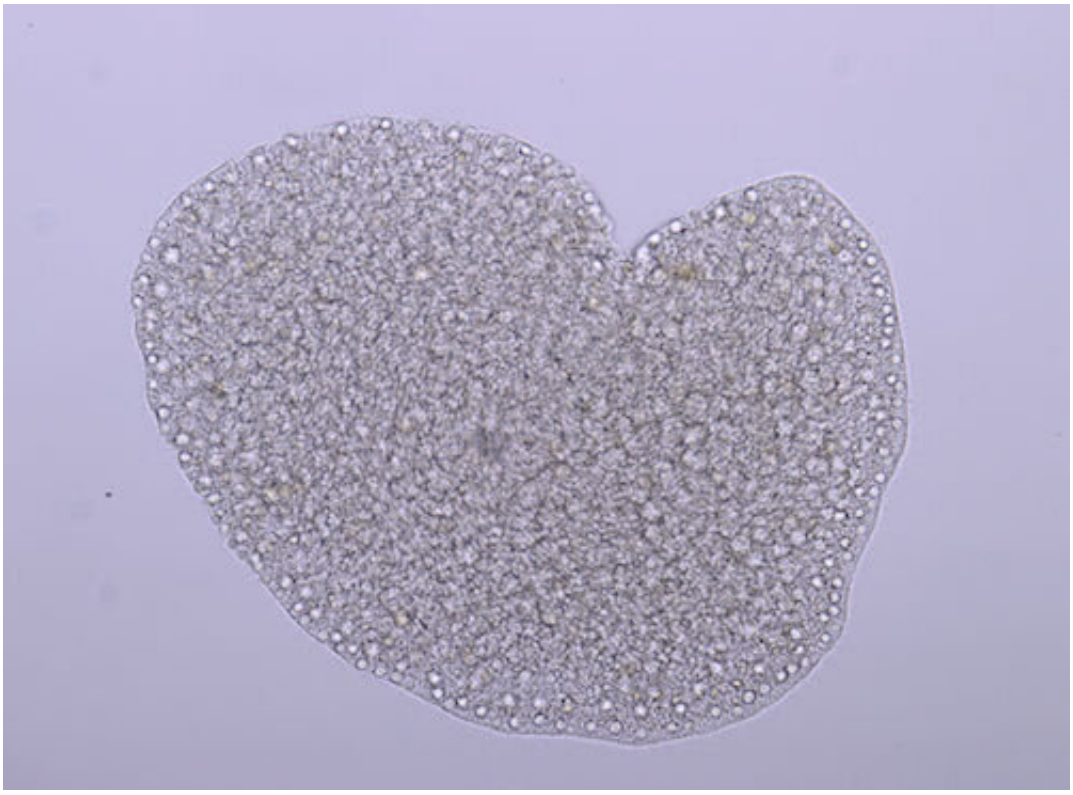
Simple is beautiful

The first observation of bacteria in *Trichoplax* was nearly 50 years ago by the German zoologist Karl Grell. But no one has really taken a closer look since then. An international group of scientists around Harald Gruber-Vodicka, Niko Leisch and Nicole Dubilier from the Max Planck Institute for Marine Microbiology, and Michael Hadfield from the University of Hawaii has now investigated the bacterial tenants of *Trichoplax* by sequencing their genomes and using high-resolution

microscopy to see where they live. "Despite being so simple, *Trichoplax* harbors two very different and highly unusual bacterial symbionts in its cells," says Gruber-Vodicka. "Both symbionts are very picky—or cell-specific, as we call it. Each symbiont lives in only one type of host cell."

Grellia—the first known symbiont to live in the endoplasmic reticulum

One symbiont, named *Grellia* after the zoologist Karl Grell, lives inside the endoplasmic reticulum (ER) of *Trichoplax*, and is the first symbiont known to live permanently in an animal's ER. The ER plays a central role in protein and membrane production. Proving that *Grellia* is truly in the ER was challenging.



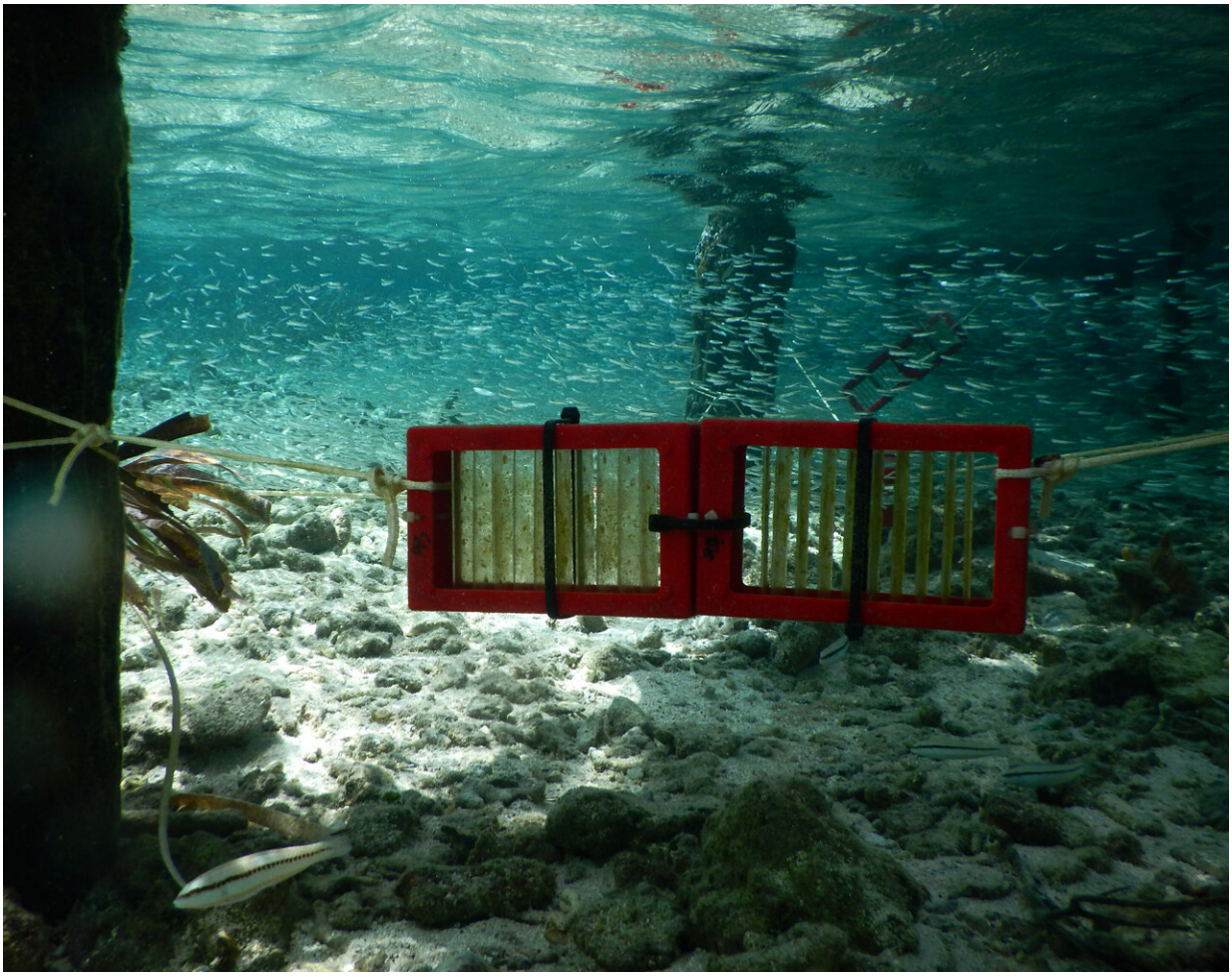
Looks like a potato chip: *Trichoplax* under the microscope. Credit: Harald Gruber-Vodicka / Max Planck Institute for Marine Microbiology

"We reconstructed a detailed three-dimensional model of the ER to show that *Grellia* lives inside of it, supported by the electron microscopy facility of the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden," Niko Leisch explains. "Other parasitic bacteria imitate the structure of the ER to trick the hosts into thinking they are not harmful. However, our imaging data clearly showed that *Grellia* lives inside its host's ER." Intriguingly, Grellia, although closely related to parasites, doesn't appear to be harmful for *Trichoplax*. "Although it has genes that would allow it to steal energy from its host, it does not use them," Leisch continues.

Ruthmannia—seeing microbial dark matter

The second symbiont of *Trichoplax*, *Ruthmannia*, belongs to a group of bacteria that were only recently discovered, the *Margulisbacteria*. "Before our study, *Margulisbacteria* were part of the so-called microbial dark matter—the vast majority of microbial organisms that biologists find through sequencing, but are unable to culture," explains Harald Gruber-Vodicka.

"We have never actually seen them, even though their genetic traces were found in aquatic samples all over the globe." Now Gruber-Vodicka and Leisch took the first images of a *Margulisbacteria*. "It's the first time we could see a member of this group. For us, observing this microbial dark matter was just as exciting as imaging black holes." This symbiont lives in cells that *Trichoplax* uses to digest its algal food. "*Ruthmannia* appears to only eat the fats and other lipids of the algae, and leaves the rest to its host. In return, we think *Ruthmannia* may provide *Trichoplax* with vitamins and amino acids." With *Trichoplax* thriving in the lab cellars of the Max Planck Institute for Marine Microbiology, the authors now have continuous access to this enigmatic group of bacteria.



In the trap: Colonized *Trichoplax* traps suspended in shallow water under a footbridge. Credit: Harald Gruber-Vodicka / Max Planck Institute for Marine Microbiology

What's next

"In this study, we focused on the symbiotic partners of a single *Trichoplax* species," says Nicole Dubilier, Director at the Max Planck Institute for Marine Microbiology. "However, at least 20 more species have been described, and our first results indicate that each host species

has its own, very specific set of symbionts. We are excited about taking a closer look at this remarkable diversity and how it evolved. These tiny animals not only look like potato chips, they also pack a crunch when it comes to what's inside them."

The study is published in *Nature Microbiology*.

More information: Two intracellular and cell type-specific bacterial symbionts in the placozoan Trichoplax H2 , *Nature Microbiology* (2019). DOI: 10.1038/s41564-019-0475-9 , www.nature.com/articles/s41564-019-0475-9

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