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Editorial: Adaptive strategies and interactions of marine phytoplankton in the contemporary ocean: From genes to ecosystems

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Editorial on the Research Topic
Adaptive strategies and interactions of marine phytoplankton in the contemporary ocean: From genes to ecosystems

Marine Phytoplankton are a key component of oceans and constitute the first trophic level of the food chains. These organisms have evolved for millions of years leading to a large variety of structural, metabolic and physiological adaptations to a wide range of environments, in close association with other living organisms. Since the appearance of the first photosynthetic prokaryotic life cells on Earth 3500 mybp, phytoplankton have diversified to include forms ranging from prokaryotic to eukaryotic that acquired their photosynthetic capacity through the process of endosymbiosis (Delwiche, 1999).

On top of this long evolutionary history, most phytoplankton show rapid cell division rates and large population sizes, giving them the ability to evolve in response to environmental changes at timescales of decades, months or weeks (Collins et al., 2013). As a result, phytoplankton have a complex phylogeny with species in all three Domains of the tree of life, interacting with each other and with their surrounding environment. Diatoms, dinoflagellates and haptophytes dominate the contemporary ocean, having developed different adaptive strategies and thus becoming the most diversified phytoplanktonic groups (Simon et al., 2009). In particular, dinoflagellates have developed the probably highest complexity in trophic functionallities (photoautotrophy, heterotrophy, and mixotrophy) as well as interactions with other organisms (symbiosis and parasitism). The aim of this Research Topic was to show cases of adaptation of phytoplankton species across time and environments in an attempt to understand phytoplankton strategies. Five contributions have been included, four of which address the variety of adaptive strategies of dinoflagellates.

The symbiosis between dinoflagellates of the *Symbiodiniaceae* family and jellyfish are treated in two of the included articles (Enrique-Navarro et al and Dall'Olio et al). Dall'Olio et al confirm that the main symbionts of investigated scyphozoans belong to the genera *Symbiodinium*, *Philozoon*, and *Breviolum*, demonstrating that associations between dinoflagellate symbionts and *Cotylorhiza tuberculata* might change from year to year and from geographical location. This symbiotic association between zooxanthellae and scyphozoan jellyfish, allow them to occupy several niches by conferring mixotrophy as an added trophic mode. Moreover, the mutualistic nature of these associations is also demonstrated by Enrique-Navarro et al. They show that the umbrella tissue of the medusae *Cotylorhiza tuberculata* absorbs ultraviolet radiation providing thus physical protection to the zooxanthellae and a benefit for both. In a third contribution, the ecological success of free-living harmful bloom-forming dinoflagellates is also studied (Chen et al.). Free living dinoflagellates can be infected by other endoparasitic dinoflagellates. In this article, Chen et al describe the ultrastructure and photosynthetic response of a harmful bloom-forming dinoflagellate (*Akashiwo sanguinea*) that acts as a host of the endoparasite *Amoebophrya*. Interesting infestation consequences are described as dinospores release can have effects of ecological relevance on the blooming species. Also, the effect of sexual events that occur in nature can be an interesting ecological strategy of other bloom forming dinoflagellates. These organisms, like the harmful algal bloom forming dinoflagellate (*Prorocentrum donghaiense*), form banks of resting cysts in marine sediments (Hu et al.). These contributions shed light on the dinoflagellate life history and their ecological success.

The time scale is important in the adaptive process and the contemporary ocean is subject to the continuous changes of its physicochemical equilibrium driven by human pressures. Nutrients and novel contaminants end up in the ocean provoking eutrophication, anoxic dead zones and changes in the life cycles of marine organisms including phytoplankton, their diversity and their interaction with other organisms. This has promoted rapid changes, ultimately affecting phytoplankton and its natural life cycle in an unprecedented temporal scale. In this context, the last article (Kang et al.) provides an insight into how environmental changes in coastal waters can vary the proportion and dominance of one group (Cryptophytes) over another (Diatoms) in a phytoplankton community in a decadal timescale.

As this topic was intended to be, the articles included analyze interesting examples of phytoplankton adaptation, with special emphasis on dinoflagellates. They specifically highlight the variability and complexity of the trophic interactions that these organisms are involved in in the marine environment.

The mesmerizing adaptation strategies that phytoplankton have implemented through time have impressed marine biologists and oceanographers; the uncertainty remains in the next steps ahead.

Author contributions

AB took the lead in writing the manuscript. All authors provided critical feedback and helped shape the manuscript. All authors contributed to the article and approved the submitted version.

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