SINGLE-CELL RNA SEQUENCING ILLUMINATES THE ONTOGENY, CONSERVATION AND DIVERSIFICATION OF SHELL BIOMINERALIZATION TOOLKIT

Hao Song*[1]

[1]Institute of Oceanology, Chinese Academy of Sciences – China

Abstract

The extraordinary diversity of shells is a defining morphological trait of marine molluscs and serves as a key basis for their taxonomic classification. However, the mechanisms by which different functional cell types within the mantle collaborate in shell formation, as well as the evolutionary trajectories these cells have followed to generate diverse shell architectures, remain poorly understood. Here, we present single-cell RNA sequencing atlases of marginal mantle cells from marine molluscs spanning diverse phylogenetic lineages (Bivalvia: *Mercenaria mercenaria*; Gastropoda: *Rapana venosa*; Polyplacophora: *Acanthochiton rubrolineatus*). Cross-species comparisons reveal that conserved cell types, including neurons, fibroblasts, and immune cells, maintain highly similar transcriptional profiles across species, whereas epithelial cells show pronounced lineage-specific divergence. This pattern highlights both the evolutionary conservation of the shell biomineralization regulatory network (SBRN) and evolutionary innovations. Among these cell types, epithelial cells directly contribute to shell matrix protein secretion and serve as the primary executors of shell biomineralization. Notably, epithelial cells display considerably young transcriptomic profiles, achieving functional diversification through frequent co-option of ancient genes and recruitment of *de novo* genes, thereby providing a molecular basis for the rapid evolution of the SBRN. Despite this rapid innovation, we identify a subset of biomineralization-specific regulatory elements that are highly conserved across lineages, likely contributing to the robustness and efficiency of the biomineralization process. Together, our cross-species single-cell atlases offer a valuable framework for elucidating the origins and evolutionary dynamics of shell biomineralization systems.

Keywords: Mollusca, Biomineralization, Single, cell sequencing, Evolution

*Speaker