Modifying the Activity of Hydrogenase and Carbonic Anhydrase Enzymes in Chaetomorpha to Mitigate Ocean Acidification

Kwok, Christopher (School: Sequoia High School)
Kwok, Nicholas (School: Sequoia High School)

Ocean acidification shifts Earth's oceans towards pH-neutral conditions. The global crisis has left thousands of coral reefs uninhabitable, jeopardizing marine biodiversity and resulting in economic devastation. Today, solutions to ocean acidification pertain to long-term plans reducing carbon emissions or over-ambitious coral restoration operations. This project pioneers an ecological, sustainable, and feasible solution to ocean acidification. By chemically modifying the hydrogenase and carbonic anhydrase enzymes in chaetomorpha, they produced algae that mitigate ocean acidification by increasing pH, reversing the interconversion between carbon dioxide and water, and dissociating ions of carbonic acid. First, they increased the hydrogenase enzymes through carotene. This enzyme catalyzes the reversible oxidation of molecular hydrogen through the use of low-potential electrons. They used carotene to transfigure the algae's pigmentation to absorb marine light more readily. Second, they decreased the carbonic anhydrase enzymes through phytic acid and iron. This enzyme catalyzes the interconversion between carbon dioxide and water and the dissociated ions of carbonic acid. Since the enzyme is a metalloenzyme of zinc, phytic acid and iron can inhibit zinc intake. The investigation discovered that 6 grams of carotene with 4 grams of phytic acid competently performed the enzyme modifications. After testing the novel strain of algae for 30 days, the modified chaetomorpha increased the hydrogen gas concentration by 0.5 ppm, reduced the bicarbonate concentration by 47%, and raised the total pH by 2! The project invented chaeto biofilters to implement the algae in oceanic habitats. The devices require no electricity and are cost-effective, viable solutions for governments.

Awards Won:
Fourth Award of $500