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Hervé Claustre,
Centre National de la Recherche Scientifique (CNRS), France

*CORRESPONDENCE
Raphaël Morard
rmorard@marum.de

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Editorial: Protists as model ecological and evolutionary study systems: Emerging methodologies of the 21st century

Raphaël Morard[1*], Manuel F. G. Weinkauf[2], Anieke Brombacher[3], Isabel Fenton[4], Jennifer Fehrenbacher[5] and Marina C. Rillo[6]

[1]Zentrum für MARine UMweltwissenschaften (MARUM) Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany, [2]Institute of Geology and Palaeontology, Charles University in Prague, Prague, Czechia, [3]School of Ocean and Earth Science, University of Southampton, Southampton, United Kingdom, [4]Department of Earth Sciences, University of Oxford, Oxford, United Kingdom, [5]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, United States, [6]Institute for Chemistry and Biology of the Marine Environment (ICBM), Carl-von-Ossietzky University Oldenburg, Wilhelmshaven, Germany

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Editorial on the Research Topic

Protists as model ecological and evolutionary study systems: Emerging methodologies of the 21st century

The emergence of new technologies has enhanced the study of past and present marine ecosystems in recent years. Shell-bearing protists, i.e. unicellular eukaryotes that form preservable skeletal structures of calcite or silica, form an important part of such ecosystems. As they occur in large quantities in all oceanic settings and have an excellent preservation potential, they are an ideal resource for ecological and evolutionary studies both in the present and in deep time. Protists are an integral part of the global food network and the carbon cycle; thus, predicting their response to projected future climate change is essential for modeling ecosystem dynamics in a changing world. A detailed understanding of protist ecology and evolution is a prerequisite for these predictions. Quantifying the relationships between these organisms and their environment also provides new insights into the processes driving adaptation and extinction as a response to environmental change. The 21st century has seen the development of new tools, and improvements to existing methodologies, that together greatly increase the capacity of data production, improve instrument accuracy, and introduce new modeling approaches to harvest the possibilities of the “virtual laboratory”. This Research Topic presents a glimpse of how novel methodologies can open novel avenues in protist research.

To increase morphometric data generation of planktonic foraminifera throughput, Knappertsbusch et al. developed an automated platform for the acquisition of such data. The large datasets their method generates will help track high-resolution evolutionary patterns through geological time. To expand our knowledge of foraminifera ecology, Zarkogiannis et al. used X-ray microcomputed tomography to study the shell mass variation of species with different trophic strategies, shedding light on the impact of these tiny organisms on large-scale processes like the marine carbonate pump. Both methodologies promise to deliver intriguing information from the biometry of these calcifying protists.

Further highlighting the importance of protists for the biogeochemical cycle, Saavedra-Pellitero et al. improved the accuracy of paleoceanographic reconstructions based on coccolithophore assemblages using a new statistical model. They found different patterns of the evolution of primary productivity and sea surface temperature during the Holocene. The paper by Anschütz et al. showcased the power of numerical modeling for practical, real-world applications. They presented an ecological model of the harmful algal dinoflagellate *Dinophysis*, and how its population dynamics are related to two other protists (a ciliate and a cryptophyte) that are the sources of *Dinophysis*' acquired phototrophy. This modeling study will greatly improve protection against harmful algal blooms in the future, as it will allow predictions of *Dinophysis* bloom conditions by monitoring diverse elements of a complex system that all contribute to algal bloom generation.

Studying photosymbiotic relationships in a new way, Takagi et al. used active chlorophyll fluorometry to quantify carbon assimilation rates of two photosymbiotic species of planktonic foraminifera. They identified significant differences in carbon assimilation rates between the species, hinting at the importance of species-specific symbiotic systems for the interpretation of geochemical parameters and their use for paleoenvironmental reconstructions. Similarly, LeKieffre et al. used NanoSIMS to trace the incorporation of nitrogen and sulfate into foraminiferal shells to understand the metabolic capacities of benthic foraminifera to utilize these elements. Their study is the first major step in understanding benthic foraminifera contributions to the sediment cycles of ammonium and sulfate, and their potential to colonize different marine habitats. Such improvements in geochemical methods will enable more detailed data to be gathered for habitat reconstructions and allow improved assessments of different species' ecological backgrounds and strategies. Finally, Girard et al. explored the potential of the newly sequenced mitochondrial cytochrome oxidase subunit 1 (COI) gene in foraminifera to be used as a novel barcode to study the diversity in this group, which may allow much more rapid systematic designation in the future.

Altogether, these research studies demonstrate that protistology is a dynamic and vibrant field of research. Protists, and the application of the knowledge we can gain from them, hold great potential for answering fundamental questions in ecological and evolutionary research.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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