An advanced seminar consisting of two major components: 1. an introduction to key concepts, theories, and empirical findings in complexity science, and 2. a review of the implications of our emerging knowledge about complex systems in three governance domains—economics, climate, and security. The first component surveys the major branches of thought about complexity in physics, biology, ecology, geography, information theory, technology studies, and economics. The second component highlights practical applications of complexity science in global governance, emphasizing research findings with clear policy implications. The course includes some exposure to computational methods of modeling complex phenomena and visualizing complex data.

**SCHEDULE**

1. 6 January Complexity: What is it, and why are human systems exhibiting more of it?
2. 13 January Energy: Open systems, thermodynamics, and energy gradients
3. 20 January Causation: Interactions, feedbacks, chaos, self-organized criticality, INUS sets, path dependence, and emergence
4. 27 January Connectivity: Networks, information, synchronization, and cascading failures
5. 3 February Nonlinearity: Critical transitions, catastrophes
6. 10 February Complex-adaptive systems: Schemas, (co)evolution, fitness landscapes, and innovation
7. 24 February Societal collapse
8. 3 March Normative implications: Risk vs. uncertainty; prudence, precaution, and resilience
9. 10 March Global governance
10. 17 March Economics
11. 24 March Climate
12. 31 March Security
GRADING

<table>
<thead>
<tr>
<th>Assignment</th>
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<tr>
<td>Weekly questions</td>
<td>10%</td>
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<tr>
<td>Research essay, proposal</td>
<td>10%</td>
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<tr>
<td>Methods assignment</td>
<td>10%</td>
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<td>Research presentation</td>
<td>20%</td>
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<tr>
<td>Research essay</td>
<td>40%</td>
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<tr>
<td>Attendance and participation</td>
<td>10%</td>
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ASSIGNMENTS

Weekly questions: Each week (starting in the seminar’s second week), each student will prepare one question relevant to the coming week’s topic, with an additional paragraph discussing the question, which may take the form of a provisional answer. Due: no later than 8 pm on the Sunday preceding each week’s class, starting Sunday, January 11. Please distribute to all seminar members.

The instructor will call upon one or two students each week to raise and discuss their questions.

Research essay, proposal: Students will each submit a 2-page outline of the topic of their research paper, stating its central argument, outlining the paper’s structure, and identifying supporting literatures and sources of evidence. Due: February 3, at beginning of class.

Methods assignment: Students will explore the NetLogo website (http://ccl.northwestern.edu/netlogo/), including its sample models (http://ccl.northwestern.edu/netlogo/models/index.cgi), tutorials (see the bottom of the page at http://ccl.northwestern.edu/netlogo/resources.shtml) and research results (http://ccl.northwestern.edu/netlogo/models/community/index.cgi), and write a 4-page (1,000 word) reflection on what they discover and its relevance to their particular interests. Due: March 10, at beginning of class.


Research presentation: Each student will prepare and present a 20-minute talk (followed by 10 minutes of discussion) on the topic of his/her research essay. Date: either March 17, 24, or 31.

Research essay: Each student will write a 20-page essay (maximum 5,000 words) using complexity science to elucidate a topic of his/her choice. Essays exceeding the maximum length will be penalized. Due: Noon, Tuesday, April 7.

Participation: In addition to regular seminar participation, each student will declare in the first week his/her particular pragmatic interests in the course’s topic; each should then be prepared to comment each week on the relevance of the week’s concepts to his/her interests.
DISCUSSION GROUP

From January 13 to March 17, core seminar discussion will take place from 9:30 to 11:20 am. Following a short break, the time from 11:30 to 12:20 will be used to pursue questions and concepts needing further discussion.

From March 17 through the remainder of the course, in order to accommodate research presentations, the discussion group will terminate and the seminar will be extended to 12:30 pm.

LATE PENALTIES

Late submissions will be penalized 10 per cent (of the 100 per cent available for that particular assignment) for each day or part thereof that they are late. Submissions will not be accepted after seven days have elapsed. Exceptions will be made only in extraordinary circumstances, usually related to medical emergencies supported by documentation. As soon as the student realizes that his or her assignment may be submitted late, he or she should contact the instructor.

ACADEMIC INTEGRITY

In order to maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility.

A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example, plagiarism), should seek guidance from the course instructor.

When misconduct has occurred, disciplinary penalties will be imposed under Policy 7—Student Discipline. See: http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm.

See also the Academic Integrity website: https://uwaterloo.ca/academic-integrity/

Finally, for those still in the dark, we can thank David Welch for this very amusing link: http://www.youtube.com/watch?v=Mwbw9KF-ACY
READINGS, VIDEOS, AND SUPPLEMENTARY MATERIALS

Students should peruse the website of the Waterloo Institute for Complexity and Innovation (www.wici.ca). Of special value will be the “Complexity Reading List” (http://wici.ca/new/resources/complexity-reading-list/), the Occasional Paper series (http://wici.ca/new/resources/occasional-papers/), and the many videos of past lectures (by some of the world’s leading complexity thinkers) under the “Events” tab on the home page.

Also worth investigating are the websites of the Santa Fe Institute (www.santafe.edu; see especially the Working Papers at http://santafe.edu/research/working-papers/) and of the Center for the Study of Complex Systems at the University of Michigan (http://www.lsa.umich.edu/cscs/).

This map of the evolution of complexity science is useful: http://www.art-sciencefactory.com/complexity-map_feb09.html.

1. January 6 What is it, and why are human systems exhibiting more of it?


Strongly recommended:


2. January 13  

Energy: Open systems, thermodynamics, and energy gradients  
(Guest: Sander van der Leeuw)


Strongly recommended:


3. January 20  

Causation: Interactions, feedbacks, chaos, self-organized criticality, INUS sets, path dependence, and emergence


Strongly recommended:


4. January 27 Connectivity: Networks, information, synchronization, and cascading failures


Strogatz, Steven, TED talk on synchronization, 2004: http://www.ted.com/talks/steven_strogatz_on_sync


Strongly recommended:


5. **February 3**  
*Nonlinearity: Critical transitions, catastrophes*


Strongly recommended:


6. **February 10**  
*Complex-adaptive systems: Schemas, (co)evolution, fitness landscapes, and innovation*


Strongly recommended:


7. February 24  Societal collapse


Strongly recommended:


8. March 3  Normative implications: Risk vs. uncertainty; prudence, precaution, and resilience


Strongly recommended:

9. **March 10**  
*Global governance:*


Strongly recommended:


10. **March 17**  
*Economics*


Vitali, Stefania, James Glattfelder, and Stefano Battiston, “The Network of Global Corporate Control,” *PLOS One* 6, no. 10 (October 2011).


11. March 24  Climate


12. March 31  Security (Guest: Jack Goldstone)


