# Bacteria probably formed symbioses with protists early in evolution

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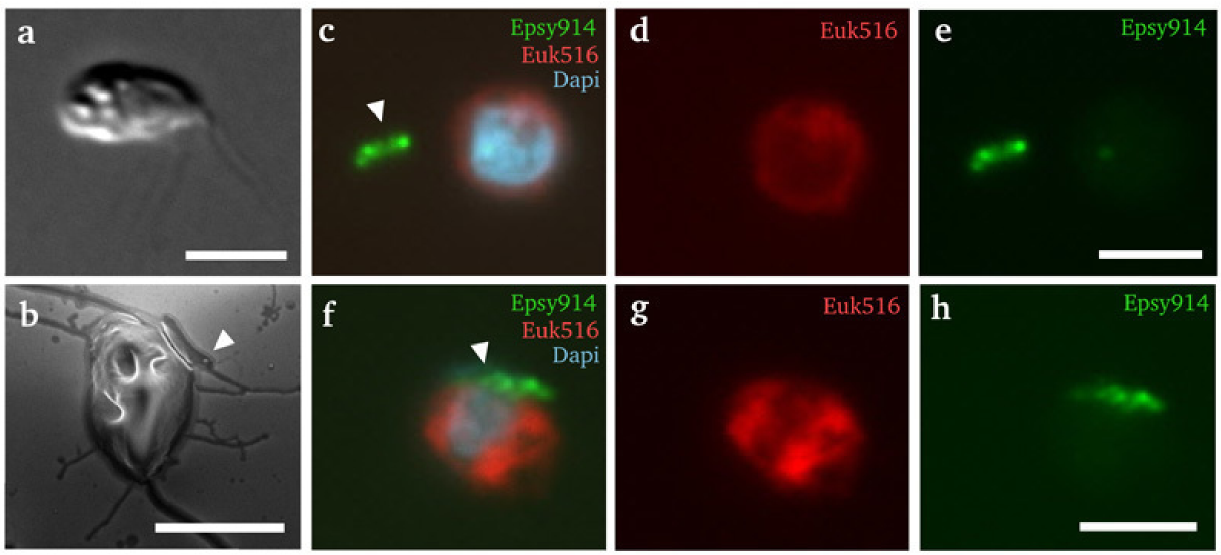


Lenisia limosa is a unicellular predator using two flagellae to move in a slow, wobbling motion (Fig. a and b). c-h: Bacterial cells of the genus Arcobacter (green, indicated by arrow) colonised L. limosa (red). The nuclea of the cells were stained blue. (Scale bar = 5 micrometer) . Credit: MPI f. Marine Microbiology

Day in, day out, in the smallest of spaces with your greatest enemy. Sounds unbearable? In the world of microbes, this has been everyday life for billions of years. This supposedly direful proximity can lead to unusual partnerships, as a study by researchers of the Max Planck Institute for Marine Microbiology and the University of Calgary now reveals.

If you want to know how our prehistoric ancestors looked like, you might take a glimpse through the microscope. If you are lucky you'll find them: tiny, unicellular eukaryotes - also called protists. Protists are direct relatives of animals, plants and fungi. However, these single-celled organisms have hardly changed their appearance in the course of evolution. Many of them still do exactly what their ancestors have been doing for ages: They hunt and eat other microorganisms. One such a group of predatory protists are the so called Breviatea. This group appeared about a billion years ago - at a time when oxygen was scarce in the deep ocean.

As an adaptation to oxygen depletion, Breviates use a rather simple metabolism: fermentation. This process yields significantly less energy than, for example, bacterial nitrate respiration. Facing this situation, wouldn't it be handy for the Breviates to cooperate with bacteria to increase the efficiency of their metabolism? Sounds logical. But there is one problem: Bacteria are the favorite prey of Breviates. An international research group led by Emmo Hamann, Harald Gruber-Vodicka and Marc Strous still wanted to know if such partnerships are possible - and provides exciting insights..

## Breviates and Arcobacter—quite best friends

Initially, Hamann and his colleagues traveled to a tidal flat in the German Wadden Sea to collect sediment samples. With a little patience and the proper mixture of nutrienst, they managed to stimulate growth of both predatory Breviates and nitrate-respiring bacteria. "The Breviate was a so-far unknown species," Hamann recounts. "We named it Lenisia limosa." The bacterium belonged to the Arcobacter-genus. Arcobacter has a bad reputation. Some representatives colonise the gastrointestinal tract of humans and animals, which can cause painful infections. In fact, Breviates don't have an intestine but the bacteria settled right on their surface.

In just a few millimetres depth, oxygen is used up in most Wadden Sea sediments. Then, anaerobic organisms take control. Credit: MPI f. Marine Microbiology/ E. Hamann

"This finding really sparked our curiosity. Why should a bacterium, whose relatives typically live with animals, colonise a predatory Breviate?" says Harald Gruber-Vodicka from the Max Planck Institute in Bremen. To answer this question, the researchers took a close look at the metabolisms of both organisms. To their surprise, they found that Arcobacter wasn't harmful at all. Arcobacter even helped to boost the Breviates' growth. "The Breviates grew about twice as well in the presence of Arcobacter", Gruber-Vodicka says.

"By means of growth experiments and protein analyses, we were able to see exactly what happens when the bacteria encounter the Breviates", Hamann explains. "During their metabolism, the Breviates produce hydrogen. This hydrogen is then removed by the bacteria. When both organisms meet each other, they sort of hot-wire their metabolisms." This facilitates the Breviates' fermentative metabolism and helps them to gain more energy. "We found several enzymes that were required for this energy gain. These enzymes were only produced when Arcobacter was present." Both organisms are able to live alone. Therefore, the symbiosis is not obligatory. However, the bacteria still have a big advantage because they use the released hydrogen to respire nitrate. Hence, we are dealing with a win-win situation.

## How do the partners get together?

The researchers found astonishing similarities to bacteria living as animal parasites. "In order to colonise their host, many bacteria use specific proteins which are known as virulence factors," says Gruber-Vodicka. These proteins help bacteria to attach to the surface of their host. "And exactly these proteins were also active in the symbiosis between Breviates and Arcobacter. It seems that virulence factors are not only important for disease but also allow beneficial relationships between predatory protists and bacteria. If this proves true, it will change the way we look at virulence factors."

"Possibly bacteria have developed their ability to form symbioses very early in evolution together with protists," says Marc Strous, who now holds a research chair at the University of Calgary . "With these partners they learned how to identify the tissue of a host and to grow on it. Later, they moved on to colonise animals." However, further research is required to prove this assumption. "We will look for other similar symbioses to further investigate this question", says Hamann. Exciting times for the researchers at the Max Planck Institute and the University of Calgary. "Who knows? Maybe protists will soon be used as tiny time machines to take a look at the origins of today's manifold symbioses."

**More information:** Emmo Hamann et al. Environmental Breviatea harbour mutualistic Arcobacter epibionts, *Nature* (2016). DOI: 10.1038/nature18297

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