Diatom pyrenoids are encased in a protein shell that enables efficient CO_2 fixation

Ginga Shimakawa, Ph.D.

Kobe University, Japan

Pyrenoids are subcompartments of algal chloroplasts that increase the efficiency of Rubisco-driven CO_2 fixation. Diatoms fix up to 20% of global CO_2, but their pyrenoids remain poorly characterized. Here, we used *in vivo* photo-crosslinking to identify pyrenoid shell (PyShell) proteins, which we localized to the pyrenoid periphery of model pennate and centric diatoms, *Pheaodactylum tricornutum* and *Thalassiosira pseudonana*. *In situ* cryo-electron tomography revealed that pyrenoids of both diatom species are encased in a lattice-like protein sheath. Single particle cryo-EM yielded a 2.4 Å-resolution structure of an *in vitro* TpPyShell1 lattice, which showed how protein subunits interlock. *T. pseudonana* TpPyShell1/2 knockout mutants had no PyShell sheath, altered pyrenoid morphology, and a high-CO_2 requiring phenotype, with reduced photosynthetic efficiency and impaired growth under standard atmospheric conditions. The structure and function of the diatom PyShell provide a molecular view of how CO_2 is assimilated in the ocean, a critical ecosystem undergoing rapid change.