Course Overview for PoCS

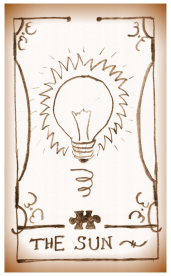
Last updated: 2025/10/28, 09:31:49 EDT

Principles of Complex Systems, Vols. 1, 2, 3D, 4 Fourever, V for Vendetta

Prof. Peter Sheridan Dodds

Computational Story Lab | Vermont Complex Systems Institute
University of Vermont | Santa Fe Institute

Outline



Describe | Explain | Create | Share | Ethos: Play

vermontcomplexsystems.org

We're interested in many things:

- Sociotechnical systems
- Social Contagion and Influence
- Happiness and Well-being
- Language and Stories
- Social unrest
- Conflict
- Robotics
- Artificial Intelligence
- Complex Networks
- Climate
- Biology
- Ecology
- Geomorphology
- Space
- Complex Fluids
- (Smart) Power Grids
- Critical infrastructure
- Defense
- Public Policy
- Health and Medicine
- ~~Brainz~~ Brains
- Neuroscience
- Food systems
- Epidemiology
- Pandemics
- Organizations
- Economics
- Wealth inequality
- Financial Systems

Vermont Complex Systems Center (2006–):

- Diverse research and teaching portfolio.
- Funding from many sources: NSF, NIH, DARPA, Microsoft, MITRE, Computer Associates, MassMutual, Google, foundations.
- Regular global press coverage: NYT, BBC, WaPo, NatGeo, ...
- Conferences: "Big Data, Big Stories", "Big Scale, Big Fail", "Prediction: the Next Big Thing", NetSci 2019, ALife 2020.
- Fully developed educational platform in Complex Systems and Data Science.
- Complex Networks Winter Workshops in Quebec City
- Faculty hires of true Complex Systems scholars.
- Numerous NSF CAREER awards (including PECASE).
- Connecting Graduate and Undergraduate Students across campus (SCRaPS).
- Paper Shredder, Research Jam, and ComplexiTea.
- Talkboctopus

Leveling up—Scaffolded educational mission:

- Data Science Undergrad.
- Graduate Certificate in Complex Systems and Data Science
- Fall, 2015–: MS in Complex Systems and Data Science
- Fall, 2018–: PhD in ~~The Study of Interesting Things~~ Complex Systems and Data Science

All the words: http://vermontcomplexsystems.org.

Some Major support:

- MassMutual Center for Excellence in Complex Systems and Data Science
  vermontcomplexsystems.org/partner/MMCOE/
- University of Vermont-Google Open-Source Complex Ecosystems And Networks (OCEAN)
  vermontcomplexsystems.org/partner/OCEAN/

Dipoloma-posters:

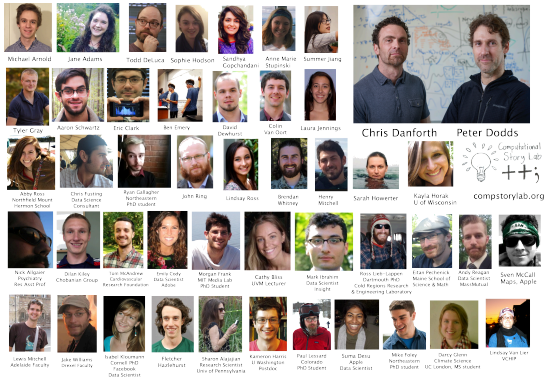
Graduate Certificate in Complex Systems and Data Science:

- Principles of Complex Systems is one of three core requirements for UVM's five course Certificate of Graduate Study in Complex Systems.
- Modelling Complex Systems I and II
- Data Science I and II
- Principles of Complex Systems Vols. 1 and 2

Framing (funfully):

Science = Area of study + Instruments of study

- Stars and Telescopes = Astronomy
- Rocks and Hammers = Geology
- Water and Partial Differential Equations = Fluid Dynamics
- Brains and Giant Imaging Machines = Neuroscience
- People and Deception = Social Psychology
- Mathematics and Mathematics = Pure mathematics
- Mind and Mind = Psychotherapy, Insight meditation, ...
- Complex Systems + Data Science = Postdisciplinary Systems Science

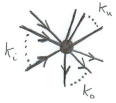


- Funding: NSF, NIH, NIDA, NASA, MITRE, James S. McDonnell Foundation, ONR, DARPA, MassMutual, Google, Computer Associates; [YOUR WONDERFUL FUNDING AGENCY HERE]

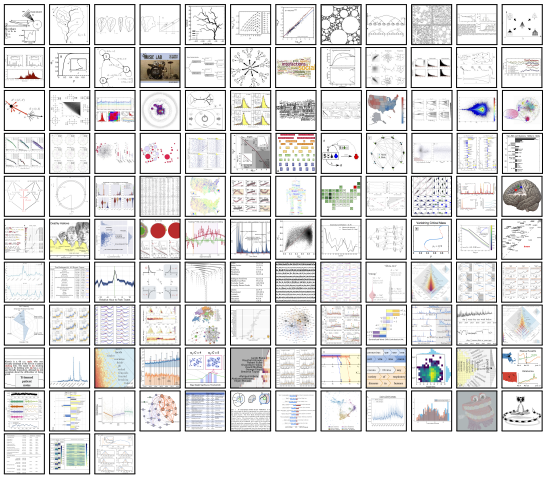
Outside

Inside the Lab that's Quantifying Happiness
by Rowan Jacobsen, August 2017.
(Reprinted in UVM Quarterly, 2018.)

Courses:



- CSYS/MATH 300: Principles of Complex Systems (@pocsvox)
- CSYS/MATH 303: Complex Networks (@networksvox)
- MATH 124/122: Matrixology (Linear Algebra) (@matrixologyvox and @svdthematrices)
- MATH 237: Numerical Analysis (@MachEps237)
- MATH 266: Chaos, fractals & dynamical systems (@NonperiodicFlow)
- MATH 330: Ordinary Differential Equations (@dallthethingsdt)
- Courses act as research incubators and have helped generate many papers



Basics:

- Instructor: Prof. Peter Sheridan Dodds
- Lecture room and meeting times:
  Cohen Hall, 10:05 am to 11:20 am
- Office: (in theory) The Ether and/or Innovation, fourth floor
- email: peter.dodds@uvm.edu
- Course Website:
  https://pdodds.w3.uvm.edu/teaching/courses/2025-2026pocsverse
- ~~Course Twitter handle: @pocsvox~~

Potential paper product:

- The Syllabus. and a Poster.

Office hours:

- See Teams calendar,
  The Ether and/or Innovation, fourth floor

No laptops in class:

- Please take notes with pencil/pen and paper.
- Also okay: Writing on a flat tablet.

Approved etiquette mechanisms:

- Raise hands for questions (always feel free to ask questions).
- The class is a G rated environment (of course, sometimes we have to discuss bad things, science-style).

Exciting details regarding these slides:

- Three servings (all in pdf):
  1. Fresh: For in-class Deliveration.
  2. On toast: Flattened for page-turning joy.
  3. Freeze-dried: Pack-and-go, 3x3 slides per page.
- ~~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 ~~XeLaTeX~~, LuaLaTeX, Beamer, perl, PerlTeX, fevered command-line madness, and an almost fanatical devotion to the indomitable emacs.
  #totallynormal

More super exciting details:

- We use ~~Open Sans~~ EB Garamond and make math look good:

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

- Still working towards putting the course on Github/Gitlab
- And finishing writing the books ...

Yet more super exciting details:

- This is Season 21 of Principles of Complex Systems, Vols. 1 and 2.
- In-person lectures will be called ~~Stories~~ Episodes (a more elevated framing than "Streams of consciousness")
- Slide-specific curated episodes are online, and are broken into clips.
- ~~Goal for all in-person lectures: Record with ScreenFlow, curate, send to Youtube.~~
- Office hours will run over Teams and be recorded.
- Some new clips may be recorded in a pretend studio.
- All lectures are bottle episodes.
- Other tropes will be involved.

Wonderful foundational support for PoCS Vol. 1, ~~CoNKS CocoNuTs~~ PoCS Vol. 2, and PoCS Vol. 3D, 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 also said nice things about PoCS

Team PoCS

Microsoft Teams + Slack

- Teams = main place for discussions about all things PoCS including assignments and projects.
- Slack = main place for students and faculty in Complex Systems and Data Science to talk about everything.
- Teams—Automatic if enrolled in the course.
- Slack—Once invited, please sign up here: https://csdsgrads.slack.com/
- Very good: Install Microsoft and Slack apps on laptops, tablets, phone, cats, dogs. Nothing will go wrong.
- Everyone will behave wonderfully.

Microsoft Teams slack

Grading breakdown:

- Assignments (66%)—All assignments will be of equal weight and there will be 10 ± 1 of them.
- Projects/talks (24%)—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: 8% for the first talk, 8% for the final talk, and 8% for the written project.
- General attendance/Class participation (10%)—Everyone is expected to behave well.

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.

Important things:

1. Classes run from Monday, August 28 to Friday, December 8.
2. Add/Drop, Audit, Pass/No Pass deadline—Monday, September 11.
3. Last day to withdraw—Monday, October 30 (Sadness!).
4. Reading and Exam period—Saturday, December 9 to Friday, December 15.

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.

Popular Science Books:

Historical artifact:

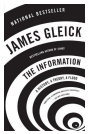
"Complexity: The Emerging Science at the Edge of Order and Chaos"
by M. Mitchell Waldrop (1993). [16]

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

Popular Science Books:

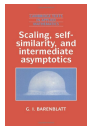
"Simply Complexity: A Clear Guide to Complexity Theory"
by Neil F. Johnson (2009). [9]

"Complexity: A Guided Tour"
by Melanie Mitchell (2009). [12]



"The Information: A History, A Theory, A Flood"
by James Gleick (2011). [6]

Books on Complexification:



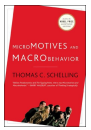
"Scaling, self-similarity, and intermediate asymptotics"
by G. I. Barenblatt (1996). [3]

"Creation of the Universe"
by Zhi and Xian (1989). [17]

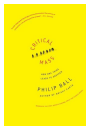
See Freeman Dyson's The Key to Everything.

On complex sociotechnical systems:

"Human Behaviour and the Principle of Least-Effort"
by G. K. Zipf (1949). [18]



"Micromotives and Macrobehavior"
by Thomas C. Schelling (1978). [14]



"Critical Mass: How One Thing Leads to Another"
by Philip Ball (2004). [2]

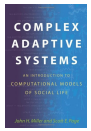
It's all about algorithms (stories):

"The Engine of Complexity: Evolution as Computation"
by John E. Mayfield (2013). [10]

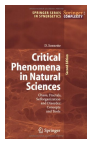
"On the Origin of Stories: Evolution, Cognition, and Fiction"
by Brian Boyd (2010). [5]

"The Storytelling Animal: How Stories Make Us Human"
by Jonathan Gottschall (2013). [7]

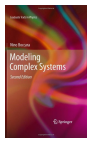
A few textbooky books (dated):



"Complex Adaptive Systems: An introduction to computational models of social life"
by Miller and Page (2007). [11]



"Critical Phenomena in Natural Sciences"
by Didier Sornette (2003). [15]



"Modeling Complex Systems"
by Nino Boccara (2004). [4]

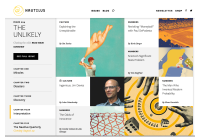
Eventually: "Principles of Complex Systems"

Centers:

- Santa Fe Institute (SFI)
- Networks Institute at Northeastern
- Northwestern Institute on Complex Systems (NICO)
- MIT Institute for Data, Systems, AND Society
- New England Complex Systems Institute (NECSI)
- Michigan's Center for the Study of Complex Systems (CSCS)
- Some Data Science groups (highly variable)
- Also: Indiana, Davis, Brandeis, University of Illinois, Duke, Warsaw, Melbourne, ...,
- Us!!!: Vermont Complex Systems Center

Other inputs:

- Complexity Digest:
  http://www.comdig.org
  https://twitter.com/@cxdig



- Nautilus Magazine:
  http://nautil.us/
- Aeon: http://aeon.co/
- Quanta Magazine: https://www.quantamagazine.org/

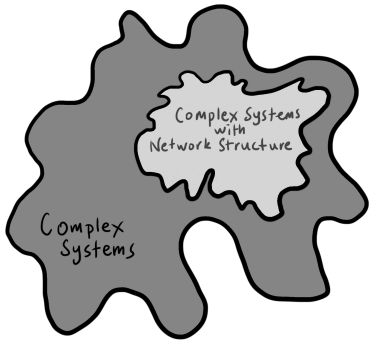
The nature of PoCS:

- Transitional from standard coursework to research-focused work. #alittlescary

Major themes:

- The Complexity Manifesto;
- Complex Systems ≡ 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.

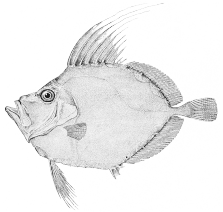
Complex Systems are the Big Story:



- Only a bit networky: Fluids-at-large (the atmosphere, oceans, ...), organism cells, ...

Cryptolect:

Course mascot:



- What's the Story?
- What's the John Dory?
- What's the John Dory for Rhyming Slang?
- Hemiteleia: beers ⇒ Edward Lears ⇒ Edwards.
- Also: Taxis ⇒ Boris Spasskies ⇒ Borises

Topics:

Scaling phenomena:

- Allometry.
- Scaling of social phenomena: crime, creativity, and consumption.
- Scaling in biology (elephants and platypuses).
- Dimensional Analysis and Renormalization.
- Power law size distributions and non-Gaussian statistics.
- The 80/20 rule, the 1%.
- Zipf's law.
- Order from randomness.
- Fundamental mechanisms for generating power law size distributions.
- The rich-get-richer mechanism.

Topics:

Robustness—Integrity of complex systems:

- Generic failure mechanisms.
- Highly Optimized Tolerance (HOT): Robustness and fragility.
- How to build optimal forests.
- Minimization of risk as a driver of heterogeneous structures in complex systems.
- How to optimally locate facilities: hospitals, schools, and coffee shops.

Fundamentals of Complexity:

- Emergence: More is Different.
- Measurement and mismeasurement.
- Universality versus path dependence.
- Complexification (it all starts with gravity [17]).

Topics:

Complex networks:

- Statistical Mechanics
- Structure and Dynamics
- Phase transitions
- Random Networks
- Scale-free Networks
- Small-world Networks
- Why your friends are better than you.
- ~~More in PoCS, Vol. 2 in the spring.~~

Topics:

Sociotechnical Systems:

- Biological and social spreading models
- Schelling's model of segregation [13]
- Granovetter's model of imitation [8]
- Collective behavior and synchrony
- Global cooperation from bad actors
- Global conflicts from good actors
- Stories (Homo Narrativus)
- The Sociotechnocene

Topics:

Collective decision making:

- Wisdom and madness of crowds.
- Systems of voting.
- The role of randomness and chance.
- Success inequality.
- The paradox of unpredictable global fame.
- Bonus knowledge: How to make things spread.
- Bonus knowledge: Fate does not exist in a world of fame.

Large-scale social patterns (maybe):

- Movement
- Cities
- Happiness
- Social media

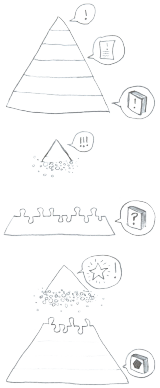
Season's Narrative Arc (or Places We Will Go):

- 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:
  - Structure, Growth Mechanisms, Processes on Networks.
- Social Contagion, Voting, Fame and Fate, Stories.
- Complexification: The Theory of Anything and the Rise of Algorithms

Projects

- Semester-long projects, teams.
- 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.
- Possible: Work with Twitter data and Story Lab on socially meaningful problems.
- 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.

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,
- ...

References I

[1] P. W. Anderson.
More is different.
Science, 177(4047):393–396, 1972. pdf

[2] P. Ball.
Critical Mass: How One Thing Leads to Another.
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