Genomes from the Sea

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Plankton is defined broadly as unicellular and multicellular life forms that are smaller than a few millimeters in size and that drift with the currents. Their common attributes are small size, high rates of metabolism and rapid generation times compared to larger organisms. Ernst Haeckel, the well known zoologist of the 19th century, popularized the plankton through his remarkable drawings. However, he appeared to believe that they were beautiful but insignificant organisms. Since then, our view has changed somewhat. For example, satellite-based observations of chlorophyll concentrations in oceanic surface waters together with in situ recordings have now led to the realization that at least 50% of the photosynthesis on Earth is carried out by photosynthetic plankton. By capturing and transducing solar energy, these organisms drive the cycles of carbon and related bioelements, thereby sustaining planetary habitability.

Notwithtanding their importance, the diversity, physiology and collective impact on marine ecosystem services of marine microbes are largely unknown because the oceans are notoriously difficult to study. As the oceans warm and become more acidic from the increasing burden of anthropogenic carbon dioxide in the atmosphere, marine plankton communities and their dynamics are also likely to change. Because of our limited understanding of even the most basic microbially-mediated processes in the sea we lack reliable predictive climate-ecosystem models. We therefore do not know how ocean life will be affected by climate change in the future.

However, recent technological developments open new avenues for exploration of the oceans and for understanding their influence on climate. For oceanographers, genomics provides detailed information on the many genes that drive biogeochemical activities of ocean-dwelling microbes. Carbon fixation, nitrogen fixation, sulphur gas formation, and many other critical processes are underlain by the collective action of genes inside individual microbial cells in the ocean environment. Genomics provides access to the genes involved and serves as an important step toward understanding their role in the ocean environment. Whole genome sequences for the major oceanic functional groups are rapidly becoming available and genomics approaches are being used to characterize entire microbial communities in their natural environments. With these new genomic-enabled approaches, oceanographers can explore the diversity and metabolic functions of the microscopic planktonic populations of the sea in highly effective ways. These approaches will improve assessments of plankton biodiversity, provide an improved understanding of the origin and evolution of life on Earth, and associate gene repertoires with functional properties of oceanic provinces, thereby providing a fuller appreciation of the fundamental contributions of the ocean to the global wellbeing of our planet.