Mathematics Provides Insight into Self-Organization in Biology

Shawn Ryan

In this talk we will consider how mathematical modeling, analysis, and simulation can be used to provide new insight into biological phenomena. In particular, we focus on the self-organization of large-scale groups of insects and bacteria. What makes this problem interesting is that individual interactions at the microscale lead to the onset of mesoscale and then macroscale patterns. In addition, when animals exhibit collective behavior one can observe remarkable properties such as enhanced movement speed, pattern formation, and increased mixing. A deep understanding of how and why these properties emerge is fundamental to pressing biological problems such as the design of microscale devices and biomaterials, treating algal blooms in Lake Erie, or preventing neurodegenerative diseases. Throughout the talk we will use mathematics to explain the underlying mechanisms that lead to these incredible features. By the end we will answer an age-old question "Is 2 > 1?". For biological systems the answer is yes!

Shawn Ryan has taught at Cleveland State University since 2016. He grew up in Northeast Ohio (Mentor) and received his Bachelors and Masters degrees in Applied Mathematics from the University of Akron in 4 total years. He then earned his Ph.D. at Pennsylvania State University studying Mathematical Biology and PDEs in 2014. During his time as a Ph.D. student at Penn State, Shawn received the Department of Mathematics Outstanding Teaching Award as well as The Pritchard Dissertation Award for the most Outstanding Mathematics Ph.D. Thesis. Following this time, Shawn spent two years as an interdisciplinary postdoctoral research scholar at Kent State University in the Department of Mathematical Sciences and the Liquid Crystal Institute designing computational algorithms for studying foam coarsening and pattern formation in liquid crystals. His active areas of research include self-organization in biological systems, bacterial contamination in the food industry, biomedicine, and material science. He has directed fifteen undergraduate and two honors undergraduate senior theses as well as four Masters exit projects. Shawn enjoys spending his free time with his wife Ashley, a pediatrician at Akron Children's Hospital, and his two daughters Nora and Eliza.

Counting Down from Infinity, and TREE(3)

Carl Mummert

One area of combinatorics looks at specific sequences of natural numbers that grow at seemingly inconceivable rates. We will begin with the sequence TREE(n) and Kruskal's theorem, a related result about the combinatorics of finite trees. We'll encounter the specific number TREE(3), once described by Popular Mechanics as "too large to notate directly, too large to comprehend, too large for physics to describe". We'll see the process of "miniturization" that transforms pure existence theorems like Kruskal's into fast-growing sequences like TREE(n). Then we'll look at a "base infinity" number system in which each "digit" can be arbitrarily large. We'll see that counting down to 1 from a base infinity number is not as easy as it sounds.

Photo Credit: Rick Haye/ Marshall University

Carl Mummert is an Associate Professor of Mathematics at Marshall University. An Appalachian native, he attended Western Carolina University, received a Ph.D. from Penn State, and held postdoctoral positions at Appalachian State and the University of Michigan. His research is in mathematical logic (particularly reverse mathematics and computability theory), topology, and combinatorics. He has supervised numerous student research projects, and has several co-authored papers with students. His teaching incorporates techniques from Inquiry Based Learining (IBL), and he is the current Program Officer of the MAA IBL SIGMAA. He is also an active member of the Digital Humanities group at Marshall.