Coral reef symbiosis: Paying rent with sugar and fat

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Scientists have revealed how coral-dwelling microalgae harvest nutrients from the surrounding seawater and shuttle them out to their coral hosts, sustaining a fragile ecosystem that is under threat.

Coral reefs are the jungles of the oceans, home to some of the planet's most fertile fishing grounds, and hotspots of global tourism. Their survival depends on an intricate relationship with tiny coral-dwelling algae. The relationship is a fragile one, as the algae are all too easily driven away by changes in water temperature and pollution. Scientists are only now beginning to understand this symbiosis at a molecular level. Publishing in the journal *mBio*, researchers from EPFL, the University of Lausanne, as well as the Museum of Natural History and the Tropical Aquarium in Paris present new discoveries on how nutrients are harvested and shuttled between algae and corals.

Charles Darwin was the first to describe what has since become known as the Darwinian Paradox: coral reef ecosystems flourish in water that is almost devoid of nutrients. Today we know that this would be impossible without tiny coral-dwelling photosynthetic algae that use sunlight to produce the nutrients needed to support their coral hosts. The corals return the favor by sheltering the algae and providing them with other nutrients.

"In this study, we are looking at the real cellular engine behind coral reefs: the algae's capability to photosynthetically extract carbon from the surrounding water and store it as sugar and fat," says principle investigator Anders Meibom. For the first time, Christophe Kopp, a researcher in Meibom's Laboratory for Biological Geochemistry, was able to visualize at the cell level how the algae produce sugars and fats using photosynthesis and store them, before being shuttling them to their coral hosts.

Kopp found that, when exposed to sunlight, it only took minutes for the micro-algae to use photosynthesis to convert bicarbonate present in the surrounding seawater to sugar, then to fat. These fats, which are passed on to the corals within 2-3 hours, can be seen within the coral tissue as small lipid droplets, from which the corals can draw energy for many of their physiological processes.

He also discovered a second form of carbon storage, in the form of granules composed of glycogen. While the lipid droplets were found throughout the coral tissue, the glycogen, a readily available source of energy, was found predominantly in the coral's outer membrane, where little hair-like structures, cilia, swirl up the water that is in direct contact with the corals to promote the exchange of nutrients.

By studying samples of corals grown at the Tropical Aquarium in Paris, Kopp was able to observe firsthand the flow of nutrients from the surrounding water first into the algae, and then into their coral hosts. He did so using a combination of two imaging techniques, one with a nanometer spatial resolution (TEM), and the other with the capability of detecting the presence of minute concentrations of atomic markers (NanoSIMS).

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