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Using Genomics to Reveal the Secrets Underlying the Ecological Success of Marine Diatoms

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Diatoms are thought to be the most successful group of eukaryotic phytoplankton in the modern ocean. Recently completed whole genome sequences from two species, *Thalassiosira pseudonana* and *Phaeodactylum tricornutum*, have revealed a wealth of information about the evolutionary origins and metabolic adaptations that may have led to their ecological success. A major finding is that they have acquired genes both from their endosymbiotic ancestors and by horizontal gene transfer from marine bacteria. This unique melting pot of genes encodes novel capacities for metabolic management, for example allowing the integration of a urea cycle into a photosynthetic cell. Our studies focus on *P. tricornutum* and exploit the availability of techniques for reverse genetics, digital gene expression profiling, genome and epigenome maps, ecotypes with differential capacities to adapt to different conditions, and distinct morphotypes that can be induced to change shape in response to ecologically relevant stimuli. Using these resources we explore both the physiological functions of diatom gene products and the evolutionary mechanisms that have led to diatom success in contemporary oceans. Specific research topics that we are currently addressing are: 1. How has diatom evolution enabled interactions between chloroplasts and mitochondria that have provided diatoms with physiological and metabolic innovations, and 2. What are the relative contributions of DNA sequence variation and epigenetic processes in diatom adaptive dynamics?
A next objective is to explore the functional roles of diatom biodiversity in the world's oceans. With biology becoming quantitative, systems level studies can now be performed at spatial scales ranging from molecules to ecosystems. Biological data generated consistently across scales can be integrated with physico-chemical contextual data for a truly holistic approach, with a profound impact on our understanding of life. While the marine planktonic ecosystems that diatoms inhabit comprise the base of the ocean food web, and are crucial in the regulation of Earth's biogeochemical cycles and climate, their organization, evolution and dynamics remain poorly understood. The *Tara* Oceans expedition was launched in September 2009 for a 3-year study of the global ocean ecosystem aboard the schooner *Tara.* A unique sampling programme encompassing optical and genomic methods to describe viruses, bacteria, archaea, protists and metazoans in their physico-chemical environment has been implemented. The project aims to generate systematic, open access datasets usable for probing the morphological and molecular makeup, diversity, evolution, ecology and global impacts of plankton on the Earth system, as well as to explore and exploit their biotechnological potential.