

**COMPLEXITY:
ANTS, NETWORKS, AND THE EMERGENCE OF ORGANIZATION**
**How does pattern and function emerge from groups of seemingly simple,
disconnected agents? And why social insects are so cool.**

Spring 2021

Instructor: **Anna Dornhaus**

The brain of an ant is smaller than a pinhead, yet we admire the apparently rigorous, effective organization and flexible problem solving of ant colonies, which make collective consensus decisions, divide up labor, and effectively search vast areas, without centralized control. This will be a fun course in which you will be introduced to the world of ants and other social insects like bees; their struggles and successes which are so reminiscent of our own society; and the people who study them.

One of the most interesting aspects of social insects is that their ability to solve problems through clever group organization is similar to a huge variety of phenomena in biology – molecules forming cellular machinery, nerve cells forming brains, or species assembling into stable ecosystems all are ‘collective systems’ which consist of simple units displaying complex behavior in a group. Such apparently ‘free’, self-organized structure can also be found in some chemical and physical systems, and engineered/human social systems (such as stockmarkets) - although in these cases, self-organization does not always lead to adaptive, i.e. positive outcomes. The research on social insects has thus generated both philosophical questions (what is emergence?) and engineering applications (how to manage an efficient internet). In this course, we will continuously draw parallels to other biological and human/engineered systems facing similar problems or showing similar outcomes.

This course will be held entirely online, in the form of live Zoom sessions

MONDAYS 1 PM - 3 PM (AZ TIME) on JANUARY 25, FEBRUARY 1, 8, 22, MARCH 1, 15, 22, 29, APRIL 5 and 12, 2021.

Each class session will include a live-streamed lecture by the instructor as well as time for questions (and answers) and discussion. Questions arising during the lecture can be asked in the ‘Chat’ function in Zoom, and the instructor will respond to these in short breaks between lecture segments.

All readings, videos, and other materials will be made available on the course’s ‘box.com’ folder – please refer to your HSP class email for detailed information on how to access it.

As an additional, optional component of the course we will be using a Slack workspace. ‘Slack’ is essentially like the Zoom Chat function, but will enable us to maintain longer, more sorted conversations, as well as allowing students and instructor to share additional links or references to interesting, course-relevant materials. Slack can be installed as an app on your phone, tablet, or computer, or you can simply access it in a browser window in any of these devices. If you are using it on more than one device, you can sign in with the same email on both, such that you can access your own messages in both.

To access and participate in Slack discussions, you will need to ‘join’ the class Slack workspace by clicking on the invitation link provided on box.com. Please feel free to send me an email to get help signing in or using Slack (dornhaus@email.arizona.edu).

Course website:

<https://hsp.arizona.edu/course/spring-2021/complexity-ants-networks-and-emergence-organization>

Course plan

Date	Topic	Details	Introductory resource	Deep resources	Other supporting material & branching out
Jan 25	1 Social insects	Ants, bees, etc.; how they live, what is cool about them.	Pearson: You're worried about the wrong bees - Wired Tschinkel chp1: Fire Ants	Ants: Nature's Secret Power (video) Seeley: Honeybee Ecology - Honeybees in Nature Kurzgesagt: The world war of the ants (video)	Kurzgesagt: Weaver ants (video)
Feb 1	2 Evolution	How evolution works and how it works differently in social insects: eusociality. Anthropomorphism and sociality vs cooperation. Evolution of cooperation. Selfish genes. Major transitions in evolution.	Gadagkar: chp 1 Survival strategies Stated Clearly (video): What Caused Life's Major Evolutionary Transitions?	Szathmáry & Maynard Smith: The major evolutionary transitions Dugatkin: Why cooperate? Futuyma: Evolution and creationism	Stated Clearly (video): How does cooperation evolve? Ridley: Origins of virtue Primer: Simulating natural selection (video) Primer: The natural selection of altruism (video)
Feb 8	3 Communication	Benefits and costs of communication: Who reads all the memos, or channel overload; overhead costs; conformity vs flexibility.	Dornhaus & Powell: Foraging and defense strategies	Grueter & Leadbeater: Insights from Insects about adaptive social information use Dawkins: Arms races and manipulation	
Feb 22	4 Division of labor	Generalists are more robust, specialists can save costs. Division of labor as progress in evolution and engineering; but with caveats. New hypotheses.	Hoyt: The Earth Dwellers - adventures in the land of ants: Worker's paradise		

Mar 1	5 Emergence	<p>Collective systems from social insects to stockmarkets. Weak and strong emergence. Is organization 'free'? Independent of evolution? Negative feedback and homeostasis: Daisyworld and Gaia; thermostats in engineering, in ants, in molecules, and in people. Positive feedback and symmetry breaking. The butterfly effect in weather; ants and social media; when is 'positive' good (mostly not).</p>	<p>Kurzgesagt (video): Emergence – How Stupid Things Become Smart Together</p>	<p>Couzin: Collective minds Crespi: Vicious circles: positive feedback in major evolutionary and ecological transitions</p>	<p>Perony TEDx Talk (video link or text transcript)</p>
Mar 15	6 Algorithms	<p>Recipes, behavior, computer programs. Re-thinking communication, division of labor, search, and consensus decisions as distributed algorithms.</p>	<p>Dornhaus: Can intelligence be measured? (video)</p>	<p>Distributed Information Processing in Biological and Computational Systems (Navlakha & Bar-Joseph)</p>	
Mar 22	7 Individual intelligence	<p>Decision-making individual and collective. Bee intelligence. Human uniqueness (or not). Behavioral genetics. Learning vs fixed behaviors. Tradeoff between collective and individual intelligence? Stigmergy.</p>	<p>Dornhaus: Evolution of mind (video)</p>	<p>Dornhaus: Aliens are likely to be smart but not 'intelligent' Dornhaus: What makes us human? (video)</p>	<p>Wystrach: We've Been Looking at Ant Intelligence the Wrong Way Dornhaus: Foraging (bk chp)</p>
Mar 29	8 Science	<p>Evolution II. Ultimate and proximate. Anthropomorphism II, incl fallacy of introspection. Strong inference. Science vs engineering. Statistics and System thinking. Politics and ecology; the role of noise; the difficulty of biology and the real world.</p>	<p>Krebs & Davies: chp1 Introduction to behavioral ecology</p>	<p>Masel: There is no certainty (video)</p>	<p>Cosmos: Hiding in the light (video)</p>
Apr 5	9 Currents in social insects	<p>How does a social insect lab operate? How behavior is</p>	<p>Schulson: In social insects, researchers find hints for</p>	<p>Moses et al.: Distributed Adaptive Search in T Cells:</p>	

		measured. Theory and experiment. Current topics: Search. Exploration. Architecture.	controlling disease	Lessons From Ants	
Apr 12	10 Human organization	Whatever topic(s) we didn't get to. Human organization(s).	Glattfelder TEDx Talk (video link or text transcript)		