ECOLOGY AND EVOLUTION

By J. Grilli

Subject fundamentals:

The goals of this class are both to teach students fundamental concepts in ecology and evolution and provide them with basic notions and tools in dynamical systems and stochastic processes. The class will be divided into two main parts. The first part will be devoted to introducing the students with classic models in population and community dynamics. At the end of this part, the students are expected to be able to quantitatively model community dynamics in the presence of different interaction types, identifying and justifying the important assumptions. They should also be able to perform stability analysis, identify the presence of bifurcations and have basic notions of limit cycles and chaos. The second part will focus on evolutionary theory and population genetics. We will discuss classic and modern experimental evidence of Darwinian (micro)evolution and the observational pieces of evidence of macroevolution. The students will study the effect of selection, mutations and drift on fixation of neutral, beneficial, and deleterious mutations in the context of simple stochastic models of population genetics. At the end of this part the student will know how to quantify the relative importance of the fundamental mechanisms of evolution (reproduction, mutation, selection, genetic drift and recombination) using the tools of stochastic processes.

Contents:

First part (Ecology, Population dynamics)

- Single Population dynamics (Exponential growth, logistic growth, Allee effect)
- Introduction to Bifurcations
- Two species dynamics. Fixed points and their stability (Lotka-Volterra equation)
- Limit cycles (Mac-Arthur Rosensweitz model)
- Few facts about chaos, discrete maps
- Multispecies communities

Second part (Ecology, Population genetics)

- Experimental and observational evidence of evolution
- Quasispecies theory
- Genetic Drift (discrete models, coalescent, diffusion approximation, first-passage problem)
- Mutation and selection (stationary distribution, fixation probabilities)
- Distribution of beneficial mutations (speed of adaptation, travelling wave approach)
- Deleterious mutations and Muller's ratchet
- Recombination, Mating
- Coevolution (bacteria-phage)

Delivery modes:
Three lectures per week. The first part (starting on Sept 30, 2019) is optional, but students are welcome to participate in the class. Only the second part (starting on Oct. 23, 2019) will be part of the exam