Phytoplankton are responsible for about half of primary production on the planet. As CO2 levels rise, phytoplankton are facing an unprecedented shift in ocean chemistry. How they acclimate and adapt to this changing chemistry will be crucial for determining the future ecology and carbon cycle of the oceans. By measuring changes in physiology of phytoplankton cultures we find that nutrient limitation and microbial interactions play important roles in determining the response of phytoplankton to elevated CO2. Gene expression data reveal how phytoplankton sense and acclimate to rising CO2 as well as providing us with important clues about the mechanisms of carbon concentration. These results are important for forecasting changes to the marine ecosystem and biogeochemical cycles over the coming century.