The astounding genome of the dinoflagellate

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The dinoflagellates aren't happy. In good times, these tiny ocean creatures live free-floating in the ocean or symbiotically with corals, serving up—or as—lunch to a host of mollusks, tiny fish and coral species. Some of them make glowing waves at night because they are bioluminescent. But when conditions are wrong, dinoflagellates poison shellfish beds with red tides and abandon coral reefs to a slow, bleached death.

More and more often, conditions have been wrong. In search of answers, a team of researchers led by UConn marine ecologist Senjie Lin sequenced the complete genome of dinoflagellate species *S. kawagutii*, the first time anyone has done so. Their results were published today in *Science* magazine.

"This species is an essential endosymbiont of coral reefs," says Senjie Lin. An endosymbiont is a life form that lives inside of another organism. When Lin says S. kawagutii is an essential endosymbiont, he means it's essential for the corals, which depend on the dinoflagellate's photosynthesis for source of sugars and nutritious compounds. Without it, the corals bleach white, cannot grow and usually die. But the relationship doesn't seem to be essential to *S. kawagutii*, although metabolic wastes from the coral host provide an enriched supply of nutrients in the otherwise nutrient-poor oceanic habitat. Researchers suspect that when conditions aren't to their liking, the dinoflagellates can jump ship and turn themselves into impervious little cysts, waiting until the time is right to recolonize corals. This versatility may explain another puzzling fact about *S. kawagutii*: it has an awfully large genome for a

symbiont. Usually endosymbionts, as well as parasites such as malaria to which dinoflagellates are closely related, depend on the cellular machinery of their hosts and lack many genes that free-living organisms have. So why does *S. kawagutii* have so many?

"This is the mystery we don't understand," Lin says.

Lin and his colleagues analyzed the entire genome of *S. kawagutii* and compared it to the genetic codes of related organisms that are better understood. The researchers found some surprising things. For example, they found genes associated with sexual reproduction. Like other dinoflagellates, *S. kawagutii* typically reproduces asexually. A single dinoflagellate will simply split in two. But when the dinoflagellates turn into cysts, they first reproduce sexually, mixing their genetic material with others, perhaps in the hope that some of the offspring will gain traits better suited to the stressful environment. Sex related genes have never been found in other dinoflagellates, however. The finding suggests that *K. kawagutii* indeed has bad times living in corals.

The researchers also found that *S. kawagutii* has a gene regulatory system that looks like it could regulate certain genes in corals—in other words, the dinoflagellates may be manipulating their host's genetic expression to make conditions comfier for themselves.

Lin says the genetic evidence they found is very suggestive that *S. kawagutii* has changed its genetic makeup in the course of its symbiotic history to better suite living in its specific host and cope with stress imposed by climate change and pollution. Understanding its genome will hopefully help researchers better understand other dinoflagellates. There are numerous species that play many different roles in the ocean ecosystem. Red tides, when dinoflagellates eaten by molluscs produce toxins that collect in the shellfish and then poison larger animals, cause tremendous economic damage and public health concerns and have

become more and more common globally. Lin's team hopes to next sequence the genome of a dinoflagellate that has been causing red tides along the north shore of Long Island, just a few miles across the water from Connecticut. Eventually, he hopes to be able to explain how dinoflagellates evolved and how environmental conditions influence their curious lifestyles.

More information: "The Symbiodinium kawagutii genome illuminates dinoflagellate gene expression and coral symbiosis " *Science*, www.sciencemag.org/lookup/doi/ … 1126/science.aad0408

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