Model explains rapid transition toward division of labor in biological evolution

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The transition from colonies of individual cells to multicellular organisms can be achieved relatively rapidly, within one million generations, according to a new mathematical model, published June 10 in the open-access journal *PLoS Computational Biology*, that simplifies our understanding of this process.

Biological organisms are highly complex and are comprised of many different parts that function together to ensure the survival and reproduction of the whole. How and why complexity increases in the course of evolution is a question of great scientific and philosophical significance. Biologists have identified a number of major transitions in the evolution of complexity including the origin of chromosomes, eukaryotes, sexual reproduction, multicellular organisms, and social groups in insects. A crucial step in many of these transitions is the division of labor between components of the emerging higher-level evolutionary unit.

Understanding how the division of labor evolved in multicellular organisms is difficult because single cells are expected to act selfishly to protect their own existence instead of working cooperatively to achieve a more productive higher level of organization, explains author Sergey Gavrilets, Associate Director for Scientific Activities at the National Institute for Mathematical and Biological Synthesis and a professor at the University of Tennessee-Knoxville.

His new approach applies not only to cells within an organism but may

be more broadly applied to the emergence of multiple cell types, complex organs, or even some insect societies. These findings help to answer many questions for evolutionary biologists working toward understanding the major transitions in the evolution of complexity.

Using germ and soma cells in volvocacean green algae as an example, Gavrilets' mathematical model describes the evolutionary emergence of the division of labor starting with a colony of undifferentiated individual cells and ending with completely differentiated multicellular organisms. It is the first model to show the evolution of complete germ-soma differentiation, where one part of the colony's cells (germ) eventually specializes in reproduction and the other part of the colony's cells (soma) specializes in survival..

In the model, the division of labor occurs through the evolution of the ability to develop in a variety of ways (developmental plasticity), meaning that some gene regulation is required. The results show that division of labor can occur if two conditions are met: there must be strong genetic relatedness and fitness trade-offs preventing individual cells from performing multiple functions efficiently.

"This particular model provides a very straightforward path for division of labor," Gavrilets said. "The model helps train our intuition about other more complex evolutionary processes."

More information: Gavrilets S (2010) Rapid Transition towards the Division of Labor via Evolution of Developmental Plasticity. PLoS Comput Biol 6(6): e1000805. doi:10.1371/journal.pcbi.1000805

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