Networks in Theory and Life

This seminar was inspired by the fall semester moderated by John Armstrong called "How Life Works", where we learned about many networks at the molecular level and tried to understand their dynamics and the resulting emergent properties. These included, at the molecular level, gene and transcriptional networks as well as protein networks as well as networks of cells that operate at the system level, such as the brain or the immune system.

Most of us found the remarkable emergence of new and unpredictable phenomena from the [relatively!] simple building blocks of these networks quite unintuitive. So one of the goals of this seminar is to improve our intuition about how networks work. In particular, we will explore how dynamic networks—that is, networks in which both the nodes and their links can change over time—can evolve through the interactions between their internal architectures and the external constraints.

Network science has exploded in the last thirty years, particularly as a result of increasing computational resources. Once scientists (not only computer scientists, but also social scientists, biologists, ecologists and others in fields with their own explosions of new tools) were able to map in detail some large real-world networks, they discovered architectures and dynamics that were quite different from those that had been examined using more traditional mathematical methods. Tracing this historical path will also be part of this seminar.

The seminar has no formal mathematics prerequisites, although it will be useful to recognize that mathematical models, such as network models, are always abstractions and always require simplifying assumptions. The skill, then, is in being able to recognize what is essential to keep and what can be discarded.

The principal role of participants will be to select a real-world network that has been studied by others and present it to the group, providing us with a variety of examples to discuss that illustrate the basic principles of network theory. Depending on the interests of the participants, we may also try our hand at building some small networks, using available on-line computational tools.

As preparation, participants are asked to read through an online textbook by one of the leading researchers in the field: *Network Science* by Albert-László Barabási at http://networksciencebook.com/. Don't worry about the parts that you don't understand, but use this as a preview of coming attractions! In addition, a set of papers and other resources of interest for this course will be constructed on a Google drive that can be accessed by participants, along with an annotated bibliography and a list of possible networks for presentation.