

Overview of Complex Systems

Principles of Complex Systems | @pocsvox

CSYS/MATH 300, Fall, 2016 | #FallPoCS2016

Prof. Peter Dodds | @peterdodds

Dept. of Mathematics & Statistics | Vermont Complex Systems Center
Vermont Advanced Computing Core | University of Vermont



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Sealie & Lambie
Productions



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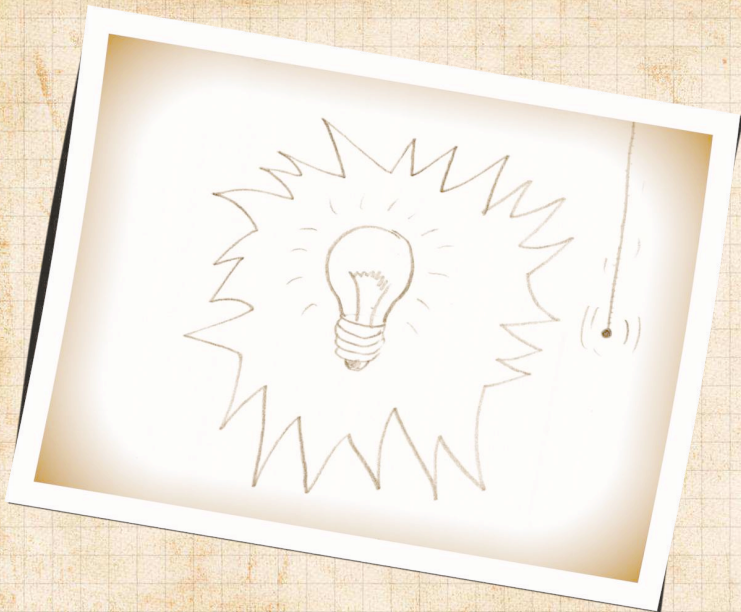
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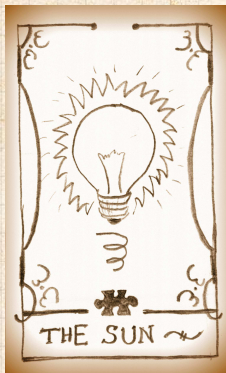


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What's the John Dory?



Peter Dodds



Andy Reagan



Nick Algaier



Eitan Pechenick



Cathy Bliss



Emily Cody



Jake Williams



Chris Danforth



compstorylab.org

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Sharon Alajajian



Dilan Kiley



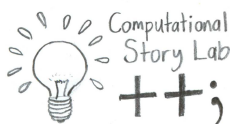
Tom McAndrew



Kayla Horak



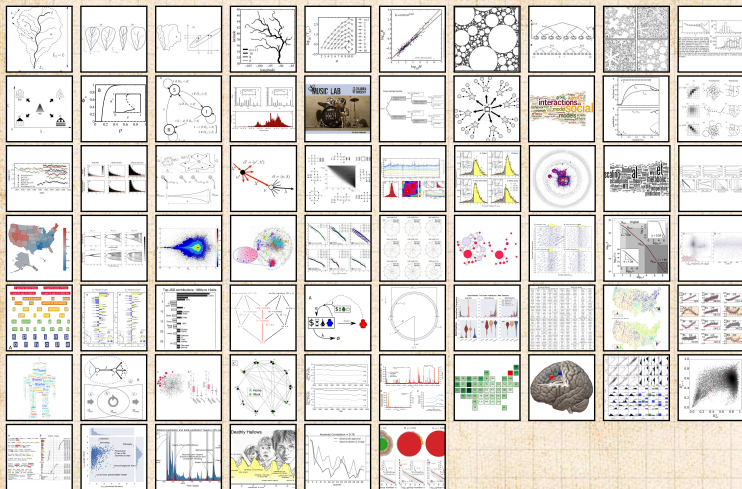
Eric Clark

Lewis Mitchell
(Adelaide)Mike Foley
(Northeastern)Morgan Frank
(MIT)Ross Lieb-Lappen
(Dartmouth)Isabel Kloumann
(Cornell)Kameron Harris
(Washington)Paul Lessard
(Colorado)Tyler Gray
(MIT)Suma Desu
(MIT)

Funding: NSF, NASA, MITRE.



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Basics:

-  Instructor: Prof. Peter Dodds
-  Lecture room and meeting times:
102 Perkins, Tuesday and Thursday, 11:40 am to
12:55 pm
-  Office: Farrell Hall, second floor, Trinity Campus
-  email: peter.dodds@uvm.edu
-  Course Website:
<http://www.uvm.edu/pdodds/teaching/courses/2016-08UVM-300> 
-  Course Twitter handle: @pocsvox
-  Course hashtag: #FallPoCS2016

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Potential paper products:

 The Syllabus  and a Poster .

Office hours:

 10:00 am to 11:55 am on Wednesdays,
Farrell Hall, second floor, Trinity Campus

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Graduate Certificate in Complex Systems (and Data Science):

-  Principles of Complex Systems is one of two core requirements for UVM's five course teaching-learning/certificate-of-study-in-complex-systems/Certificate of Graduate Study in Complex Systems .
-  Other required course: Prof. Maggie Eppstein's "Modelling Complex Systems" (CSYS/CS 302).
-  The Sequel to PoCS: "Complex Networks" (CSYS/MATH 303).

New [movie voice]:

-  MS in Complex Systems and Data Science (Fall 2015) .
-  PhD in Complex Systems (Eventually ...)

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Three versions (all in pdf):

1. Presentation,
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3. Handout (3x2 slides per page).

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⚙ Presentation versions are hyperly navigable:
⏪ ⏩ ≡ back + search + forward.

🔗 Web links look like this [🔗](#).

🔗 References in slides link to full citation at end. ^[1]

🔗 Citations contain links to pdfs for papers (if available).

🔗 Some books will be linked to on Amazon.

🔗 Brought to you by a frightening melange of [Xe_LTeX](#) [🔗](#), [Beamer](#) [🔗](#), [perl](#) [🔗](#), [Per_TEX](#) [🔗](#), fevered command-line madness [🔗](#), and an almost fanatical devotion [🔗](#) to the indomitable [emacs](#) [🔗](#).
[#evilsuperpowers](#)



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


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More super exciting details:

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 We use Open Sans and make math look good:

```
\setmainfont[Ligatures=TeX]{Open Sans}
\setsansfont[Ligatures=TeX]{Open Sans}
\usefonttheme[onlymath]{serif}
```


 Working towards putting the course on Github.







Yet more super exciting details:

PoCS | @pocsvox

What's the John Dory?

 This is Season 10 of Principles of Complex Systems.

 Lectures will be called Episodes.

 All lectures are bottle  episodes .

 Other tropes  will be involved.

 Last season's Episodes are here .

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Wonderful foundational support for PoCS and CoNKS has come from the NSF:

-  "CAREER: Explorations of Complex Social and Psychological Phenomena through Multiscale Online Sociological Experiments, Empirical Studies, and Theoretical Models." 2009–2015.
-  SES Division of Social and Economic Sciences
SBE Directorate for Social, Behavioral & Economic Sciences
-  Abstract is here .

-  People have said nice things about PoCS 

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What's the John Dory?

We'll continue to try out Slack:



Place for discussions about all things PoCS including assignments and projects.



Once invited, please sign up here:
<http://teampocs.slack.com>



Very good: Install Slack app on laptops, tablets, phone.



Everyone will behave wonderfully.

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slack





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Grading breakdown:

 **Projects/talks (36%)**—Students will work on semester-long projects. Students will develop a proposal in the first few weeks of the course which will be discussed with the instructor for approval. Details: 12% for the first talk, 12% for the final talk, and 12% for the written project.

 **Assignments (60%)**—All assignments will be of equal weight and there will be 10 ± 1 of them.

 **General attendance/Class participation (4%)**

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How grading works:

Questions are worth 3 points according to the following scale:

-  3 = correct or very nearly so.
-  2 = acceptable but needs some revisions.
-  1 = needs major revisions.
-  0 = way off.

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Important things:

1. Classes run from Tuesday, August 30 to Tuesday, December 6.
2. Add/Drop, Audit, Pass/No Pass deadline—Monday, September 12.
3. Last day to withdraw—Monday, October 31 (Sadness!).
4. Reading and Exam period—Saturday, December 10 to Friday, December 16.

Do check the course Twitter account, @pocsvox, for updates regarding the course (part of the course site).

Academic assistance: Anyone who requires assistance in any way (as per the ACCESS program or due to athletic endeavors), please see or contact me as soon as possible.

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The nature of PoCS:

 Transitional from standard coursework to research-focused work. *#alittle scary*

Major themes:

-  The Complexity Manifesto 
-  Complex Systems \equiv Modern, Normal Science
-  Roles and limits of Data, Theory, and Experiment
-  Emergence
-  Universality and Accidents of History
-  Structure and Stories: Micro-to-macro Mechanisms
-  Elements: Scaling, Surprise, Networks, Robustness, Failure, and Spreading
-  The Theory of Anything: Why Complexify?
-  It's all about stories.

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
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
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It's all about jokes.

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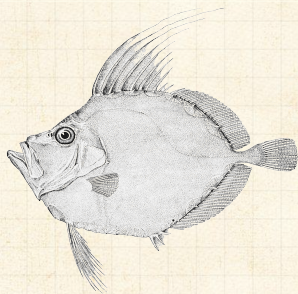
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Cryptolect:

Course mascot:



 What's the Story?

 What's the John Dory?

 What's the John Dory for Rhyming Slang?

 Hemiteleia: beers \Rightarrow Edward Lears \Rightarrow Edwards.

 Also: Taxis \Rightarrow Boris Spasskies \Rightarrow Borises

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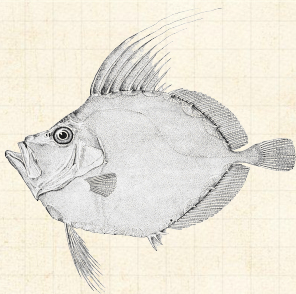
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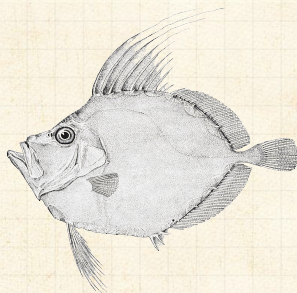
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Cryptolect:

Course mascot:



-  What's the Story?
-  What's the John Dory?
-  What's the John Dory for Rhyming Slang ?

 Hemiteleia: beers \Rightarrow Edward Lears \Rightarrow Edwards.

 Also: Taxis \Rightarrow Chris Spasskies  \Rightarrow Borises

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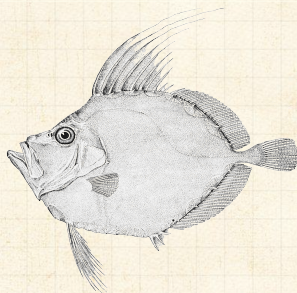
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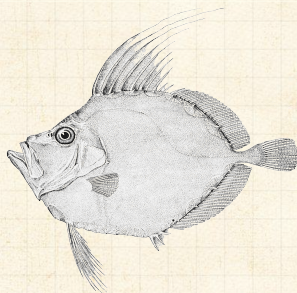
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Scaling phenomena:

- 🧱 Allometry
- 🧱 Scaling of social phenomena: crime, creativity, and consumption.
- 🧱 Power law size distributions and non-Gaussian statistics
- 🧱 Zipf's law
- 🧱 Key mechanisms for generating power law size distributions
- 🧱 Scaling in biology (elephants and platypuses).
- 🧱 Law and Order—Theoricide Unit.
- 🧱 Dimensional Analysis and Renormalization.

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Topics:

Complex networks:

-  Structure and Dynamics
-  Statistical Mechanics
-  Phase transitions
-  Random Networks
-  Scale-free Networks
-  Small-world Networks
-  Multilayer networks
-  Much more in Complex Networks next semester

Multiscale complex systems:

-  Hierarchies and Scaling
-  Modularity

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Topics:

Integrity of complex systems:

-  Generic failure mechanisms
-  Network robustness
-  Highly Optimized Tolerance (HOT): Robustness and fragility
-  Predictability

Information and Language:

-  Search in networked systems (e.g., the web, social systems)
-  Search on scale-free networks
-  Knowledge trees, metadata and tagging
-  Evolution and structure of natural languages

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Sociotechnical Systems:

- 🧱 Biological and social spreading models
- 🧱 Schelling's model of segregation ^[12]
- 🧱 Granovetter's model of imitation ^[7]
- 🧱 Collective behavior and Synchrony
- 🧱 Global cooperation from bad actors
- 🧱 Global conflicts from good actors
- 🧱 Stories (Homo Narrativus)
- 🧱 The Sociotechnocene

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Large-scale social patterns:

-  Movement of individuals
-  Cities
-  Happiness
-  Twitter

Collective decision making:

-  Wisdom and madness of crowds
-  Systems of voting
-  The role of randomness and chance
-  Success inequality: superstardom

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The Secret of Success will be revealed:

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Season's Narrative Arc (or Places We Will Go):



Overview of Complex Systems with bonus Manifesto .



Thread of Understanding Sociotechnical Systems.



Allometric scaling in complex systems.



Size distributions of system elements:



Power-law size distributions



Description and mechanisms of becoming



Robustness of Complex Systems.



Complex networks—how system elements are connected:



Structuring growth mechanisms: Processes on Networks



Social Contagion: Voting, Fame and Fake News



Complexification: The Theory of Anything.

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Schedule in detail:

Week # (dates)	Tuesday	Thursday
1 (8/30 and 9/01)	Overview; Fundamentals: The Complexity Manifesto	Scaling
2 (9/06 and 9/08)	Power-law size distributions	Zipf's law; Fundamentals: Data, Emergence, Limits to Understanding
3 (9/13 and 9/15)	Projects; Power-law mechanisms: Randomness	Power-law mechanisms: Variable Transformation
4 (9/20 and 9/22)	Power-law mechanisms: The Rich-Get-Richer	Power-law mechanisms: Optimization
5 (9/27 and 9/29)	Robustness and Fragility	Fundamentals: Statistical Mechanics Language evolution
6 (10/04 and 10/06)	Robustness vs. SOC	Complex networks: Introduction Basics and Examples networks Small-world networks
7 (10/11 and 10/13)	Complex networks: Key Properties Generalized random	Complex networks: Small-world networks
8 (10/18 and 10/20)	Complex networks: Scale-free networks	Project presentations [†]
9 (10/25 and 10/27)	Project presentations [†]	Complex networks: Scale-free networks
10 (11/01 and 11/03)	Complex networks: Scale-free networks	Contagion: Introduction
11 (11/08 and 11/10)	Contagion	Biological Contagion
12 (11/15 and 11/17)	Social Contagion	Social Contagion
13 (11/22 and 11/24)	Thanksgiving	Thanksgiving
14 (11/29 and 12/01)	Voting and Success	The Sociotechnocene
15 (12/06)	The Big Story	—

†: 3-4 minutes each + 1 or 2 questions;

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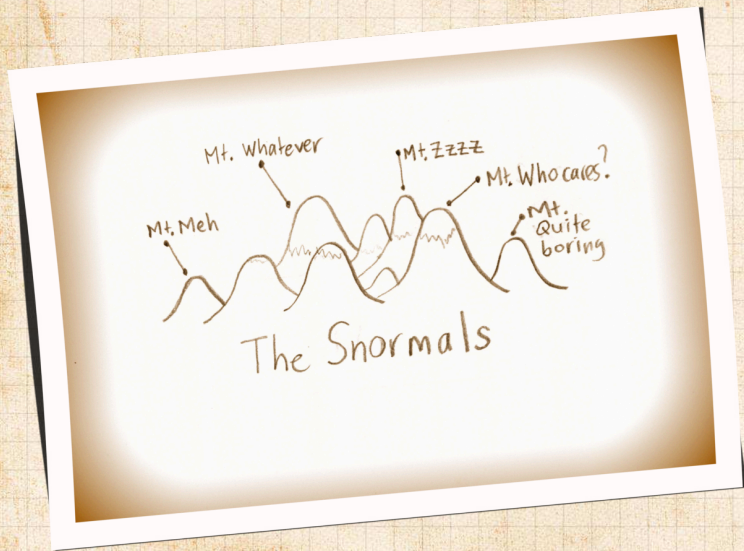
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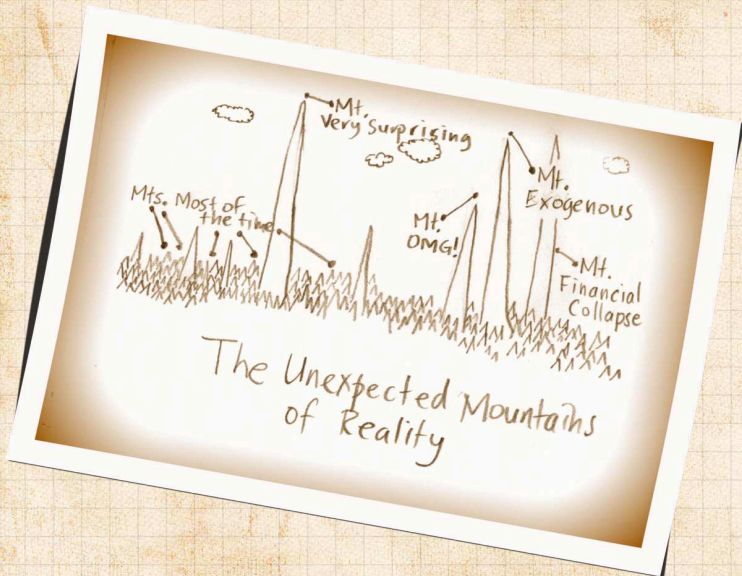
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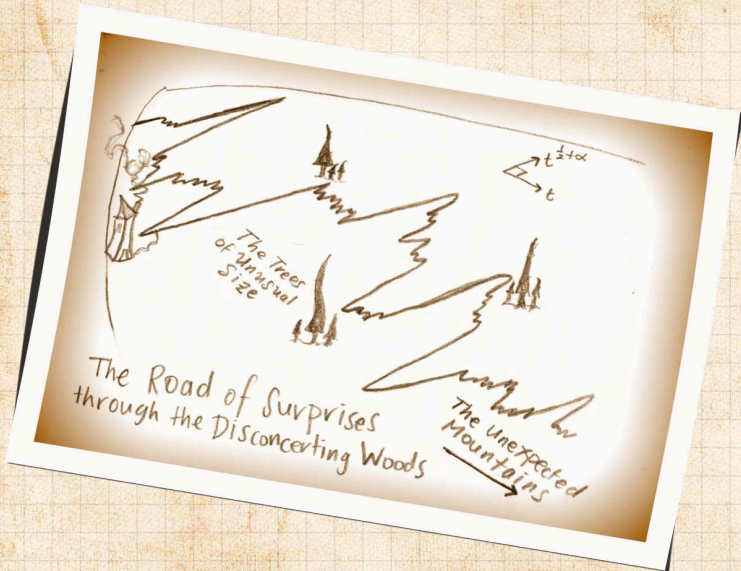
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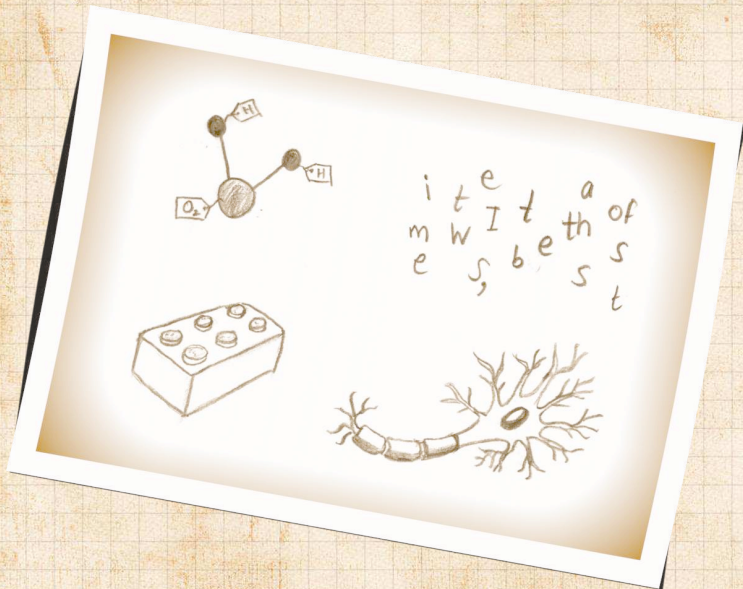
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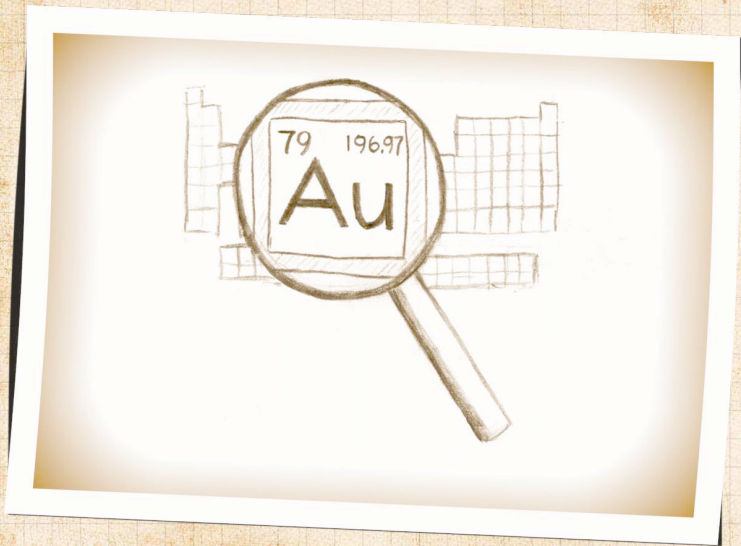
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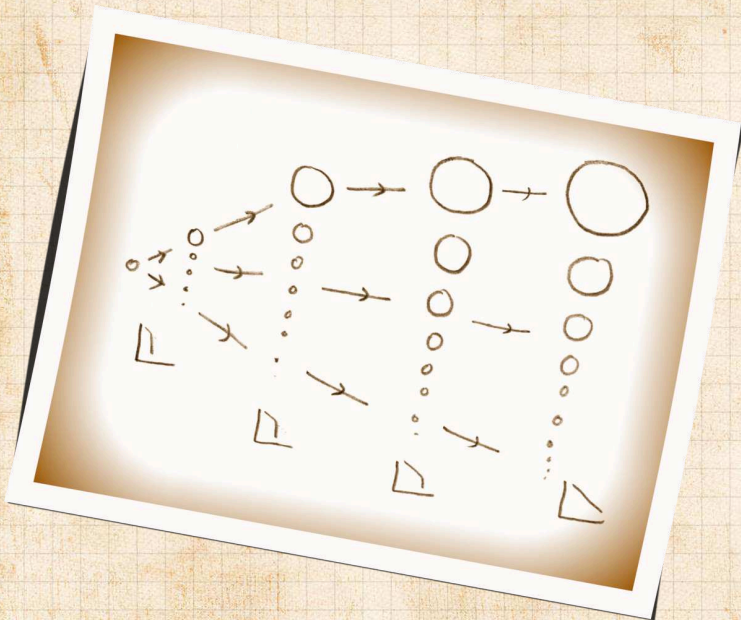
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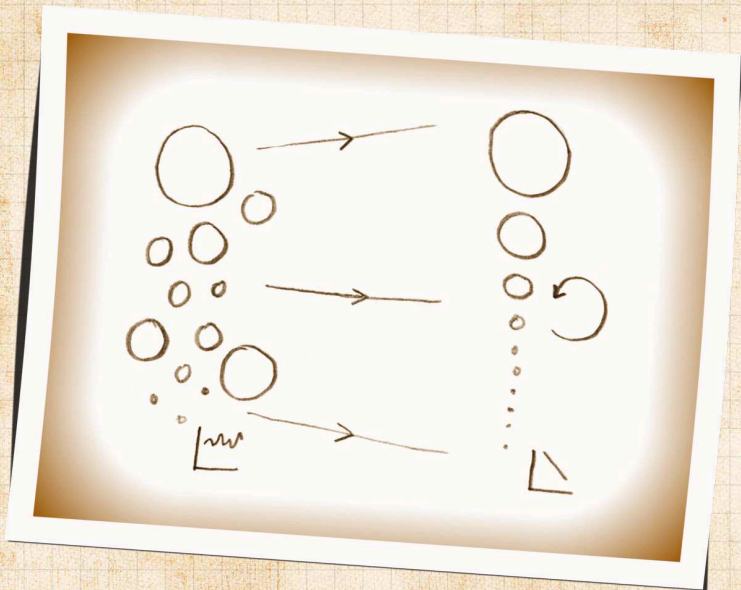
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- 📦 Semester-long projects, individual or in pairs.
- 📦 Develop proposal in first few weeks.
- 📦 May range from novel research to investigation of an established area of complex systems.
- 📦 Two talks + written piece.
- 📦 Usage of the VACC  is encouraged (ability to code well = super powers).
- 📦 Massive data sets available, including Twitter.
- 📦 Academic output (journal papers) resulting from Principles of Complex Systems and Complex Networks can be found [here](#) . Add more!
- 📦 We'll go through a list of possible projects soon.

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




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The narrative hierarchy—Stories and Storytelling on all Scales: ↗





 1 to 3 word encapsulation = a
soundbite = a buzzframe,


 1 sentence, title,


 few sentences, a haiku,

 a paragraph, abstract,

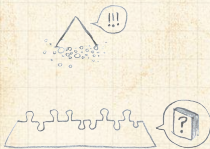
 short paper, essay,

 long paper,

 chapter,

 book,

 ...



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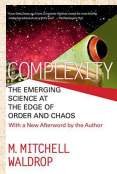


Popular Science Books:

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What's the John Dory?

Historical artifact:



"Complexity: The Emerging Science at the Edge of Order and Chaos" [a](#) [↗](#)
by M. Mitchell Waldrop (1993). ^[15]

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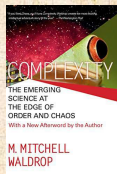


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Shout-out: Dr. Andrew P. Morokoff [🔗](#),
MBBS PhD FRACS D.Thau (Bug) [🔗](#)



Popular Science Books:

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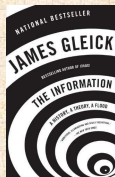
What's the John Dory?



“Simply Complexity: A Clear Guide to Complexity Theory” [a](#) [🔗](#)
by Neil F. Johnson (2009). [8]



“Complexity: A Guided Tour” [a](#) [🔗](#)
by Melanie Mitchell (2009). [11]



“The Information: A History, A Theory, A Flood” [a](#) [🔗](#)
by James Gleick (2011). [5]

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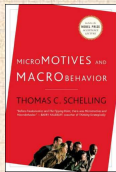
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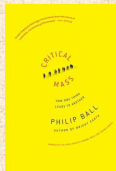
On complex sociotechnical systems:



“Human Behaviour and the Principle of Least-Effort” [a](#) [↗](#)
by G. K. Zipf (1949). [16]



“Micromotives and Macrobehavior” [a](#) [↗](#)
by Thomas C. Schelling (1978). [13]



“Critical Mass: How One Thing Leads to Another” [a](#) [↗](#)
by Philip Ball (2004). [2]

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It's all about algorithms (stories):

PoCS | @pocsvox

What's the John Dory?



"The Engine of Complexity: Evolution as Computation" [a](#) [↗](#)

by John E. Mayfield (2013). ^[9]



"On the Origin of Stories: Evolution, Cognition, and Fiction" [a](#) [↗](#)

by Brian Boyd (2010). ^[4]



"The Storytelling Animal: How Stories Make Us Human" [a](#) [↗](#)

by Jonathan Gottschall (2013). ^[6]

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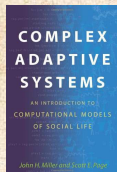
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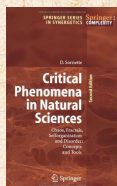


A few textbook books:



“Complex Adaptive Systems: An introduction to computational models of social life” [a](#) [↗](#)

by John H. Miller and Scott E. Page and John H. Miller and Scott E. Page (2007). ^[10]



“Critical Phenomena in Natural Sciences” [a](#) [↗](#)

by Didier Sornette (2003). ^[14]



“Modeling Complex Systems” [a](#) [↗](#)

by Nino Boccara (2004). ^[3]

Eventually: “Principles of Complex Systems”



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Relevant online courses:

**Melanie Mitchell (Santa Fe Institute):**[Introduction to Complexity](#)**Lada Adamic (Facebook):**[Social Network Analysis](#)**Principles of Complex Systems and Complex
Networks**

Centers:

-  Santa Fe Institute (SFI)
-  New England Complex Systems Institute (NECSI)
-  Michigan's Center for the Study of Complex Systems ([CSCS](#) )
-  Northwestern Institute on Complex Systems ([NICO](#) )
-  Also: Indiana, Davis, Brandeis, University of Illinois, Duke, Warsaw, Melbourne, ...
-  [Vermont Complex Systems Center](#) 

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Other inputs:

PoCS | @pocsvox

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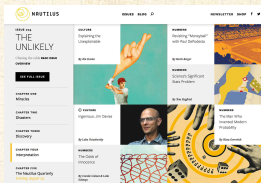
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Complexity Digest:

<http://www.comdig.org>

<https://twitter.com/@cxdig>



Nautilus Magazine:

<http://nautil.us/>



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