Developmental dynamics through metamorphosis from larva to juvenile: a single cell approach

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Abstract

One intriguing and still open fundamental question in biology is how different embryonic structures or distinct organs, originating from the same embryonic tissue, developed and evolved in different animals. Metazoans comprise diverse tissues and cell types, each essential for the survival of the organism. Most of these cell types are established early in embryogenesis and persist into adulthood. However, in indirectly developing animals, the continuity between embryonic and adult stages is interrupted by a larval stage that undergoes complete metamorphosis. An extreme case of indirect development occurs in echinoderms which feature a biphasic life cycle with free-swimming bilaterally symmetric planktotrophic or lecithotrophic larvae, followed by a radical metamorphosis leading to animals characterized by a pentaradial adult body plan.

The great variation in body plans occurring during the life cycle of echinoderms, from their bilaterally symmetric larvae to their pentameral adults, has led to many inquiries about how such a change in developmental programs can be carried out by the same genome. The answer to these questions most likely lies in the complex nature of the developmental gene regulatory networks (GRNs) that functionally connect transcription factors (TFs) to the terminal differentiation genes of a specific cell type. By testing the degree to which developmental GRNs and cell types are shared between the bilaterally symmetric larva and the juvenile that emerges from it during metamorphosis is one method of resolving this conundrum.

In this project, we propose a twofold study, using a “static” and a “dynamic” cell type approach. In Aim 1 (static approach), we will compare, at the transcriptomic, GRN and morphological levels, the cell types that constitute the 4-arm sea urchin *Paracentrotus lividus* larva with the cell types of the post-metamorphosis juvenile. In Aim 2 (dynamic approach), we will study the dynamics of the process of metamorphosis, at the morphological (using whole organism imaging by x-ray tomography and 3D segmentation) and the cell lineage level, recording *in vivo* the movements and fate of specific cells marked by fluorescent reporter constructs.