Surprises from the ocean: Marine plankton and ocean pH

June 21 2011

The world's oceans support vast populations of single-celled organisms (phytoplankton) that are responsible, through photosynthesis, for removing about half of the carbon dioxide that is produced by burning fossil fuels – as much as the rainforests and all other terrestrial systems combined. One group of phytoplankton, known as the coccolithophores, are known for their remarkable ability to build chalk (calcium carbonate) scales inside their cells, which are secreted to form a protective armour on the cell surface. On a global scale this calcification process accounts for a very significant flux of carbon from the surface ocean, and hence coccolithophores are an important component of the global carbon cycle, as cells die and the calcium carbonate sinks to form ocean sediments.

In an article published in *PLoS Biology* on 21st June, a team of scientists from the Marine Biological Association and Plymouth Marine Laboratory in the UK and the University of North Carolina Wilmington, USA report the unexpected finding that coccolithophores use a similar mechanism to the one previously characterised in vertebrate cells, to facilitate calcification. They found that this process may be directly affected by the current increasing levels of dissolved carbon dioxide in the oceans.

The armour scales of coccolithophores are formed by transporting calcium and bicarbonate into the cell where they combine to form calcium carbonate. Calcification is a strongly pH-dependent process and is likely to be affected by the increase in carbon dioxide levels that are

making the ocean increasingly acidic.

The researchers used a combination of single cell physiology and molecular biology to identify the molecular machinery that underlies calcification. A by-product of the calcification reaction is the formation of protons (H+) inside the cell. "These H+ ions can potentially accumulate in the cell causing it to become acidic - a process known as metabolic acidosis" says Alison Taylor, article author. Cells use a variety of pH-regulatory processes to alleviate the burden of excessive H+ ions. The team showed that coccolithophores dispose of unwanted H+ by allowing them to exit cells through specialised protein pores, or ion channels, that are selectively permeable to H+. This process keeps the pH inside the cells at acceptable levels and allows coccolithophores to produce their calcium carbonate scales.

The team identified the gene that encodes for the H+ channel protein. "These H+ channels belong to a unique group of transport proteins that were discovered quite recently in certain types of animal cells that experience metabolic acidosis" explains Glen Wheeler, co-author of the study. "It turns out that H+ channel genes are also present in other groups of phytoplankton… [which] belong to groups that are not closely related to either plants or animals. Our discovery shows that H+ channels are more widespread than previously thought and that they serve a critical function in regulating cellular pH during a range of cellular processes in evolutionarily distant organisms" says Wheeler.

"A key finding of the work is that H+ channel activity in coccolithophores is dependent on external pH", explains Colin Brownlee of the Marine Biological Association. "The findings will ultimately allow a better understanding of how [phytoplankton] respond to changes in ocean chemistry due to increased dissolution of atmospheric carbon dioxide in the oceans' surface waters."

More information: Taylor AR, Chrachri A, Wheeler G, Goddard H, Brownlee C (2011) A Voltage-Gated H+ Channel Underlying pH Homeostasis in Calcifying Coccolithophores. *PLoS Biol* 9(6): e1001085. doi:10.1371/journal.pbio.1001085