Understanding the specialized cellular mechanisms that support calcification in coccolithophores

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Coccolithophores are a group of calcifying phytoplankton that play a major role in the global carbon cycle by producing most of the biogenic calcification that occurs in modern oceans. Extant coccolithophores calcify to very different degrees, and heavily calcified species contribute to most of the carbonate flux to the deep ocean. The degree of calcification also has an important impact on coccolithophore physiology. In lightly calcified species, calcification represents only a minor fraction of total cellular carbon fluxes, whereas in heavily calcified species, calcification can occur at up to twice the rate of photosynthesis. We have been investigating the physiological processes that enable coccolithophores to perform intracellular calcification at such remarkable rates by focusing on the mechanisms of calcium and carbon uptake and subsequent regulation of intracellular pH. Direct measurements of the cellular microenvironment around coccolithophore cells have allowed us to determine how carbonate chemistry changes around the cell during calcification and have provided insight into the interactions between photosynthesis and calcification. Furthermore, we have identified a novel family of calcium channels that are likely to play an important role in supporting the high rates of calcium uptake required by coccolithophores. These calcium channels are found in all haptophytes, but have become greatly expanded in the calcifying lineages, which supports their potential role in coccolith formation. In combination, our results demonstrate major physiological differences between lightly calcified and heavily calcified coccolithophore species that likely contribute to their distinct biogeographical distributions. Understanding how coccolithophore physiology is constrained by these specialized mechanisms is important if we are to have a better understanding of their response to future environmental changes.