Spring 2024

BIOL 337-002 Collective Intelligence in Biological Systems

Simon Garnier

BIOL 337 – Collective Intelligence in Biological Systems

Spring 2024

Description and goals:

Instructor: Simon Garnier (garnier@njit.edu, http://www.theswarmlab.com).

Understanding collective intelligence is one of the main challenges of contemporary science. Social dynamics are essential for the organization of gregarious and social organisms, and they are an important part of many human activities including the selection of social and industrial norms, the growing use of crowd-sourcing and viral marketing in social networks, and the influence of media and entourage on the outcome of democratic processes. For instance, did you know that …

- ...in spite of their tiny brains, ants regulate the traffic on their trails almost optimally while human beings, with their sophisticated technologies, still get stuck in traffic jams on a daily basis?
- ...Facebook, Twitter, and Google can tell us in advance when and where there will be a flu outbreak?
- ...virtual ant colonies and bee swarms can help optimize the transfer of your phone calls and your emails?
- ...being too smart individually can make us stupid as a group, and vice versa?

And did you know that you can explain all of the above and even more with only a handful of simple mechanisms?

Through lectures, tutorials and documentaries, this course will provide an overview of the fundamental principles underlying the organization of animal societies. It will include detailed consideration of the behavioral, social, and physical processes that are responsible for the coordination of activities in large animal and human groups.

This course will emphasize an integrative view of collective animal behaviors, with elements of ethology, behavioral ecology, sociology, socio-physics, and mathematical and computer modeling. It will also address topics in the evolution of sociality, the development of social and cultural conventions, and the applications of swarm intelligence.

Course objectives:

Upon completion of this course, students will be able to:

1. Demonstrate knowledge of the essential concepts that underlie social behaviors in animals and humans: mechanisms of social interactions, social networks, positive and negative social feedback, self-organization, information polling, and collective intelligence.
2. Integrate and relate knowledge about the behaviors of individual animals (or humans) in a social context to their consequences on the higher-order group dynamics. In particular, students will demonstrate their knowledge of how simple, individual-based behaviors and interactions can lead to the emergence of aggregation, segregation, morphogenesis, collective movement and traffic organization, leadership, collective decision-making, and democratic consensus.
3. Relate basic concepts of statistical physics and applied mathematics to the analysis and modeling of collective intelligence phenomena.
4. Students will be able to critically evaluate discussions on course topics and communicate effectively their understanding by participating in instructor-led discussions of the material.

Course organization:

Class meets: Monday & Wednesday, 11.30 am to 12.50 pm, in Kupfrian Hall room 108.

Office hours: Thursday 1 to 2 pm, or by appointment.

Course prerequisites: R120:201/202 and BIOL 205/206.

Required texts: None.

Recommended texts:

1. "Self-organization in biological systems", by Scott Camazine, Jean-Louis Deneubourg, Nigel Franks, James Sneyd, Guy Theraulaz and Eric Bonabeau (Princeton University Press, 2001).
2. "Critical mass: how one things leads to another", by Philip Ball (Farrar, Straus and Giroux, 2004).
3. "Collective animal behavior", by David Sumpter (Princeton University Press, 2010).
4. "The perfect swarm: the science of complexity in everyday life", by Len Fisher (Basic Books, 2009).
5. "The Smart Swarm: How Understanding Flocks, Schools, and Colonies Can Make Us Better at Communicating, Decision Making, and Getting Things Done", by Peter Miller (Avery, 2010).
6. "Honeybee democracy" by Thomas Seeley (Princeton University Press, 2010).
7. And to relax during the weekend: "Prey", by Michael Crichton (Harper Collins, 2002).

Class website: via Moodle (http://moodle.njit.edu).

Grading policy:

- There will be NO midterm or final exam. There will be NO quizzes.
- All grades will be based on assignments. Assignments will consist of short essays (2,000 words max. + figures and references) summarizing the main concepts discussed in class. The course will be divided into chapters, each covering a different topic. Each assignment will be due one week after the end of each chapter and will cover the corresponding topic. Each of these assignments will be worth 100 points and their average will make up the final grade.
- Extra assignments can be made available on request and during the semester only to students interested in increasing their overall grade through additional work.
- I will add 5 points to your worst assignment grade if you send me an email before Wednesday, January 24 to confirm that you have read this document.

Grading scale:

- A: 88-100
- B+: 81-87
- B: 74-80
- C+: 67-73
- C: 60-66
- F: 0-59

Important rules and policies:

- Academic Integrity: the University Code on Academic Integrity is STRICTLY ENFORCED! Cheating and plagiarism will be taken into account when grading written assignments.
- Electronic Devices: the use of personal laptops and tablets during class will be authorized for notetaking and class-related research exclusively.
- Make-ups: make-ups for missed assignments will require an excuse validated by the Office of the Dean of Students and Campus Life.