

Understanding the Evolution of Development during the Evolution of Multicellularity. E. R. Hanschen¹, R. E. Michod¹, B. J. S. C. Olson². ¹University of Arizona, hanschen@email.arizona.edu, ²Kansas State University

To understand the hierarchy of life in evolutionary terms we must explain why groups of one kind of individual evolve into a new higher-level individual as observed in the evolution of eukaryotes, multicellular organisms, and eusocial societies. In these major transitions, such as the the the evolution of multicellularity, two fundamental steps are the evolution of development and division of labor into reproductive germ and non-reproductive soma. However, given the divergence time of most multicellular clades from their unicellular relatives, the evolution of these traits remain poorly understood. Using the volvocine algae, a well developed model system for the evolution of multicellularity, we investigate the evolution of development and cellular differentiation. Like multicellular plants and animals, volvocine algae regulate the cell cycle through the retinoblastoma (RB) cell cycle pathway. Additionally, it is previously known that somatic differentiation in multicellular *Volvox* is regulated through the *regA* gene. Using genomic data from the undifferentiated colonial *Gonium*, we demonstrate the evolution of development, via cooption of the retinoblastoma cell cycle regulation pathway, occurred strikingly early in the volvocine algae. These genetic changes suggest the evolution of group level adaptations occurring surprisingly early in the evolution of multicellularity, indicating the capacity to evolve as Darwinian entities, surprisingly early in the evolution of multicellularity. However, the genetic basis for somatic cells, *regA*, also evolves strikingly early, as we demonstrate using the presence of *regA* in diverse volvocine species. We show that *regA* evolved early in the volvocine algae, shortly after group formation but before the evolution of cellular differentiation. The variation in presence of soma may be explained by multiple lineages independently evolving soma utilizing *regA* or alternate genetic pathways, informing the evolution of multicellularity as a fundamental process. We conclude that the history of development and cellular differentiation in the volvocine algae is more complicated and labile than previously appreciated on theoretical grounds and suggests the evolutionary transition to individuality is driven by group level adaptations surprisingly early in this process.