Probability Problems Arising from Genetics and Ecology

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Keywords:
AMS keywords:

Lecture 1. Philosophy and Anecdotes. The Wald Lectures provide me with an opportunity to reflect on 20 years of trying to use probability to shed light on questions that arise from biology. The philosophical question I will address is: what is good applied probability? To attempt to answer this question and to describe some of the challenges that come from trying to publish work that mathematicians think is trivial and biologists find incomprehensible, I will describe some of the research I have done recently with Nathanael Berestycki, Deena Schmidt, and Lea Popovic. *Lecture 2. Recent work in Genetics with Jason Schweinsberg.* The first half of the talk concerns the problem of approximating selective sweeps, which in turn leads to a consideration of coalescents with multiple collisions and their application to species with heavy-tailed family sizes (e.g., marine species and domesticated animals). In the second half, we will cover work done with Deena Schmidt on regulatory sequence evolution and a model for multistage carcinogenesis, showing the power of mathematical abstraction to realize that these two applications are special cases of one problem in population genetics. How long do we have to wait until some member of the population has experienced a prespecified sequence of m mutations? *Lecture 3. Coexistence in Stochastic Spatial Models.* For the much of the last twenty years I have worked to understand when competing species can coexist. An answer is provided by the competitive exclusion principle: the number of coexisting species cannot exceed the number of resources. Unfortunately, it is often not clear how many resources a system has. I will describe five examples, being with the Cornell Ph.D. theses of Claudia Neuhauser and Glen Swindle, work on bacterial competition models with Simon Levin, and ending with recent research with Nicolas Lanchier and Ben Chan.