

Course Overview for PoCS

Last updated: 2020/09/26, 14:34:08 EDT

Principles of Complex Systems, Vol. 1 | @pocsvox
CSYS/MATH 300, Fall, 2020

Prof. Peter Sheridan Dodds | @peterdodds

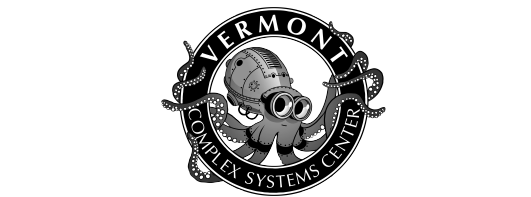
Computational Story Lab | Vermont Complex Systems Center
Vermont Advanced Computing Core | University of Vermont



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Describe | Explain | Create | Share | Ethos: Play



vermontcomplexsystems.org



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Vermont Complex Systems Center (2006–):

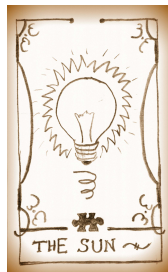
- Diverse research and teaching portfolio (> 400 papers in 2010–2015).
- Funding from many sources: NSF, NIH, DARPA, Microsoft, MITRE, Computer Associates, MassMutual, Google, foundations.
- Regular global press coverage: NYT, BBC, WaPo, NatGeo, ...
- Conferences: "Big Data, Big Stories", "Big Scale, 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 \("Canoe"\)](#)
- 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.
- [Talkbotoopus](#)



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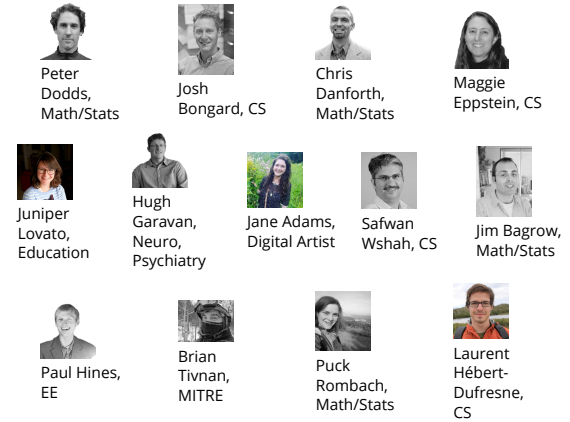


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Vermont Complex Systems Center—Misfit toys:



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We're interested in many things:

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



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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



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

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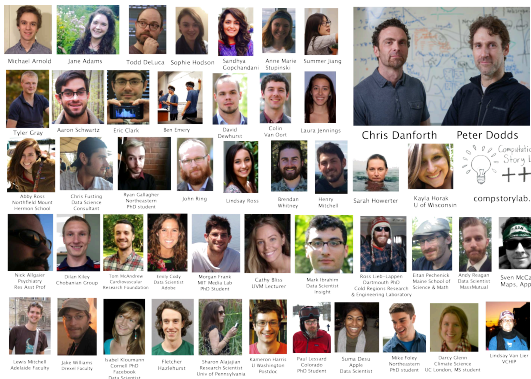
Graduate Certificate in Complex Systems (and Data Science):

- Principles of Complex Systems is one of three core requirements for UVM's five course [Certificate of Graduate Study in Complex Systems](#).
- Prof. Laurent Hebert-Dufresne's "Modelling Complex Systems" (CSYS/CS 302).
- Prof. Jim Bagrow's "Data Science I" (STAT 287)
- The Sequel to PoCS: "Complex Networks" (CSYS/MATH 303).
- In fact: 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]

Adjacent: [Strava Story Lab team](#)

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Outside

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



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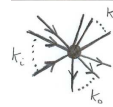
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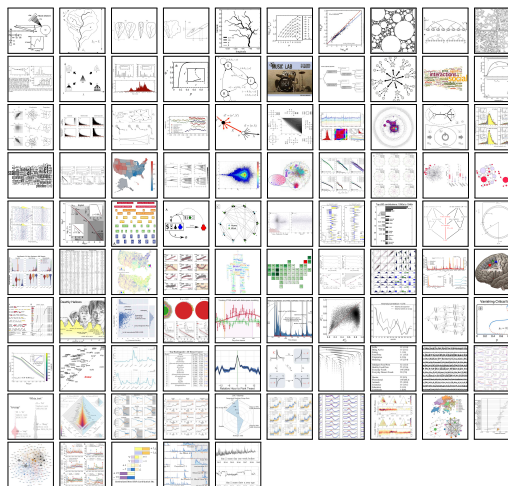
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Courses:



- 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 (60+)



Basics:

- Instructor: Prof. Peter Sheridan Dodds
- Lecture room and meeting times: Online, To be sorted out
- Office: (in theory) Innovation, fourth floor
- email: peter.dodds@uvm.edu
- Course Website: <http://www.uvm.edu/pdodds/teaching/courses/2020-08UVM-300>
- Course Twitter handle: @pocsvox
- Course hashtag: #FallPoCSVol12020

Potential paper products:

- The [Syllabus](#) and a [Poster](#).

Office hours:

- Tuesdays, 12 to 12:50 pm; Wednesdays, 1:15 pm to 2:05 pm; Thursdays, 12 to 12:50 pm; all scheduled on Teams, Innovation, fourth floor

Exciting details regarding these slides:

- Three versions (all in pdf):
 - Presentation,
 - Flat Presentation,
 - Handout (3x2 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.
- 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 [XeTeX](#), [Beamer](#), [perl](#), [PerlTeX](#), [fevered command-line madness](#), and an almost [fanatical devotion](#) to the indomitable [emacs](#).
[#evilsuperpowers](#)

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More super exciting details:

- ☞ We use Open Sans and make math look good:

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

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

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Yet more super exciting details:

- ☞ This is Season 15 of Principles of Complex Systems, Vol. 1.
- ☞ Lectures will be called Episodes.
- ☞ Episodes will be broken into clips.
- ☞ 2020 on: new clips will be recorded in a pretend studio.
- ☞ 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 CocoNuTs 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](#).

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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.



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Grading breakdown:

- ☞ **Assignments (75%)**—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 (1%)**—Everyone is expected to behave well.

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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 Monday, August 31 to Friday, December 4.
2. Add/Drop, Audit, Pass/No Pass deadline—Monday, September 14.
3. Last day to withdraw—Thursday, October 29 (Sadness!).
4. Reading and Exam period—Monday, December 7 to Friday, December 11.

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" [a](#) [g](#)
by M. Mitchell Waldrop (1993).^[16]



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

 
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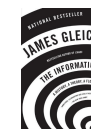
Popular Science Books:



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



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



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

 
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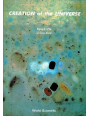
 
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Books on Complexification:



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

Have to strongly disrecommnd "Scale" by West. No.



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

See Freeman Dyson's [c](#) The Key to Everything [c](#).

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A few textbook books (dated):



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



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



"Modeling Complex Systems" [a](#) [c](#)
by Nino Boccara (2004). ^[4]

Eventually: "Principles of Complex Systems"

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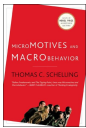


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On complex sociotechnical systems:



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



"Micromotives and Macrobehavior" [a](#) [c](#)
by Thomas C. Schelling (1978). ^[14]



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

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Centers:

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



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It's all about algorithms (stories):



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



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



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

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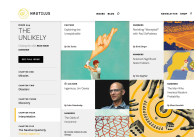
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Other inputs:

[c](#) Complexity Digest:
<http://www.comdig.org>
<https://twitter.com/cxdig>



[c](#) Nautilus Magazine:
<http://nautil.us/>

[c](#) Aeon: <http://aeon.co/>
[c](#) Quanta Magazine:
<https://www.quantamagazine.org/>



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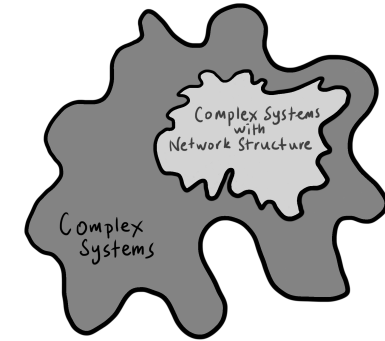
The nature of PoCS:

[c](#) Transitional from standard coursework to research-focused work. #alittle scary

Major themes:

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

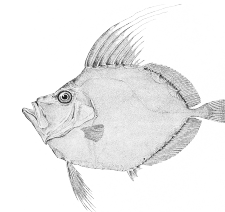
Complex Systems are the Big Story:



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

Cryptolect:

Course mascot:



- [c](#) What's the Story?
- [c](#) What's the John Dory?
- [c](#) What's the John Dory for Rhyming Slang [c](#)?
- [c](#) Hemiteleia: beers \Rightarrow Edward Lears \Rightarrow Edwards.
- [c](#) Also: Taxis \Rightarrow Boris Spasskies [c](#) \Rightarrow Borises



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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.

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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.

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Fundamentals of Complexity:

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

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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.

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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,
- ...

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