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SELF-ORGANIZATION IN BIOLOGICAL SYSTEMS: FROM INDIVIDUAL DECISION TO GROUP COHESION AND POPULATION STRUCTURE

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Before the 1990s scientists used mostly a top-down approach to understanding the evolutionary process by which social life developed, but today the bottom-up approach is more widely used to assess mechanisms underlying large-scale patterns such as formation of groups and changes in their structures. Bottom-up approaches deal with interactions between individuals: how an individual behaves with its conspecifics and/or how it can influence their behavior. More and more studies show that the interactions between individuals may be local and simple, whatever the species and its cognitive abilities. Complex systems such as collective decision-making may emerge from simple and local interactions among the lower-level components of the system, i.e. the group members. This definition characterizes self-organized systems. Mathematical modeling or individual-based models are now important tools for understanding these complex systems. Many animal groups show some complex patterns that may be explained by the self-organization theory, from schools of fish, flocks of birds, migration of locusts and of ungulates, and even traffic flow in human crowds. Collective movements in cohesive groups, fission-fusion dynamics or irreversible fusions, and size distribution of stable groups may be explained by considering only two individual rules, namely, physiological needs and the social relationships, as dynamic processes. Bridging the gap between the individual and the population level is crucial if we want a deeper understanding of how simple and local interactions drive population structure and ecological systems.

Keywords: Network, Mathematical modeling, Fission-fusion, Collective movements