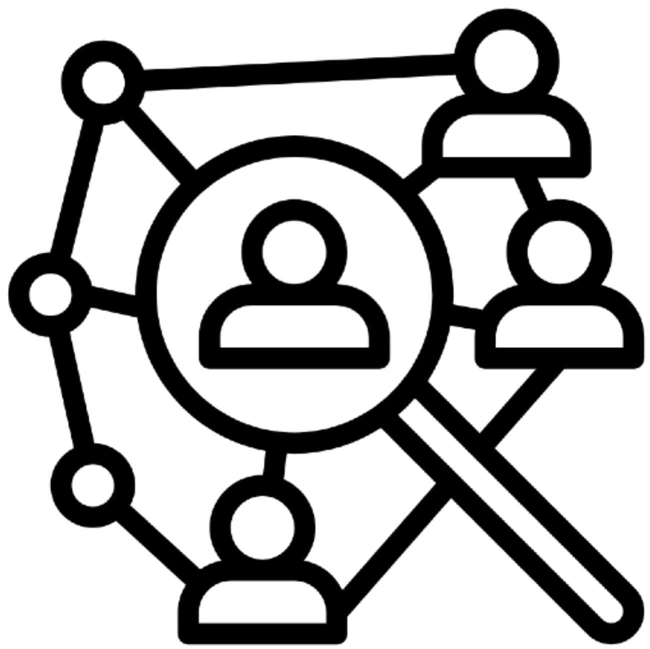
How to Teach Modeling
or
Thoughts on a Pedagogy for Cultural Evolution

Paul E. Smaldino
Department of Cognitive & Information Sciences
University of California, Merced

Social science is more important than ever.



Some pressing questions for our time

- How does information (and misinformation) spread?
- How do beliefs and opinions change?
- What facilitates or impedes people working together toward common goals?
- How do norms emerge and change?
- Is now like then, and will it be again?

Researchers studying human behavior are siloed into many distinct disciplines, with different methods, theoretical frameworks, and perspectives.

This limits the sort of questions researchers tend to ask, and the approaches they use to answer those questions.

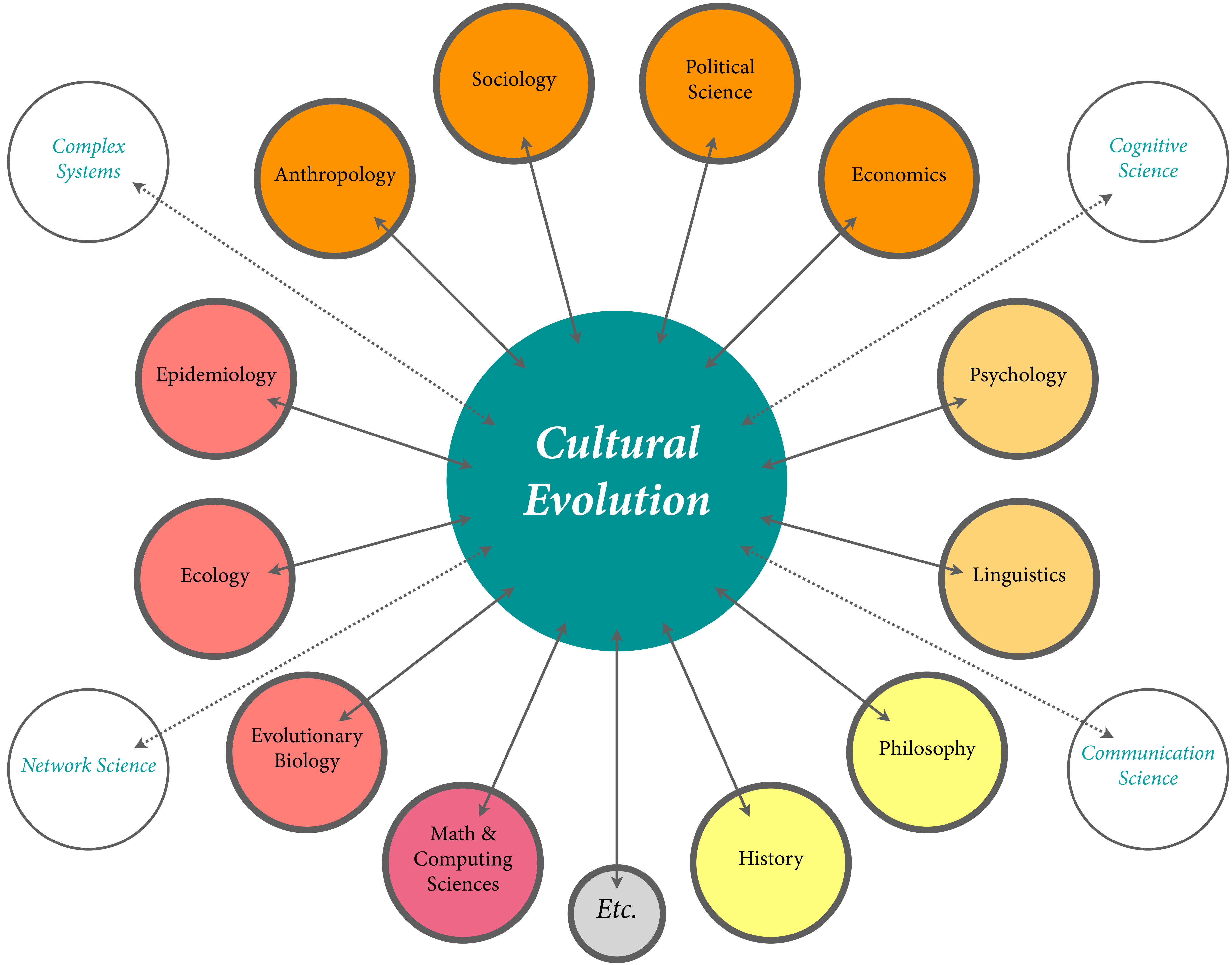
Researchers often lack frameworks or tools for dealing with complex problems at multiple scales.

It would be helpful to have a **bridging framework** to facilitate communication between researchers and to foment better research questions.

Cultural Evolution

A potential unifying framework for understanding human behavior and social change.

- Inherently interdisciplinary
- Incorporates multiple scales
  - Organizational: from individuals to societies
  - Temporal: From milliseconds to millennia
- Rooted in formal theory


Cultural Evolution
Sociology
Political Science
Anthropology
Economics
Complex Systems
Cognitive Science
Epidemiology
Psychology
Ecology
Linguistics
Network Science
Evolutionary Biology
Philosophy
Communication Science
Math & Computing Sciences
Etc.
History

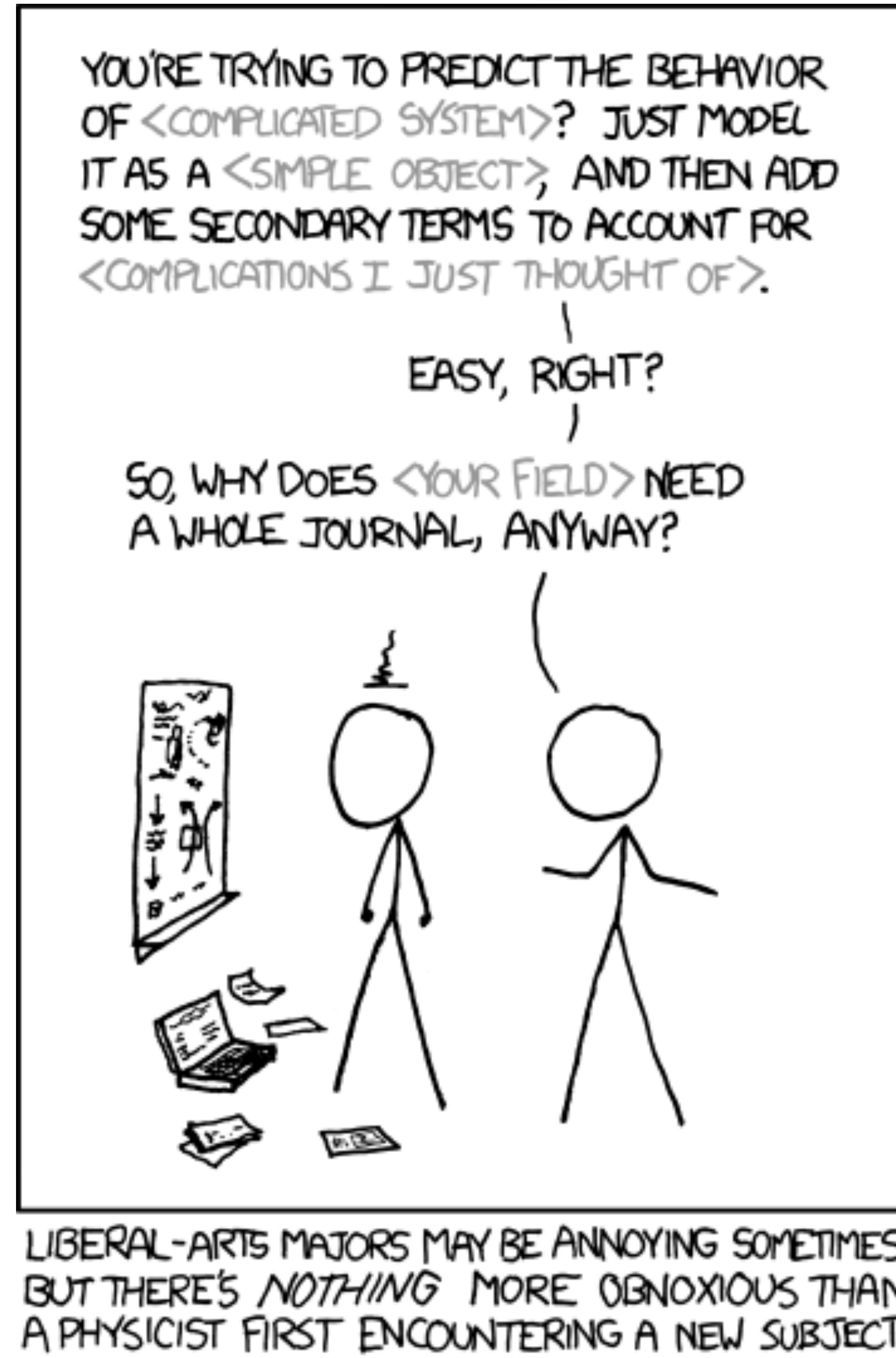
Formal Theory in the Inexact Sciences

Exact sciences: theories involve direct mapping between measurable constructs and model predictions.

Inexact sciences: mapping between measures and theories are imprecise.

This creates a challenge for theory in the inexact sciences, and widespread preference for empirical (heuristic, verbal) models rather than formal models.

The social sciences are inexact.



Griesemer J (2013) Formalization and the meaning of "theory" in the inexact biological sciences. *Biol Theory* 7:298–310.

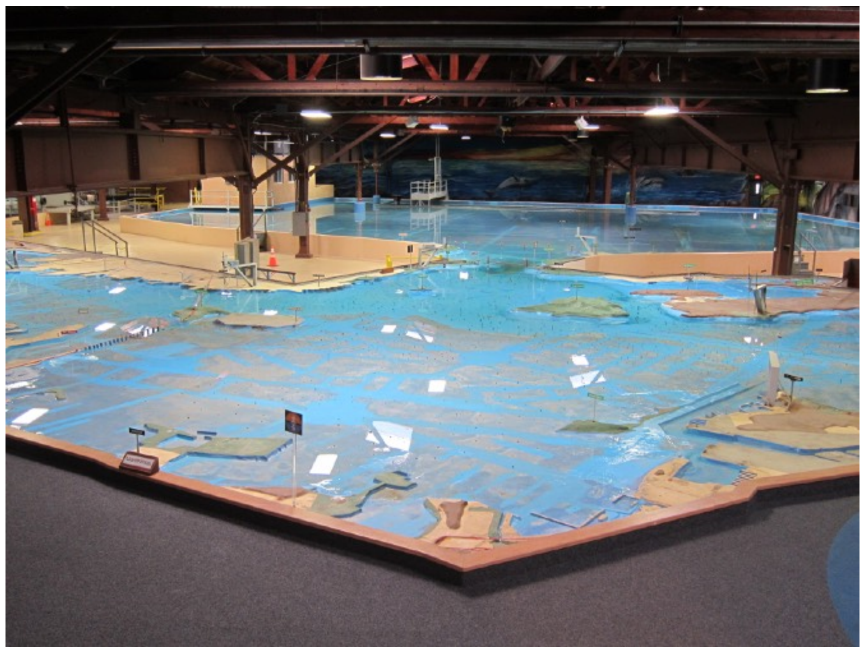
xkcd

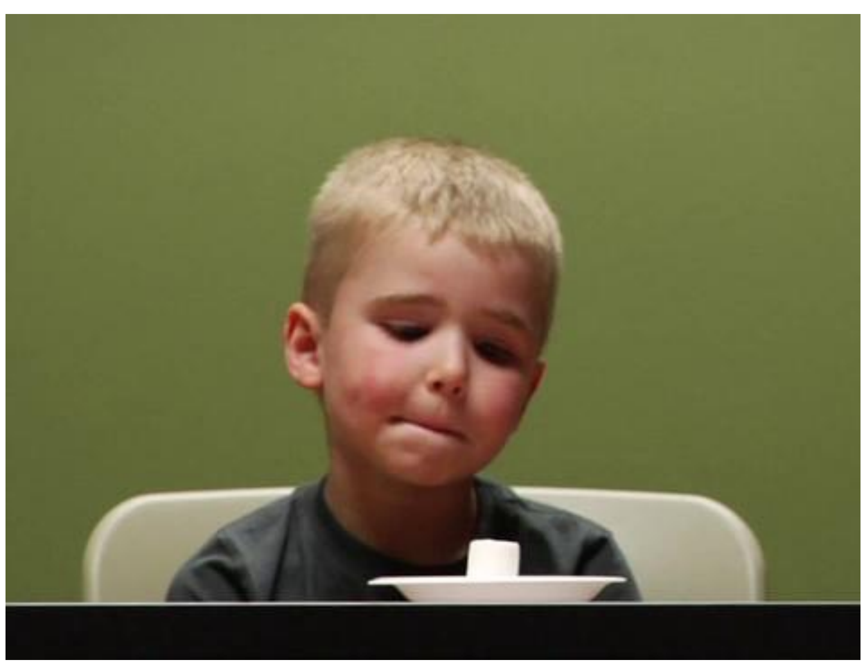
Formal models still get you a lot

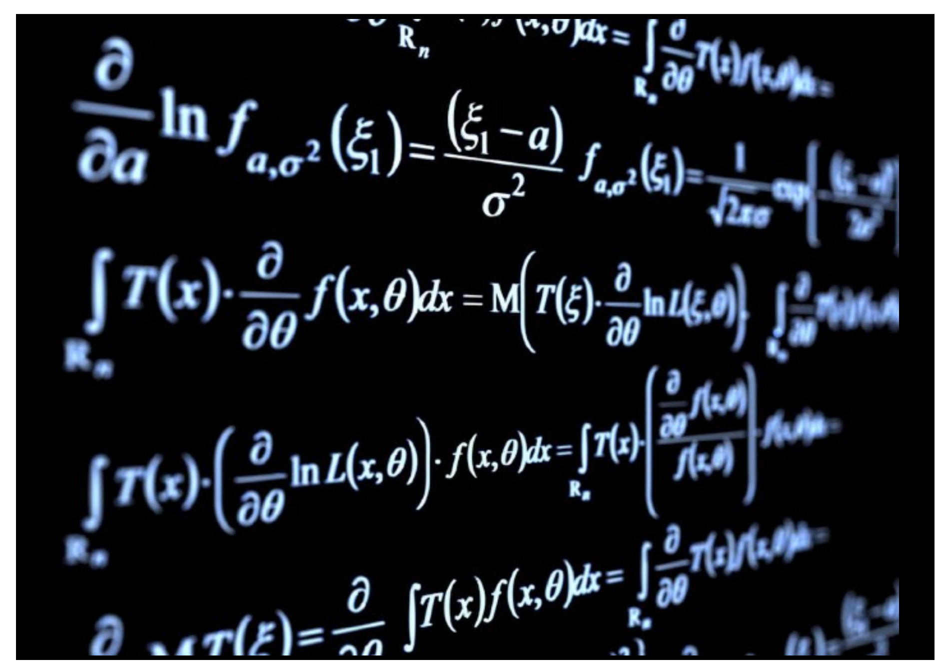
- Clear articulation of what is and isn't included in theory
- Formal analysis of assumptions and the consequences that arise from them
- Qualitative predictions with clear scope
- Mental models for understanding the dynamics of relevant complex adaptive systems
- Common language for talking about those systems

Smaldino PE (2017) Models are stupid, and we need more of them. In *Computational social psychology.* Routledge.

Models are structures (abstract or physical) that can potentially represent real-world phenomena.



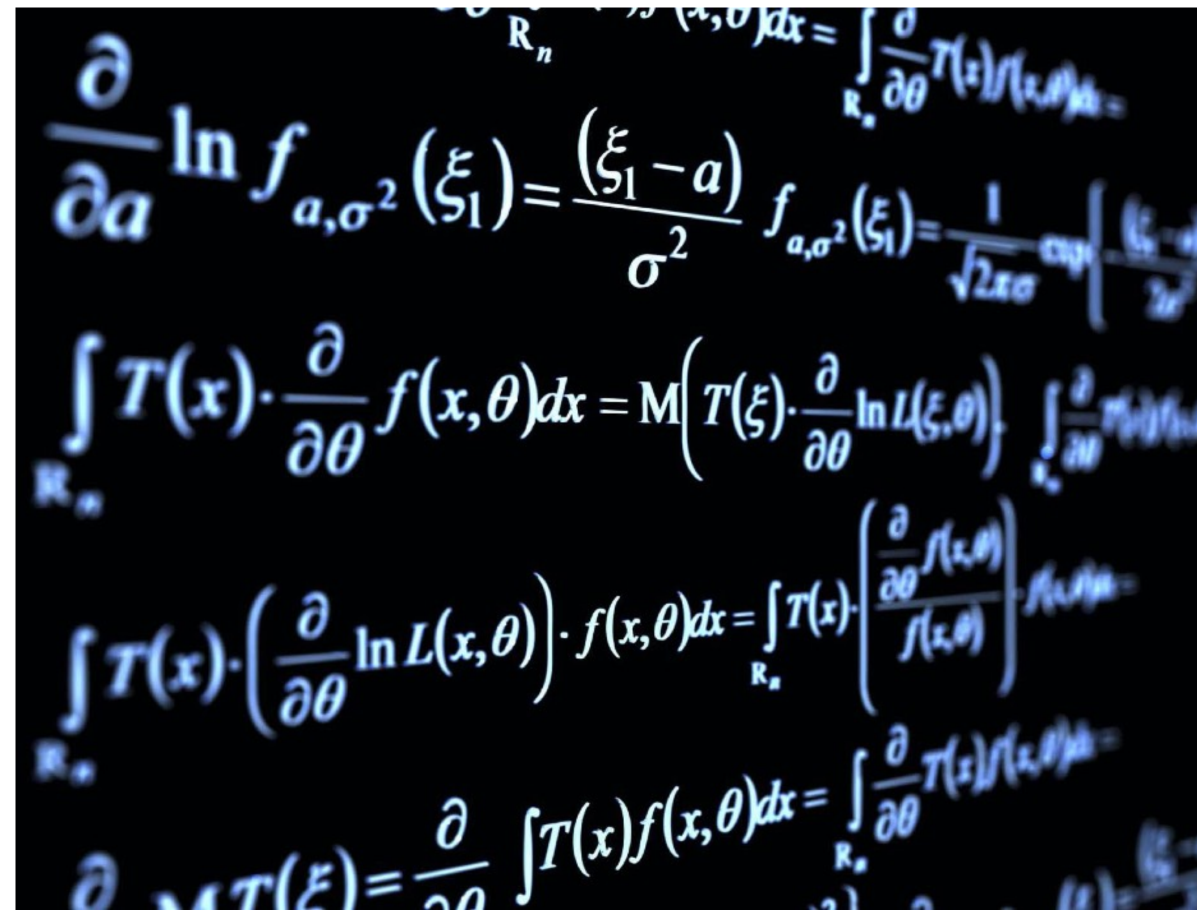




Weisberg M (2013) *Simulation and similarity: Using models to understand the world*. Oxford University Press.

Formal models

- A simplified version of a system with a specification of parts and relationships between them
- A logical engine for turning assumptions into conclusions



We want to understand the behavior of some system. **We first have to articulate that system.**

Decomposition: What are the parts? What are their properties? What are the relationships between the parts? How do those properties and relationships change?

The decomposition depends on the questions you are trying to answer. There is no one right way.

However, some **canonical decompositions** can help to drive theory forward and encourage communication and collaboration.

♫ BREAK IT DOWN ♫

Smaldino PE (2020) How to translate a verbal theory into a formal model. *Social Psychology* 51: 207–218.

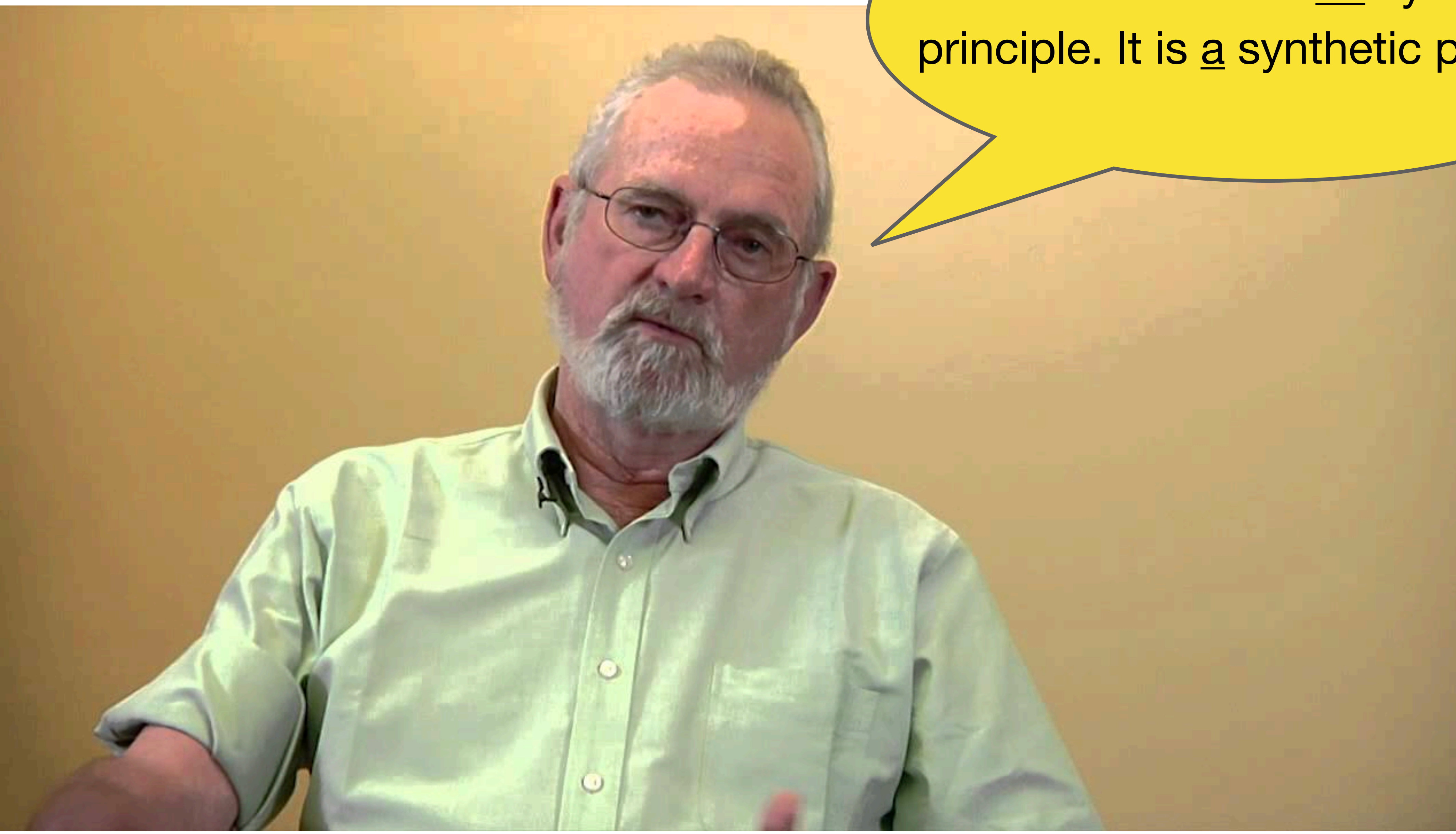
Most social science students often receive little-to-no training in modeling

Exceptions are economics (rarely dynamic) and cognitive science (rarely population-level)

Sometimes training in game theory and agent-based modeling (often atheoretical)

Existing modeling pedagogies are useful, but not designed with a cultural evolutionary framework in mind

Mostly from biology (rarely geared toward cultural/social systems) or complexity science (often focused on "emergence," weak on theoretical motivations)



Evolution is not the synthetic principle. It is a synthetic principle.

We need to go beyond (just) evolutionary modeling to understand social processes. Integrating the social sciences requires a new pedagogy of modeling.

Long-run goal: A core modeling pedagogy for understanding human social behavior

Challenge: Human behavior is too varied and idiosyncratic to distill a core

Solution: Focus on universal and central features of human existence

Challenge: Lack of deep mathematical training among social scientists and humanities scholars

Long-run solution: Better training for social scientists in math and computing

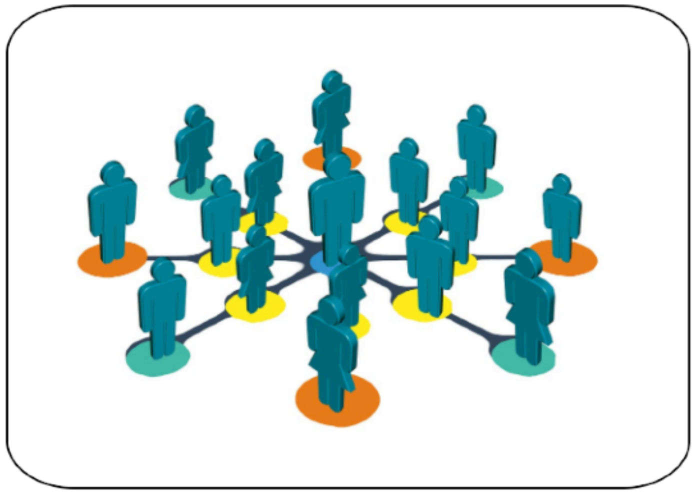
Short-run solution: Focus on simple models that require minimal formal training

THE CULTURAL EVOLUTION SOCIETY'S ONLINE LEARNING SERIES

Home | Lectures | Readings | Designer

CES Online Learning Tutorials

Models of Social Dynamics: An Introductory Module



Welcome to this short course on models of social dynamics.

Understanding complex dynamics in social, ecological, and evolutionary systems is challenging. Verbal models are often ambiguous, and statistical models rarely establish causal origins for phenomena of interest. In contrast, formal mathematical and computational models can help us to form intuitions and develop generative theories about the behaviors of complex social systems. This short course takes an interdisciplinary approach to modeling social behavior, drawing on insights from across the social sciences as well as from evolutionary ecology.

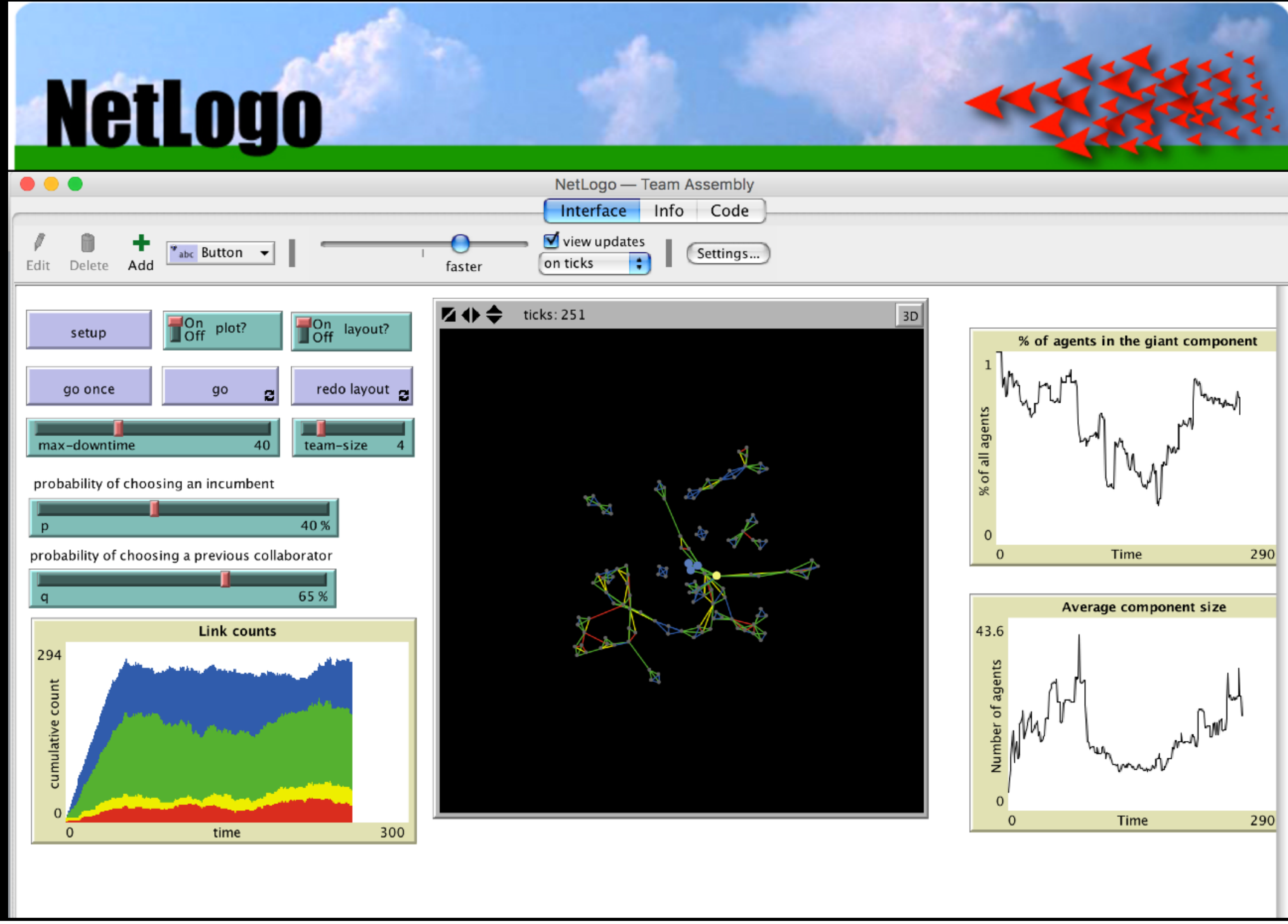
This course is about formal models: mathematical and computational models of complex processes. More specifically, in this module we'll focus on relatively simple computational models that even those without heavy math or programming backgrounds should be able to get off the ground relatively painlessly. Formal models can help us communicate ideas unambiguously, and they provide us with a toolkit with which we are better able to form intuitions and develop generative theories about the behaviors of complex social systems.

The material for this course is inherently interdisciplinary. We will cover models on topics that should be of interest to almost anyone who studies social behavior. After the introductory unit, each of the next five units will focus on a broad topic and some simple but illuminating models, constructing and analyzing simulations using the NetLogo programming language. Key topics include contagion, opinion dynamics, cooperation, norms, and sociopolitical cycles. A lecture script, slides and references are provided with each unit. NetLogo code and exercises are provided for the five modeling units.

Module Designer

Paul E. Smaldino, Cognitive and Information Sciences, University of California, Merced

http://www.dysoc.org/cesmodules/social_dynamics_module/



Pros

- Free and open source
- Widely used
- Lots of built-in features
- Low bar to entry, but still powerful (“low threshold, no ceiling”)

Cons

- Can be slow for complex models
- Built-in features can be overly constraining
- Reduced control

Models of Social Dynamics

Lecture Units

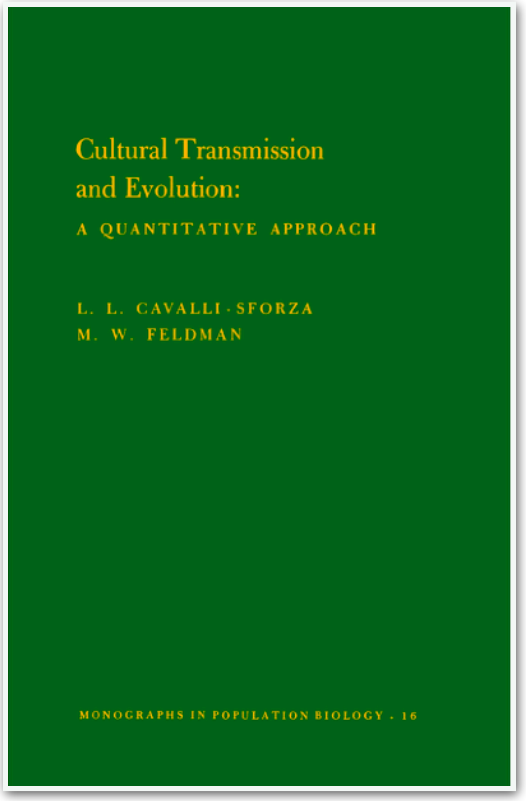
Unit 1: Introduction	This introductory unit discusses what models are and how they are useful, and provides a brief introduction to the NetLogo programming language and how we will use it to explore agent-based models. We conclude with an outline of the course.
Unit 2: Contagion	Diseases, information, behaviors, and technologies spread from one person to another - this is contagion. In this unit we explore models of adoption by both individual exploration and social influence.
Unit 3: Opinions and Polarization	In this unit, we'll use models to explore how our assumptions about social influence affect the long-run distribution of opinions in a population. The greater the extent to which people are influenced only by those who are similar to themselves, the more distinct communities will form. If we also seek to distance ourselves from those with whom we disagree, the result can be polarization and extremism.
Unit 4: Cooperation	There are obvious benefits to helping one another and working together. However, in a world of altruists, those that free ride can reap the benefit without paying the cost. How can cooperation emerge in a population? Once present, how can it be maintained? This unit tackles these questions and also introduces the logic of evolutionary modeling.
Unit 5: Coordination and Norms	Understanding one another's intentions, norms, and goals is critical for effective cooperation. In this unit we'll explore how coordinating norms emerge in a population, and the challenges faced in spreading group-beneficial norms when they are initially rare.
Unit 6: Sociopolitical Cycles	Most of the social systems we've modeled thus far evolve toward a stable equilibrium. Yet much of life is cyclical and never reaches a steady state. In this last modeling unit, we explore two models that allow for cyclical behavior: a spatial host-pathogen model and the metaethnic frontier model of empires.
Unit 7: Coda	In this final unit, we review the key principles that form the basis for understanding human social organization and cultural evolution, recap lessons from each of the previous modeling units, and discuss more advanced topics, including analyzing agent-based models, mathematical proofs, and the relationship between models and empirical data.

Each unit includes a video lecture, slides, notes, code, and exercises for independent study

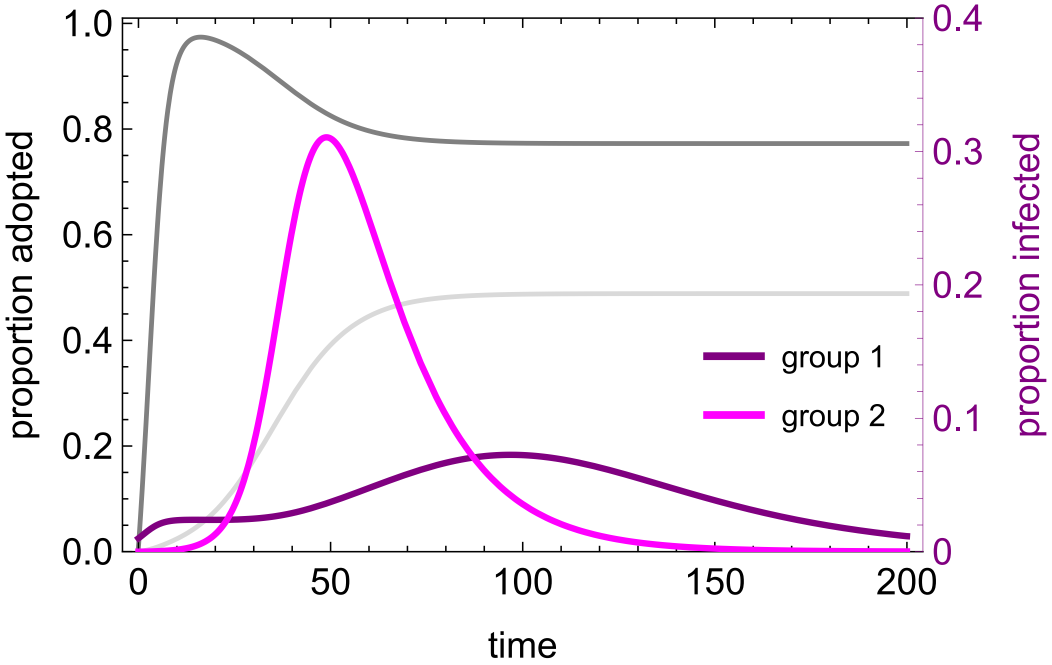
Contagion

Another biological model may offer a more satisfactory interpretation of the diffusion of innovations [than those derived from population genetics]. **The model is that of an epidemic.**

–Cavalli-Sforza & Feldman (1981) *Cultural transmission and evolution: A quantitative approach.*



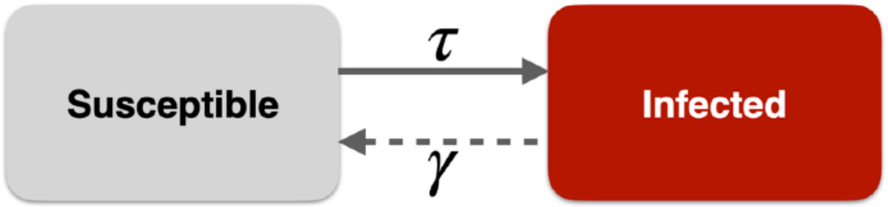
- Contagion models help to understand how ideas, behaviors, and innovations spread, as well as diseases.
- These dynamics can also be **coupled**, as socially learned behaviors affect disease infection.

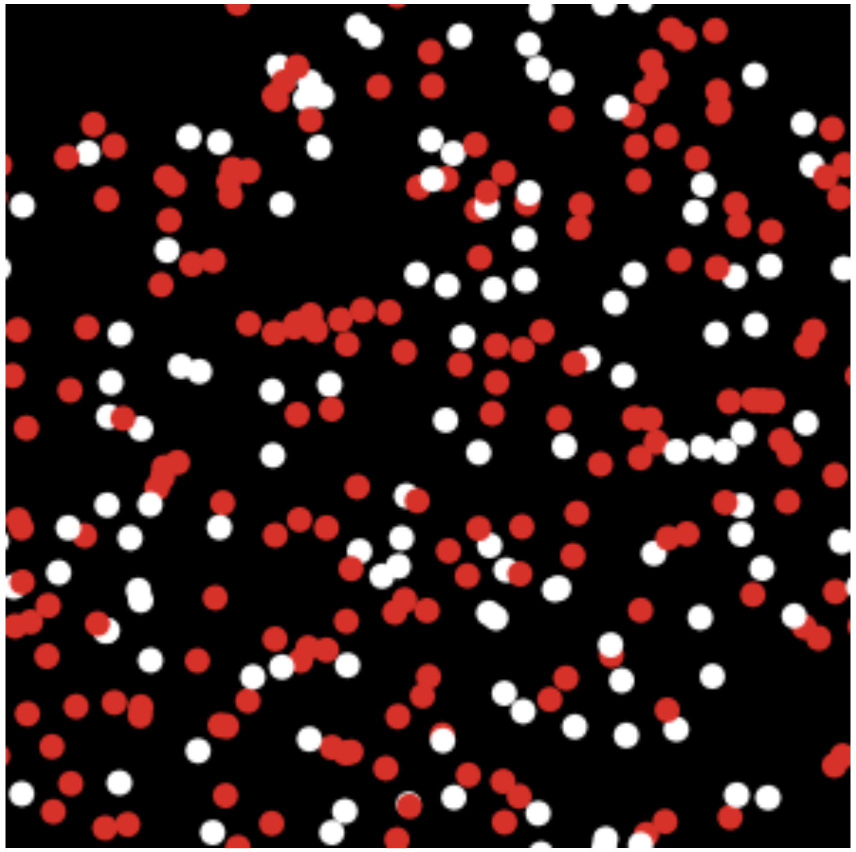


Smaldino PE, Jones JH (2020) Coupled dynamics of behavior and disease contagion among antagonistic groups. *bioRxiv* 2020.06.17.157511

Unit 2: Contagion

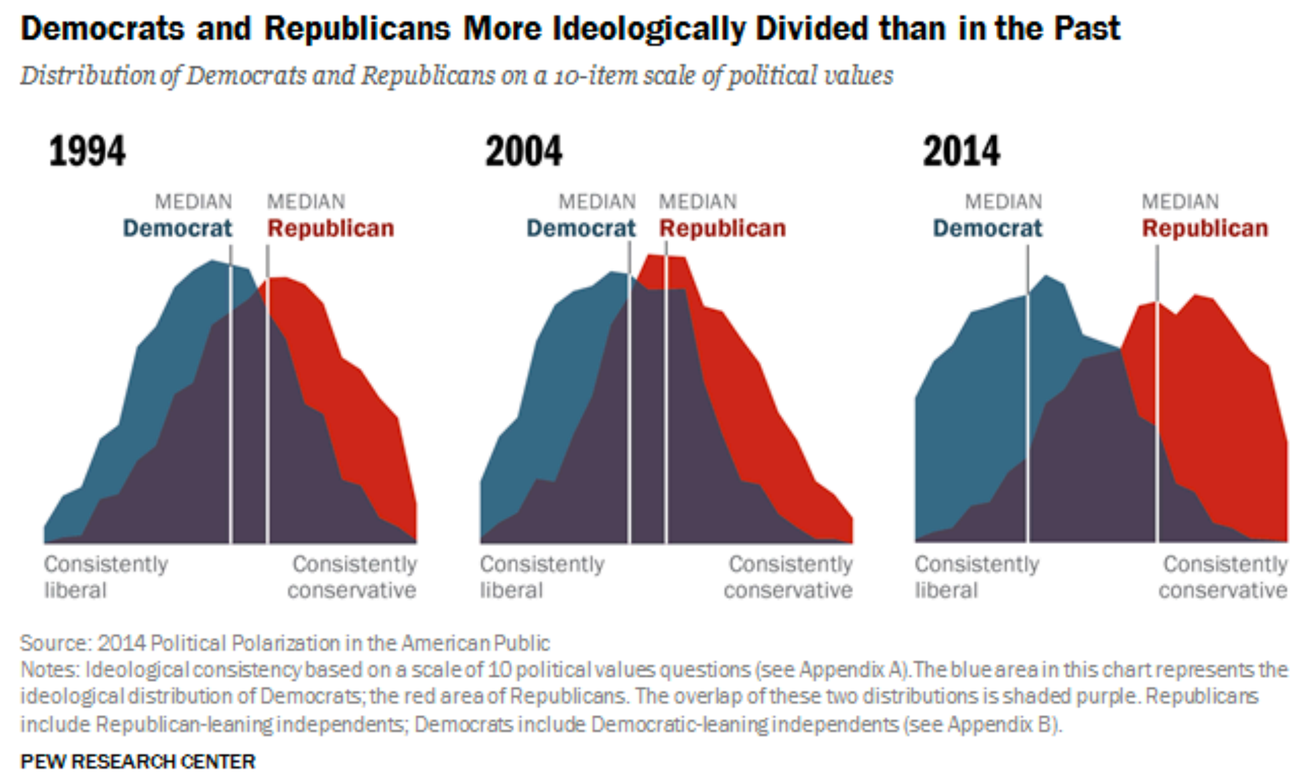
- Study SI and SIS models of contagion with mobile agents
- Consider how the time course of adoption for a disease, technology, or behavior depends on how it is socially transmitted.





Opinions and Polarization

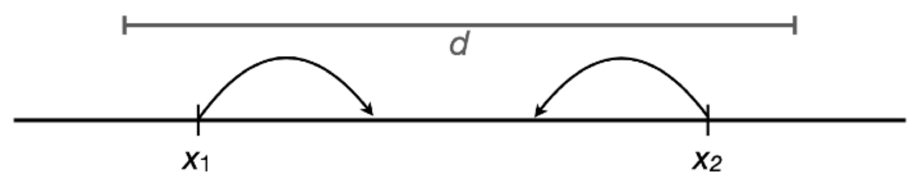
- Polarization is a defining issue of our times.
- Models force us to consider how individuals communicate and internalize opinions and beliefs.
- How do opinions change? How does polarization arise? Is there anything we can do about it?
- Prior work suggests that our assumptions about the details matter a lot.

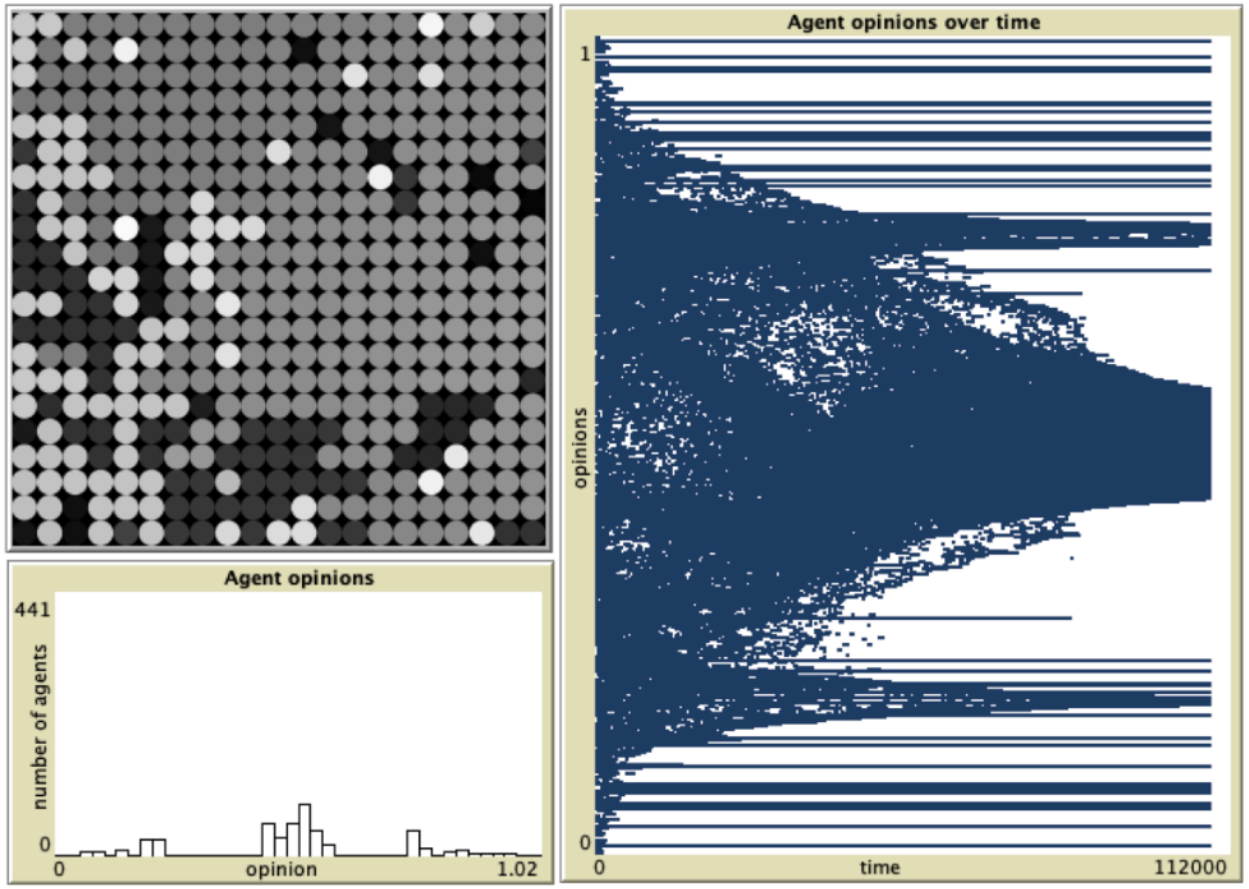


Unit 3: Opinions and Polarization

- Study simple models of opinions with positive and negative influence
- Consider how the way people are influenced by similar and different opinions shapes the emergence of distinct cultural communities
- Consider the influence of simple network structures on social dynamics

$$x_1 \leftarrow x_1 + k(x_2 - x1)$$
$$x_2 \leftarrow x_2 + k(x_1 - x2)$$





Cooperation

Each year 1.6 billion passengers fly to destinations around the world. Patiently we line up to be checked and patted down by someone we've never seen before. We file on board an aluminum cylinder and cram out bodies into narrow seats, elbow to elbow, accommodating one another for as long as the flight takes. …

I cannot keep from wondering what would happen if my fellow human passengers suddenly morphed into another species of ape. **What would happen if I were traveling with a planeload of chimpanzees?** Any one of us would be lucky to disembark with all ten fingers and toes still attached, with the baby still breathing and unmaimed. Bloody earlobes and other appendages would litter the aisles.

– Hrdy SB (2009) *Mothers and others: The evolutionary origins of mutual understanding.*

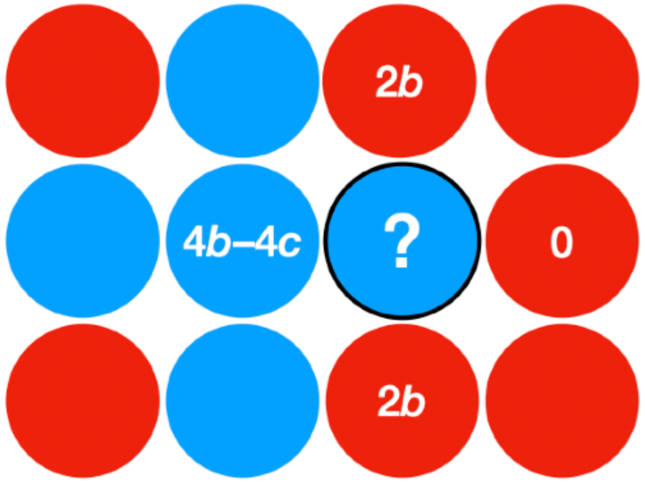
- Cooperation—providing mutual benefit at a person cost—is a bedrock of human behavior.
- Understanding the conditions for how cooperation arises, stabilizes, and fails is an essential task for a science of social behavior.
- Modeling also provides an opportunity to consider how behaviors and patterns of interactions coevolve.

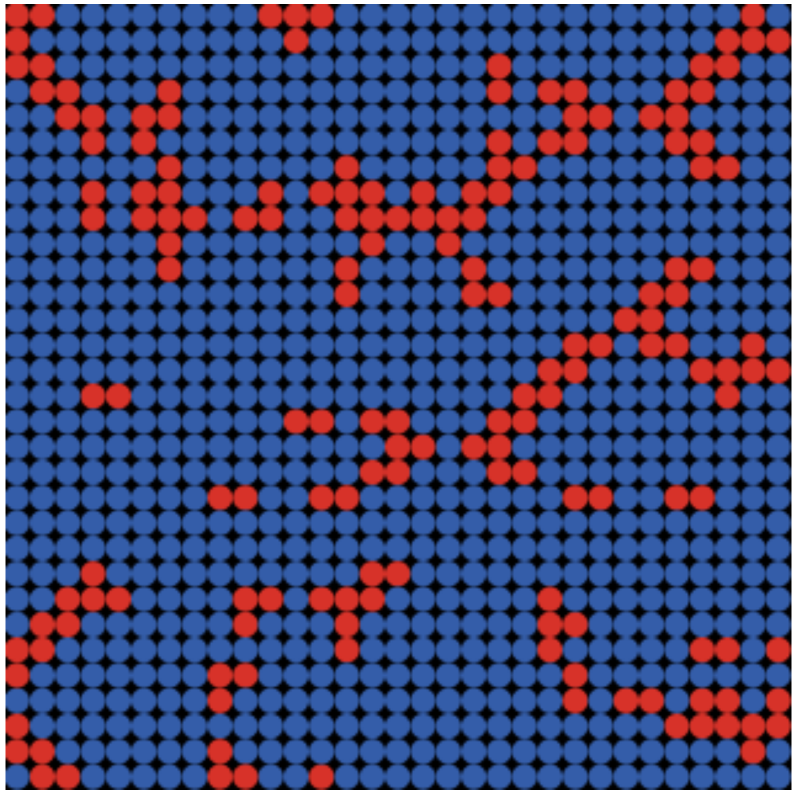
Unit 4: Cooperation

- Study cooperation and reciprocity using the frameworks of the prisoner's dilemma and evolutionary game theory

- Consider how assortment among behavioral types influences the evolution of cooperative strategies

- Consider why a savvy reciprocating strategy can evolve where naïve cooperators cannot





Coordination and Norms

- Norms, not rational calculations of optimal outcomes, guide much of our behavior in social settings.

- Often arbitrary, norms allow communities to coordinate and thereby cooperate more effectively.

- Some norms are obviously better than others, but a population that enforces current norms may resist. How do norms change in such settings?

- Related question: How do diverse populations signal norms to potential partners?

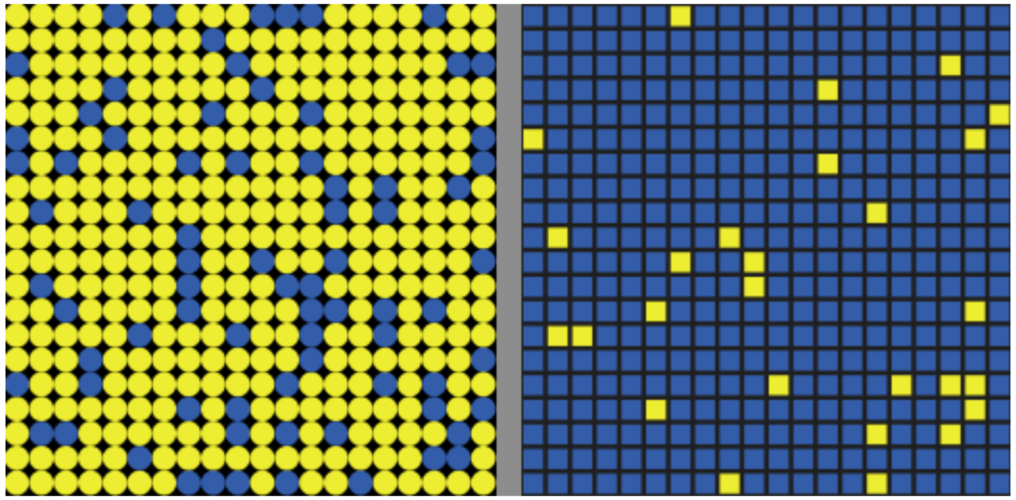
Unit 5: Coordination and Norms

- Study the evolution of norms using the framework of a coordination game

- Consider how group-beneficial norms can fail to spread when rare

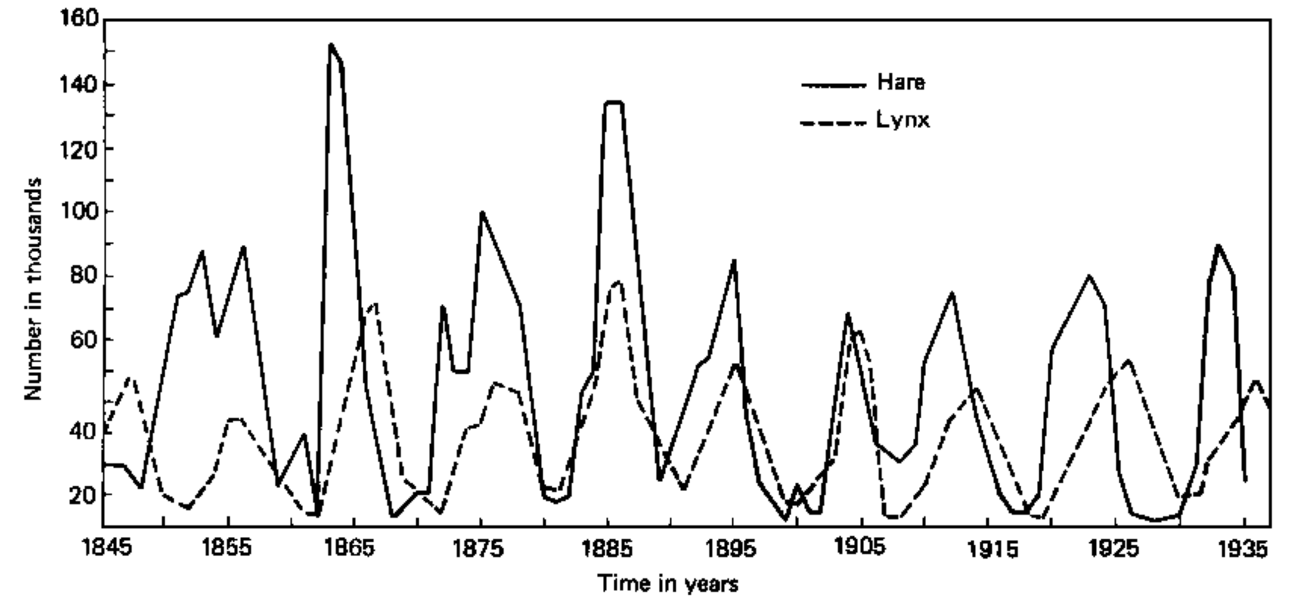
- Consider how interaction between largely separate communities can facilitate the spread of group-beneficial norms

Player 1 \ Player 2	Norm 1	Norm 2
Norm 1	$1+\delta+g$	$1-h$
Norm 2	$1+g$	1

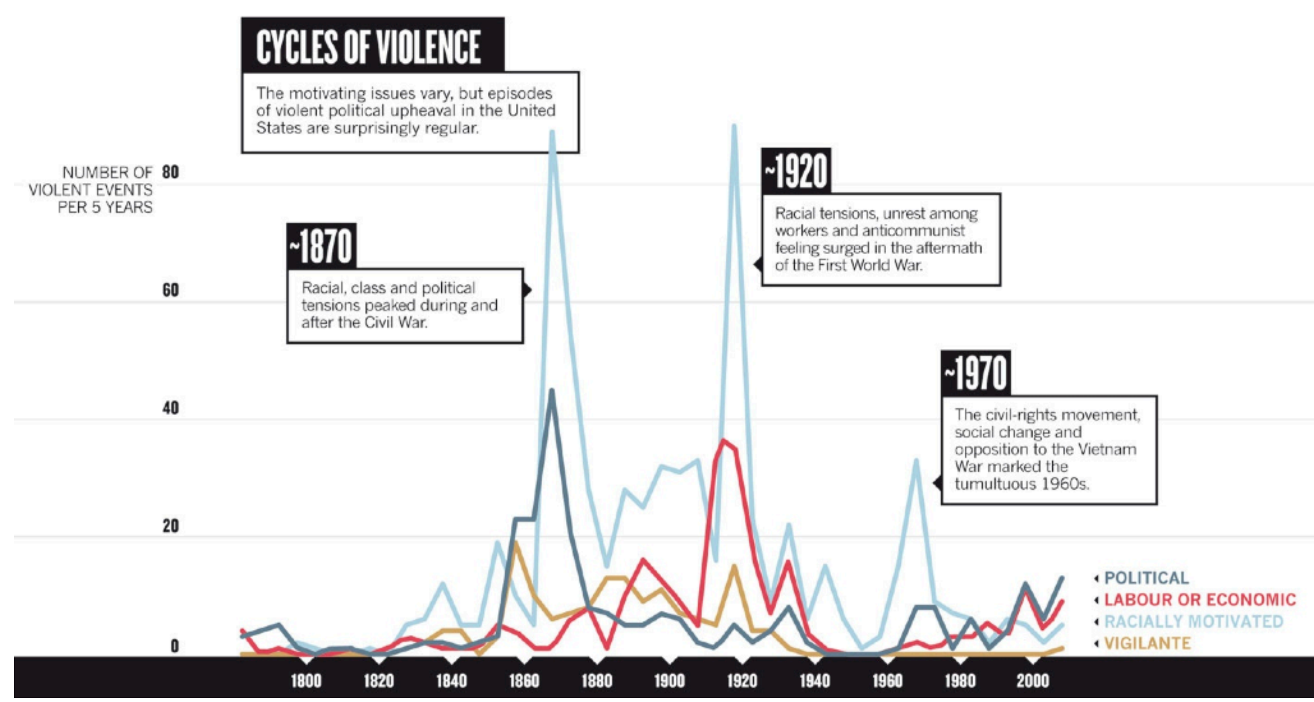


Cycles

- Many social phenomena don't settle to an equilibrium, but are cyclical.
- Understanding the dynamics causally coupled quantities is therefore important for understanding social processes.
- Examples range from predator-prey relations to the dynamics of political instability and the rise and fall of empires.



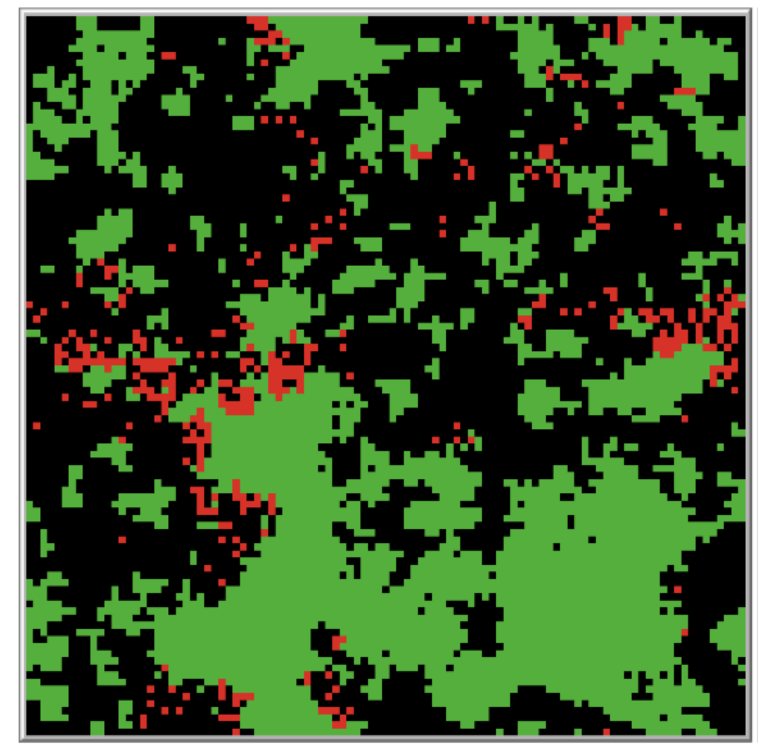
Elton CS (1924) Periodic fluctuations in the numbers of animals: Their causes and effects. *J. Exp. Biol.* 2: 119–163.

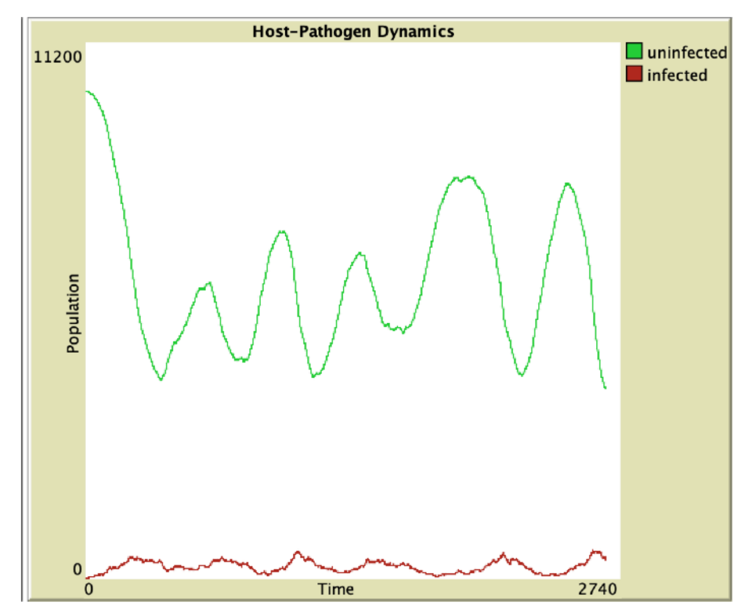


Turchin P (2012) Dynamics of political instability in the United States, 1780–2010. *J. Peace Res.* 49: 577–591.

Unit 6: Cycles

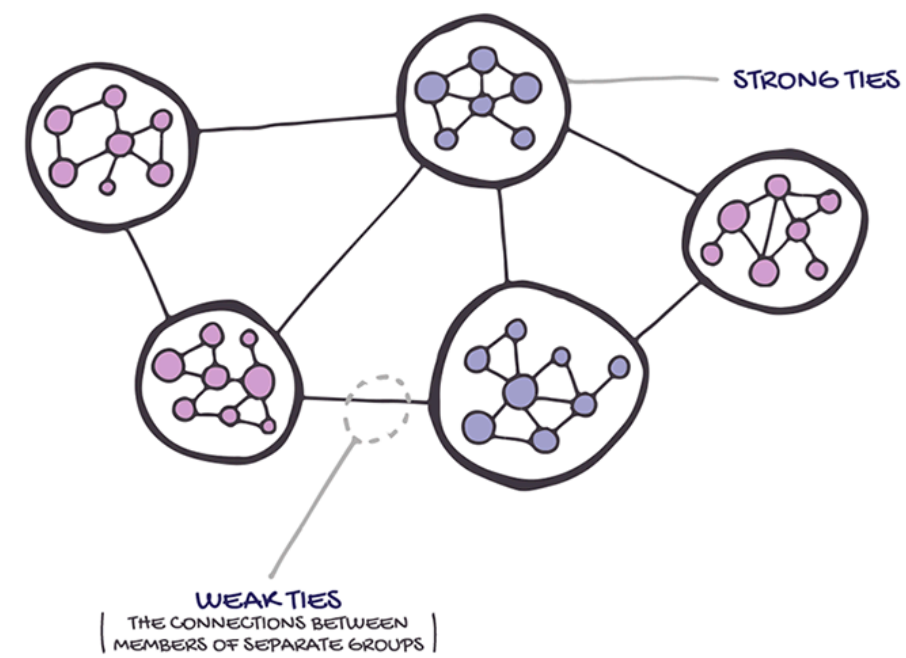
- Study the cyclical dynamics of the ecological host-parasite model
- Study Turchin's metaethnic frontier models of how empires rise and fall
- Consider how something that spreads rapidly when rare but becomes weakened by its own growth provides the foundation for cyclical dynamics
- Consider how factors that limit growth may benefit an organism or society in the long run





Moving forward, broadly

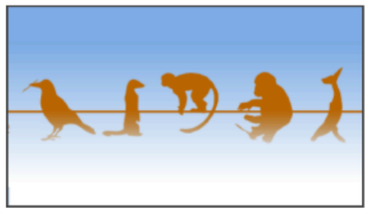
- **Overarching goal**: create better integration among the human sciences
- **Not the goal**: getting rid of separate disciplines. There are benefits for having separate epistemic communities (Lazer & Friedman 2007, Derex & Boyd 2016, Smaldino & O'Connor in prep)
- But, we need communication between these disciplines as well! (All these models suggest that some communication is optimal). **Cultural evolution provides a framework for talking to each other.**
- We also need a set of **core models** from which to develop theories of human behavior.
- I'm not saying that these are THE models, but centering this core around universal features of human social existence— **cooperation, coordination, and communication**—seems reasonable.



Moving forward, narrowly

Models of Social Dynamics: An Introductory Module

This module takes an interdisciplinary approach to modeling social behavior, drawing on insights from across the social sciences and evolutionary ecology. It focuses on constructing and analyzing simulations using the NetLogo programming language.



Animal Cultures: Core Discoveries and New Horizons

This module offers an overview of core discoveries and new developments in the study of animal cultures. The significance of animal culture for evolutionary biology and ecology, understanding human cultural evolution, and conservation are highlighted.

The Neverending Story: Cultural Evolution and Narratives

This module explores the universal and uniquely human behavior of narrative and how cultural evolution theory has provided vital insights into the transmission and evolution of narratives and why some become culturally successful.

Foundations of Cultural Evolution

An introductory guide to the body of formal theory in the study of the cultural evolution in humans and other animals, this module guides participants through the basic machinery of dynamic models and key results from a variety of cultural evolution topics.

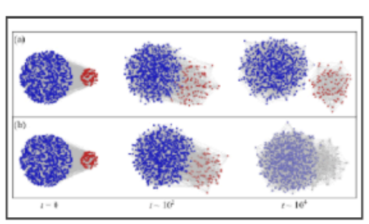
Modeling the Dynamics of Cultural Diversification

This module trains researchers in a model-based Bayesian framework that allows them to estimate rates of cultural change, distinguish stochastic fluctuations from actual rate changes, and identify when major events, trends, or evolutionary mechanisms shaped the history of a cultural population.

Coming soon!

Dynamic Models of Human Systems

This primarily non-mathematical introduction to dynamic models of human ecosystems describes Lotka-Volterra models of early hunter-gatherers, farming communities, agrarian civilizations, and runaway technical civilizations. Related models of socio-political dynamics, economic growth, and epidemiology are also presented.

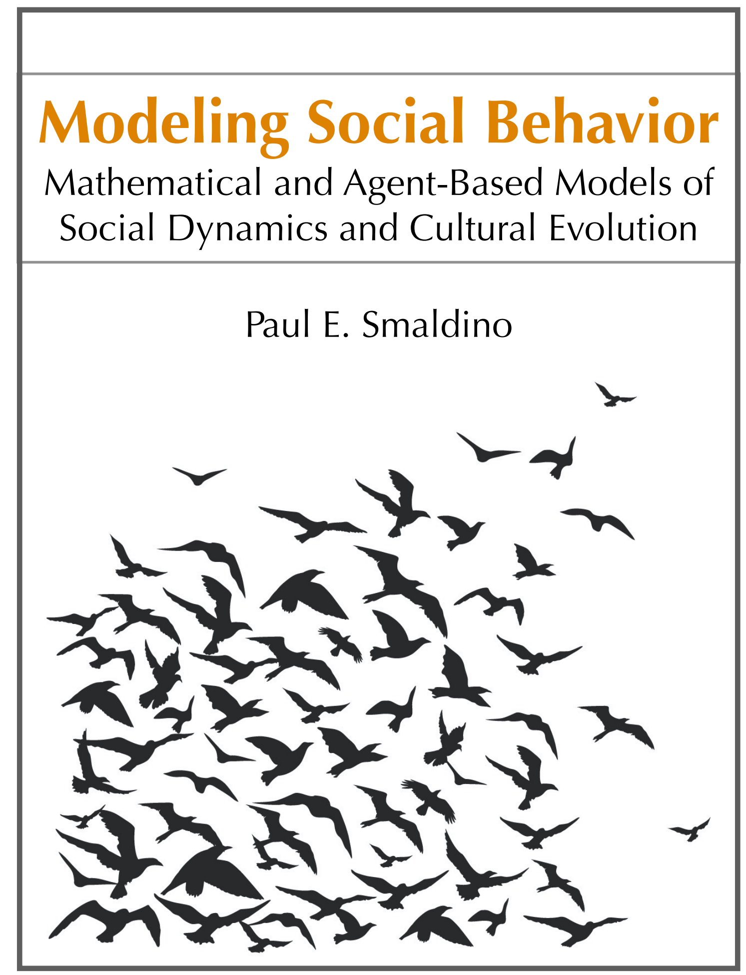


Coming soon!

Cultural Evolution of Dynamic Learning

In order to better understand the complex interplay between culture and social network structure, this module introduces participants to the concept of cultural learning algorithms, fixed and dynamic social networks, and how to model the two components together.

Coming Soon(ish)



Thanks!

twitter: @psmaldino
web: http://smaldino.com
email: psmaldino@ucmerced.edu