This course uses complexity science to bridge between old and new conceptions of social science. Newtonian science, neoclassical economics, and existing social sciences, in general, all build on the assumptions:

1. That all the basic “agents” comprising phenomena (atomic particles, atoms, molecules, organisms, people, groups, firms, etc.) are “homogeneous” and that the behavior of one is “independent” of the behavior of the others; and
2. Go forward in time under equilibrium conditions (interspersed with occasional, short-term disequilibrium periods).

None of these assumptions hold for most of human behavior in social settings. So, what to do to do good science?

“New” Economics, “New” Management, “New” Social Science, Complexity Science, and Agent-based Models posit that order-creation is the dominant condition of social systems and that order-creation is the outcome of interactions among autonomous heterogeneous agents. In New Science, equilibrium conditions are not things to be assumed but rather to be marveled at and studied if, when, and where they occur. New Science (mostly complexity science) simply accepts agents as stochastically idiosyncratic and then asks how and why macro structures emerge.

Complexity science focuses on “order-creation” rather than the “order-translation” process underlying the 1st Law of Thermodynamics (energy conservation), and replaces the 19th century mathematics of neoclassical economics, management, and social science with agent-based computational models (ABMs). Since order-creation is a more characteristic aspect of social phenomena than order-translation, it follows that New Science ABMs map onto social phenomena better than math models styled after classical physics and now dominating neoclassical economics. After all, People are the Brownian motion! The key question becomes, How to research social systems as complex adaptive systems, in which agents and emergent structures coevolve in the context of pressures from ever changing environmental contexts?

New Science is often called “rule-based science” or “bottom-up science.” The idea is to explain the emergence of macro social phenomena—such as networks, groups, organizations, and larger structures—by taking extant theories and translating them into the “rules” that autonomous heterogeneous agents have to be following in order for such structures to emerge. Furthermore, agents (people) adaptively learn and coevolve with other learning agents and higher-level social structures—both upward and downward causality involved. Some of the research questions are:

1. What are the active agent rules?
2. Why do agents follow some rules and not others?
3. How and when do agents’ rules change?
4. What kinds of emergent social phenomena arise from interacting and learning agents?
5. What role do contextual energy differentials (adaptive tension) play in motivating agent behaviors?
6. How to “manage” agents and get them to produce more economically viable teams, new product developments, entrepreneurial ventures, and generally, more effective socioeconomic and/or organizational (complex adaptive) systems?

Complexity scientists use agent-based models—often termed “adaptive learning models” to

1. Meet the model-centered epistemology of modern philosophy of science;
2. Model social phenomena without the warping homogeneity, independence, and equilibrium assumptions inherent in math models; and
3. Run computational experiments over time to more fully understand the interactions of nonlinearly related variables (rather than simply linearizing them) related to self-organizing phenomena.

Modern computers allow the use of increasingly sophisticated agent-based adaptive-learning models such as cellular automata, genetic algorithms, and neural networks. These offer methods of studying how macro structures emerge from the interactions of stochastically idiosyncratic, learning, agents. They are the methods of choice of many complexity scientists. Since people are the Brownian motion in social systems, it is surely ironic that the use of these models in the social sciences considerably lags their use in the physical and life sciences. A couple of years ago there were over 200 more cites per journal in natural science than in sociology. This course introduces you to the logic of agent-based theorizing, the different kinds of model platforms, and gets you started in the process of developing the agent “simple rules” that allow one to translate from old to new ways of modeling social phenomena.
✓ Open to All, BUT, Designed like an “Honors” Undergrad Course
✓ Grades are based on a Term Paper:
✓ For each week, key readings identified by the ➔. Where there are two ➔➔s, the first book is my first choice, but you may prefer the second one. Reading either one is ok with me. Other readings listed each week offer a more focused set of optional additional readings for the student particularly interested in that week’s topic.
✓ The syllabus provides a broad overarching framework within which each student may develop a more idiosyncratic learning experience particularly suited to his/her preferred social science.
✓ Additional, more general, reading lists are available.

A CHALLENGE
If you would like to read ONE—very challenging book—instead of several, you are welcome to buy and read:
Thinking in Complexity (Klaus Mainzer, 1994/2004).
This is my favorite book. BUT, you probably should have a background in physics or biology or computer science before taking up this challenge!! Or a lot of nerve!
# 1. BASIC COMPLEXITY SCIENCE

**Topics:**
- Natural Science Origins
- Kinds of Complexity
- The Region of Emergence
- External Energy Impositions, Thermodynamics, and Emergent Dissipative Structures
- European School

**Readings:**
- *Dynamic Patterns: Self-Organization of Brain and Behavior* (Scott Kelso, 1995).
- *Complexification* (John Casti, 1994).
- *Dynamic Patterns: Self-Organization of Brain and Behavior* (Scott Kelso, 1995).
- *Complexification* (John Casti, 1994).


# 2. ORDER-CREATION SCIENCE APPLIED to SOCIAL PHENOMENA

**Topics:**
- Order-Creation at Different Levels of Analysis: Matter—Life—Brain—Artificial Intelligence—Social Systems
- From Chaos to Complexity Theory: From Equations to Agents
- Intrasytem Order-creation Dynamics: “Butterfly” Effects, Positive Feedback, Emergence
- Independence vs. Interdependence
- American School

**Readings:**
- *At Home in the Universe* (Stewart Kauffman, 1995).
- *Out of Control* (Kevin Kelly, 1994).

3. DYNAMICS OF COEVOLVING ECONOMIC ADAPTIVE SYSTEMS

Topics:
Orthodox and Evolutionary Economics: A Critique
Economies as Complex Adaptive Systems
Economists’ Assumptions—Assuming Away What Is Interesting So the Math Works!!
Pareto Distributions, Power Laws, and Scale-free Theory

Readings:

- The Self-Organizing Economy (Paul Krugman, 1996).
- Agent-Based Computer Simulation of Dichotomous Economic Growth (Roger McCain, 2000).
- Computable Economics (Kumaraswamy Velupillai, 2000).
- The Economy as an Evolving Complex System II (B. Arthur, S. Durlauf, D. Lane, eds., 1997). (ADL)
- The Death of Economics (Paul Ormerod, 1994).
- Chaotic Economic Dynamics. (Richard Goodwin, 1990)
- Economic Complexity. (William Barnett, John Geweke, & Karl Schell, eds. 1989)

4. ORGANIZATION, STRATEGY AND MANAGING COMPLEXITY DYNAMICS

Topics:
Kauffman’s “Complexity Catastrophe”
Organization and Strategy Analysis
Details of the NK Model and NK Applications
Managing Complexity, Positive Feedback, and Coevolutionary Dynamics

Readings:

- Surfing the Edge of Chaos (Richard Pascale, Mark Millemann and Linda Gioja, 2000).
- The Complexity Advantage (Susanne Kelly and Mary Allison, 1998).
- [Dynamics of Organizations (Alessandro Lomi and Erik Larsen, 2001)].
- Managing Complexity (Robin Wood, 2000)
- Learning and Innovation in Organizations and Economies (Bart Nootboom, 2000).
- Systemic Choices: Nonlinear Dynamics and Practical Management (Gregory A. Daneke, 1999).
- Chaos, Catastrophe, and Human Affairs (Stephen Guastello, 1995).
- Networks In and Around Organizations (Steven Andrews and David Knoke, eds., 1999).
- The Unshackled Organization (Jeff Goldstein, 1994).
5. **BOTTOM-UP SCIENCE—THINKING LIKE AN AGENT**

**Topics:**
- Order-Creation continued
- Agent-Based, Bottom-Up Science
- Growing an Artificial Economy
- Growing Cities
- Modeling Stock Markets

**Readings:**

- *Growing Artificial Societies* (Joshua Epstein & Robert Axtell, 1996)


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6. **SIMULATION AND SCIENCE:**

**Topics:**
- Overall View of Agent-Based Computational Modeling
- Kauffman’s NK Model
- Cellular Automata
- Detailing the NK Model

**Readings:**

- *Connectionist Models of Social Reasoning and Social Behavior* (Stephen Read and Lynn Miller, eds. 1998).

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7. **JOHN HOLLAND AND OTHER “HOW TO DO IT” TEXTBOOKS**

**Topics:**
- Model Platforms
- Genetic Algorithms
- Neural Networks
- Pattern Finding vs. Experiments
- Detailing a GA

**Readings:**


*Multi-Agent Systems* (Jacques Ferber, 1999).

*Simulation for the Social Scientist* (Nigel Gilbert and Klaus Troitzsch, 1999).


8. **MODEL-CENTERED SOCIAL SCIENCE**

**Topics:**
- Role of Models in Science
- Models as Mediators
- Model-centered Science
- Math vs. Agent-based Models
- Agent models as "models" and "experiments"

**Readings:**
- [Models as Mediators](MM) (Mary Morgan and Margaret Morrison, eds., 2000)—Source, but don’t read

9. **EPISTEMOLOGY and PHENOMENA OF ORDER-CREATION SCIENCE**

**Topics:**
- Science vs. Postmodernism
- Relation between Postmodernism and Complexity Science Ontologies
- Force-based vs. Rule-based Science
- Aristotelian Causality

**Readings:**
- *The Philosophy of Artificial Life* (Margaret Boden, 1996).

10. **PHILOSOPHICAL FOUNDATIONS of ‘NEW’ BOTTOM-UP SOCIAL SCIENCE**

**Topics:**
- Recent Trends in Philosophy of Science
- Legitimacy of Social Science
- Centrality of Formalized Models
- Evolutionary Scientific Realism
- Campbellian Realism

**Readings:**
Relevant Web Sites

Leigh Tesfatsion, Iowa State  
http://www.econ.iastate.edu/tesfatsi/  
http://www.econ.iastate.edu/classes/econ308x/tesfatsion/

Kathleen Carley, CMU  
http://www.casos.ece.cmu.edu/home_frame.html

Art De Vany, UC Irvine:  

Robert Axlerod, Michigan  
http://www-personal.umich.edu/~axe/complexity_syllabus.htm

Scott Page et al.  
http://www.pscs.umich.edu/lab/documentation/ICPSR-00/icpsr-Nonlinear-00.txt

Douglas R. White, UC Irvine  
http://eclectic.ss.uci.edu/~drwhite/Anthro179a/syllabus.htm

James Hughes, Chicago  
http://www.changesurfer.com/Acad/SocEco.html

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\Repast:  
(Java-based multi-agent platform)  
http://repast.sourceforge.net/

\Cougaar  
(Java-based multi-agent platform)  
http://cougaar.org/

\AgentBuilder:  (commercial)  
http://www.agentbuilder.com/

\DIET  
(Java-based multi-agent platform)  

\Journal of Artificial Societies & Social Simulation  
http://jasss.soc.surrey.ac.uk/JASSS.html