The generation and multifunctional roles of calcium signals in single celled protists. Evolutionary alternatives and environmental implications.

Colin Brownlee[1,2], Katherine Helliwell[1,3], Abdul Chrachri[1], Alison Taylor[4], Frederic Verrett[5], Friedrich Kleiner[1] and Glen Wheeler[1]

[1] *Marine Biological Association, Plymouth UK*

[2] *School of Ocean and Earth Sciences, University of Southampton, UK*

[3] *Department of Biological Sciences, University of Exeter, UK*

[4] *Department of Biology and Marine Biology, University of North Carolina, Wilmington NC, USA*

[5] *Institute of Marine Biology, Biotechnology and Aquaculture, Hellenic Centre for Marine Research, Crete*

Many marine protists that comprise the marine phytoplankton have complex evolutionary origins arising from primary, secondary or even tertiary endosymbiotic events. Genomic studies have revealed a range of conserved and novel ion channel families, including cation channels that potentially play important roles in calcium signalling. These include canonical 4-domain cation channels, 2-pore channels and a novel class of eukaryotic single pore domain channels that superficially resemble bacterial single domain Na+ channels. We have focussed our attention on the generation and roles of calcium signals in two of the most abundant classes of marine phytoplankton, the single celled silica-forming diatoms and the calcium carbonate-forming coccolithophores, which together account for approximately 25% of global photosynthesis and play major roles in global biogeochemical cycles. By using a combination of genetic reporters, gene knock out and electophysiology we have shown key roles for calcium signalling in the perception of a range of environmental cues, including osmotic changes, nutrient availability, temperature and light. In diatoms we have shown a key role for single-domain Ca^{2+} and Na+-permeable channels in the generation of calcium signals in species that lack 4-domain cation channels, providing alternative mechanisms for fast Ca+ signalling. Surprisingly, in coccolithophores, the same class of single domain channels act as Na+-selective channels that underlie the generation of fast action potentials. Together, our findings point to alternative pathways for evolution of Ca^{2+} and Na+ channel selectivity and fast kinetics in eukaryotes. Likely evolutionary drivers of these processes will be discussed.