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BORING ALGAE ARE NOT SO "BORING"!

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LIVING ORGANISMS BUILD CORAL REEFS

Coral reefs are made of coral colonies that look and feel like rock, but are in fact thousands of animals living together. These tiny individuals, called polyps, look like small jellyfish. For protection and structure, most polyps produce calcium carbonate skeletons, which give them their rock-like appearance.

Corals cannot survive alone. Most rely on organisms called zooxanthellae that live inside each polyp and produce energy for them. Corals also have many other organisms, like boring algae, living with them.

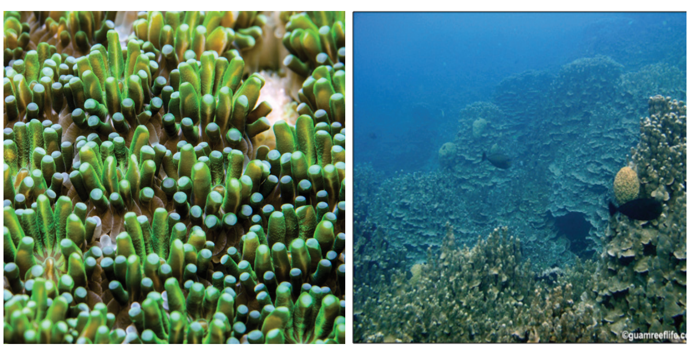

Figure 1. Most coral species retract their polyps (left) during the day, so colonies look like rocks to us (right). At night, polyps extend out of their skeletons to feed, transforming the coral colonies into beautiful living organisms. Colonies of the plate-and-pillar coral *Porites rus i*n Apra Harbor (right). *Images courtesy of David Burdick.*

BORING ALGAE LIVE INSIDE CORAL SKELETONS

Boring algae are tiny organisms that bore (or dig) into the skeletons of living and dead corals. They live underneath coral tissues, not inside them. There are many types of boring algae and they can all live in the same coral skeleton at the same time as a microbial community. Boring algae, like zooxanthellae, turn sunlight into energy. They survive off of the small amount of light that makes it into coral skeletons.

BORING ALGAE HAVE TWO IMPORTANT ROLES IN CORAL REEF ECOSYSTEMS

Boring algae are coral symbionts that live directly under the tissues of living corals. Healthy corals are also home to zooxanthellae, another algal symbiont that lives inside the coral tissues and gives them their color. When corals get stressed, usually because the surrounding ocean water gets too hot, they expel zooxanthellae from their tissue and become transparent. This phenomena is called coral bleaching. If water conditions do not improve quickly, the zooxanthellae do not return to the corals and the corals die. Recent research shows that boring algae can help corals survive bleaching. When coral tissues are transparent, more light reaches the underlying boring algae. With more available light, the boring algae grow much faster; thereby passing extra sugar to the coral tissues, helping them survive (Fine and Loya 2002). Boring algae can replace zooxanthellae when corals are bleached and help them survive until the zooxanthellae return!

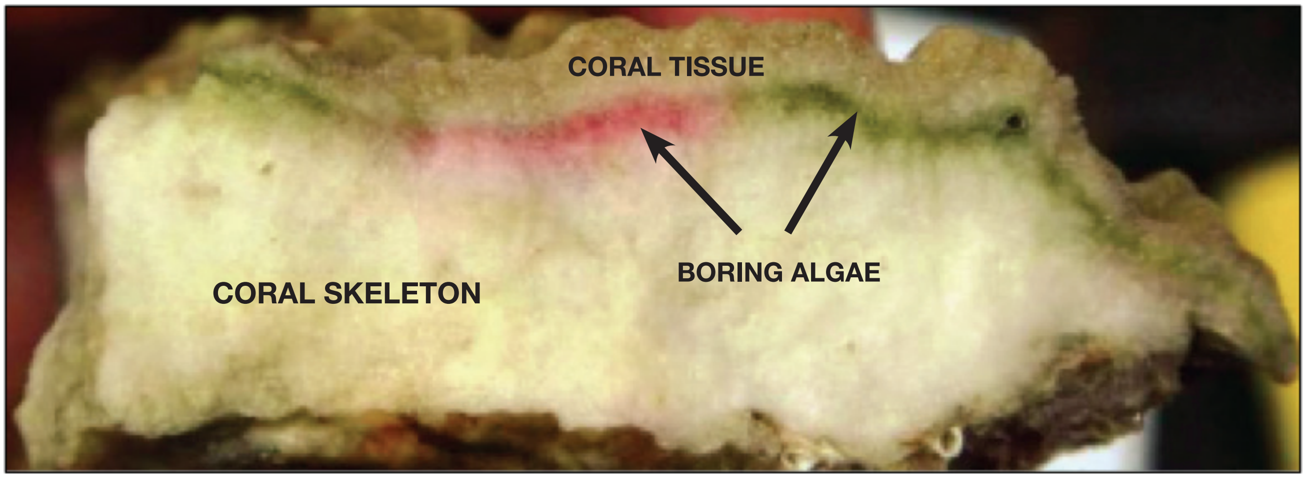

Figure 2. Boring algae are scattered throughout the skeleton and appear as colored bands where they are most concentrated. Boring algal communities are composed of many different kinds of algae, including green and red algae, seen here as red and green bands. *Image courtesy of Marcelino et al. 2013.*

Boring algae function as bioeroders. They break the skeletons of dead corals into smaller and smaller pieces. This process recycles elements like calcium and carbon, which all coral reef organisms need to survive. As boring algae dig into the skeletons of live and dead corals, molecules of calcium carbonate are released into the water. These molecules are subsequently taken up into the skeletons and shells of other corals, snails, and crabs. After corals die, their skeletons are slowly removed by the activity of boring algae and other bioeroders, making space for new corals to grow. Without bioeroders, coral reefs would become too crowded with dead corals that lock away vital materials.

HOW DO WE STUDY THEM?

Boring algae are difficult to study. They are very small and many types look alike. So, we analyze their deoxyribose nucleic acid, or DNA. By studying their cells' DNA we can learn what they are and how each type is related to the others.

This approach is called DNA sequencing. DNA molecules carry a genetic code in the form of four bases (A, T, C, and G). The order, or sequence, of these bases is the code that determines how algae look and live. Every type of algae contains a unique sequence, so if we know the sequence of DNA found in a boring alga, we know what type of alga it is. Imagine two algae, one with a DNA sequence that begins with AAA and the other with AAT. We know that they are different because the last base is different (A versus T). We also know they are closely related because the first two bases are the same (AA). These two sequences are unique but share similarities. To make our work easier, we concentrate on sequencing types of similar DNA segments.

Figure 3. Collecting from pillars of the stony coral *Porites rus* in Apra Harbor. Pillars were removed carefully to avoid damaging the colonies. *Image by Anna Simeon.*

You can find boring algae in most coral skeletons, including those of the common plate-and-pillar coral *Porites rus*. To get samples of boring algae, we received permission to remove pillars of *P. rus* from individual colonies at three different sites in Apra Harbor. Then we extracted algal DNA from the coral pieces in the laboratory, and sequenced it using special machines.

WHAT HAVE WE LEARNED ABOUT BORING ALGAE?

We found boring algae in all 22 pillars of *Porites rus* that we collected, and we extracted DNA from each. Interestingly, the amount of DNA extracted and sequenced differed greatly between coral pillars, suggesting that although each pillar contained boring algae, the amount of algae differed between them. This difference might reflect different environmental conditions at each study site.

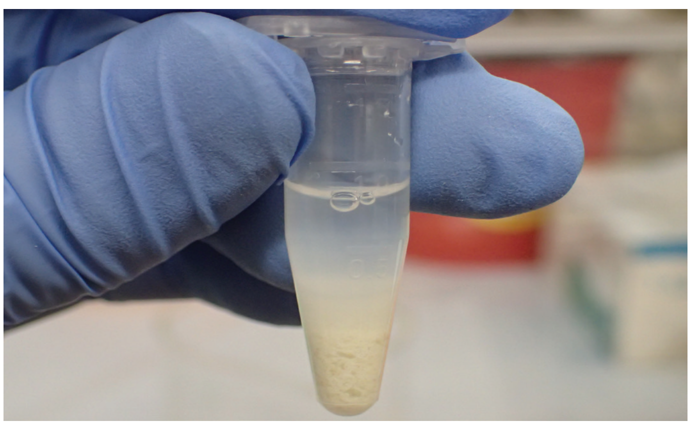

Figure 4. Extracting boring algal DNA from coral skeletons. The tube holds skeletal material that contains boring algae. The extraction process involves extensive lab work.

The boring algal communities that we sequenced were very diverse. We found algae from all four of the major algal groups: green algae, red algae, brown algae, and cyanobacteria. Overall, 104 different types of algae were sequenced. We determined that 29 of those 104 algae were green algae, closely related to the most abundant type of boring algae, called *Ostreobium*.

WHY IS THIS KNOWLEDGE IMPORTANT?

The communities of boring algae found inside corals consist of many organisms that have not been properly documented. One goal of biology is to document and catalog all living things, so exploring the diversity of the boring algal communities of *Porites rus* is necessary – understanding the diversity of a specific community is reason for study in and of itself.

Boring algae have important roles in coral reef ecosystems. Learning how they interact with their environment is key to understanding how coral reefs operate and change over time in response to natural and human influences. How can we manage a system where we don't understand how all the pieces work? Coral reefs are dying worldwide, and we need a better understanding of how their ecosystems function in order to help conserve them.

Finally, boring algae are microscopic. Microscopic communities respond to changing environmental conditions faster than larger communities (Ainsworth 2010). Changes in boring algal communities might let us know about changing conditions on coral reefs long before we can detect changes in the corals and other larger organisms. Studying boring algae could help us see dangers to our coral reefs before it is too late to help them.

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