Patterns of Life: Mathematical Exploration of Self-Organization in Biological Systems

Abstract:
Self-organization within a group of organisms manifests as global macroscopic patterns, emerging not from external stimuli but rather from localized microscopic interactions among individuals. This phenomenon spans diverse scales in nature, from pedestrian street crossings to the intricate molecular alignment of atoms. In this talk, we use mathematical modeling, analysis, and simulation to uncover the fundamental mechanisms governing the emergence of self-organization in biological systems. Specifically, we introduce differential equation-based models describing the microscopic behavior of ants, providing insight into the formation of trails. Expanding on this foundation, we apply new knowledge to address a problem in Applied Ecology, investigating the role of ants as an invasive species. The talk concludes with recent work using mathematics to identify key features used by chromosomes to locate their homologous pairs during meiosis, a critical step in cell replication. Remarkably, these disparate systems share a common mathematical framework capable of generating macroscopic patterns across various length scales, hinting at the existence of potential universal properties.

Brief Bio Dr. Shawn Ryan:

Shawn Ryan is an Associate Professor in the Department of Mathematics and Statistics at Cleveland State University since 2016. He was also appointed the co-Director of the Csu Research Center for Applied Data Analysis and Modeling (ADAM). He got his Ph.D. in Mathematics from Penn State University in 2014 under the direction of Leonid Berlyand and then worked as a Postdoctoral Fellow at Kent State University with a dual appointment in the Department of Mathematical Sciences and the Liquid Crystal Institute. Dr. Ryan's research interest include modeling, analysis, and simulation of active biosystems. In particular, his research focuses on Mathematical Biology and Material Science. Current active projects focus on self-organization in social insects, swimming bacteria, and chromosome dynamics.