

# Course Overview for PoCS

Last updated: 2024/08/27, 08:14:58 EDT

Principles of Complex Systems, Vols. 1, 2, & 3D  
CSYS/MATH 6701, 6713, & a pretend number,  
2024–2025 | @pocsvox

Prof. Peter Sheridan Dodds | @peterdodds

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



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These slides are brought to you by:

Sealie & Lambie  
Productions



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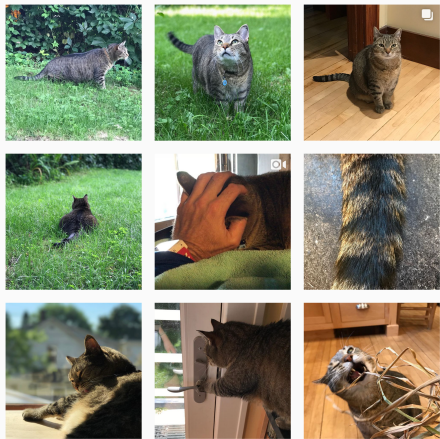
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# These slides are also brought to you by:

## Special Guest Executive Producer



 On Instagram at [pratchett\\_the\\_cat](https://www.instagram.com/pratchett_the_cat) 

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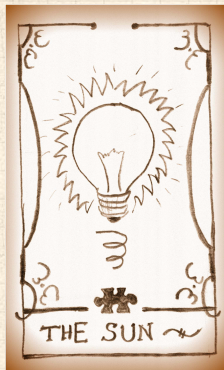
## References

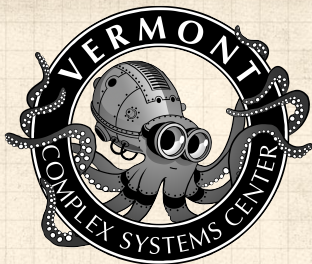
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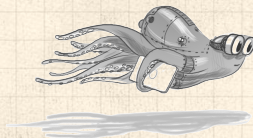


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Describe | Explain | Create | Share | Ethos: Play



[vermontcomplexsystems.org](http://vermontcomplexsystems.org) 

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## 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](#)

## Some Major support:


 MassMutual Center for Excellence in Complex Systems and Data Science  
[vermontcomplexsystems.org/partner/MMCOE/](http://vermontcomplexsystems.org/partner/MMCOE/) 

 University of Vermont-Google Open-Source Complex Ecosystems And Networks (OCEAN)  
[vermontcomplexsystems.org/partner/OCEAN/](http://vermontcomplexsystems.org/partner/OCEAN/) 








# 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


## Leveling up—Scaffolded educational mission:

 Data Science Undergrad.




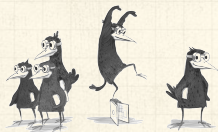
 Graduate Certificate in Complex Systems and Data Science



 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> 

# Dipoloma-posters:

**BE STRANGE AND ADORABLE**



2023  
Approved by the Bohemians in an Egalitarian Way

**Persephone McFoggleton**  
has snaffled  
**The Graduate Certificate in  
Complex Systems and Data Science**  
Vermont Complex Systems Center - University of Vermont

**KNOW MANY THINGS**



2023  
Approved by the Bohemians in an Egalitarian Way

**Basil Gastropodhunter**  
unlocked the next level of  
**Masters in  
Complex Systems and Data Science**  
Vermont Complex Systems Center - University of Vermont

**SOMETHING TO CROW ABOUT**



2023  
Approved by the Bohemians in an Egalitarian Way

**Emanuel Fugestate**  
has ascended to the plane of  
**PhD in  
Complex Systems and Data Science**  
Vermont Complex Systems Center - University of Vermont



**A GOOD POSTDOCTORAL FELLOW**





2021  
2023  
Approved by the Bohemians in an Egalitarian Way


**Porcupina Thwackett**  
Vermont Complex Systems Center - University of Vermont

## 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



Michael Arnold Jane Adams Todd DeLuca Sophie Hodson Sandhya Gopchandani Anne Marie Stupinski Summer Jang



Tyler Gray Aaron Schwartz Eric Clark Ben Emery David Dewhurst Colin Van Dort Laura Jennings



Abby Ross Northfield Mount Hermon School Chris Fusting Data Science Consultant Ryan Gallagher Northwestern PhD student John Ring Lindsay Ross Brendan Whitney Henry Mitchell



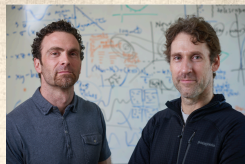
Nick Altshuler Psychiatric Res Asst Prof Dylan Kisey Chobanian Group Tom McAndrew Career Institute Research Foundation Emily Gray Data Scientist, Adobe Morgan Frank MIT Media Lab PhD Student Cathy Bliss UVM Lecturer Mark Ibrahim Data Scientist Insight



Ross Lieb Lappen Dartmouth PhD Cold Regions Research & Engineering Laboratory Liam Pichonick Maine School of Science & Math Andy Scapan Data Scientist MassMutual Sven McCall Maps, Apple



Lewis Mitchell Adelaide Faculty Jake Williams Drexel Faculty Isabel Khourammi Cornell PhD Facebook Data Scientist Fletcher Hazlehurst Sharon Alajajani Research Scientist Univ of Pennsylvania Kameron Harris U Washington Postdoc Paul Lessard Calstate PhD Student Suma Desai Apple Data Scientist Mike Foley Northwestern PhD student Darcy Green Climate Science UC London, MS student Lindsay Van Lier VCHIP



Chris Danforth Peter Dodds




compstorylab.org

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

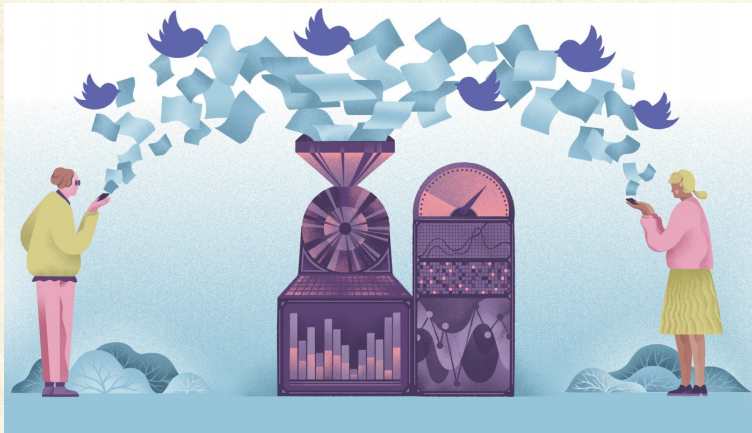


# Outside

Inside the Lab that's Quantifying Happiness 

by Rowan Jacobsen, August 2017.

(Reprinted in UVM Quarterly, 2018.)



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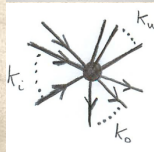
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# Courses:

-  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 

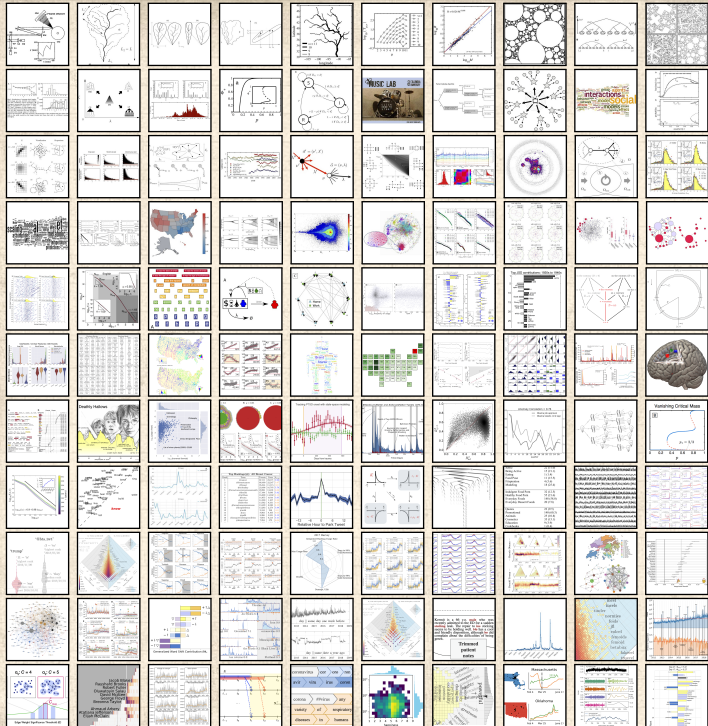
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**Instructor:** Prof. Peter Sheridan Dodds



**Lecture room and meeting times:**

Morrill Hall, 010, 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/2024-2025pocsverse> 




**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.



# Exciting details regarding these slides:



Three servings (all in pdf):

1. Fresh: For in-class Delivery.
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. <sup>[1]</sup>



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 X<sub>Y</sub>TeX , Lua<sub>A</sub>TeX , Beamer , perl , PerlTeX , TeX , fevered command-line madness , and an almost fanatical devotion to the indomitable emacs .

**#totallynormal**



# 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}
```






Still working towards putting the course on  
Github/Gitlab



And finishing writing the books ...





# Yet more super exciting details:



- 🧱 This is Season 20 of Principles of Complex Systems, Vols. 1, 2, & 3D.
- 🧱 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.





# Grading breakdown:



**Assignments (66%)**—All assignments will be of equal weight and there will be  $10 \pm 1$  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).

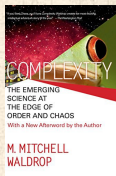
**Academic assistance:** Anyone who requires assistance in any way (as per the ACCESS program or due to athletic endeavors), please see or contact me as soon as possible.



# Popular Science Books:

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Historical artifact:



“Complexity: The Emerging Science at the Edge of Order and Chaos” [a](#) [↗](#)  
by M. Mitchell Waldrop (1993). <sup>[16]</sup>

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



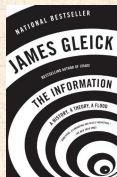
# Popular Science Books:



“Simply Complexity: A Clear Guide to Complexity Theory” [a](#) [↗](#)  
by Neil F. Johnson (2009). <sup>[9]</sup>



“Complexity: A Guided Tour” [a](#) [↗](#)  
by Melanie Mitchell (2009). <sup>[12]</sup>



“The Information: A History, A Theory, A Flood” [a](#) [↗](#)  
by James Gleick (2011). <sup>[6]</sup>

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# Books on Complexification:

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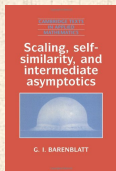
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"Scaling, self-similarity, and intermediate asymptotics" [a](#) [↗](#)  
by G. I. Barenblatt (1996). [3]



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

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



# On complex sociotechnical systems:

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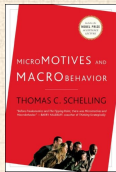
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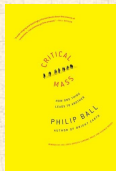
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“Human Behaviour and the Principle of Least-Effort” [a](#) [↗](#)  
by G. K. Zipf (1949). [18]



“Micromotives and Macrobehavior” [a](#) [↗](#)  
by Thomas C. Schelling (1978). [14]



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



# It's all about algorithms (stories):

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

by John E. Mayfield (2013). <sup>[10]</sup>



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

by Brian Boyd (2010). <sup>[5]</sup>



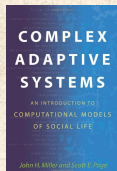
"The Storytelling Animal: How Stories Make Us Human" [a](#) [↗](#)

by Jonathan Gottschall (2013). <sup>[7]</sup>



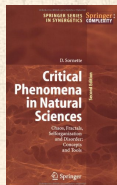


# A few textbook books (dated):



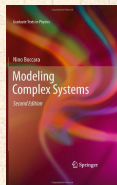
“Complex Adaptive Systems: An introduction to computational models of social life” [a](#) [↗](#)

by Miller and Page (2007). <sup>[11]</sup>



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

by Didier Sornette (2003). <sup>[15]</sup>



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

by Nino Boccara (2004). <sup>[4]</sup>

Eventually: “Principles of Complex Systems”

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# 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 



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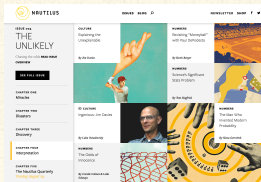
## References



### 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  $\equiv$  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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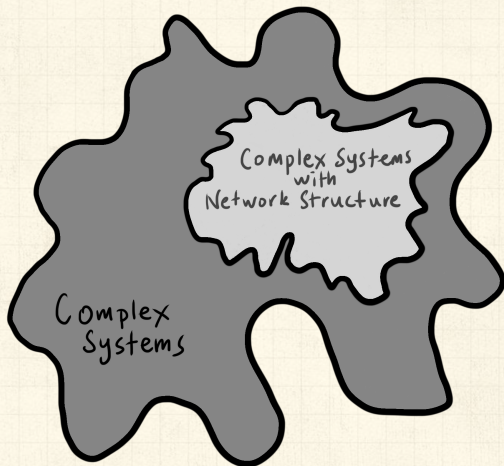
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# Complex Systems are the Big Story:



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

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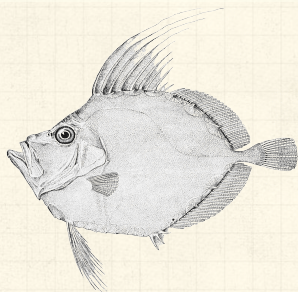
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# Cryptolect:

## Course mascot:



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

# 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<sup>[17]</sup>).



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## 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.

## Sociotechnical Systems:




-  Biological and social spreading models
-  Schelling's model of segregation <sup>[13]</sup>
-  Granovetter's model of imitation <sup>[8]</sup>
-  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

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

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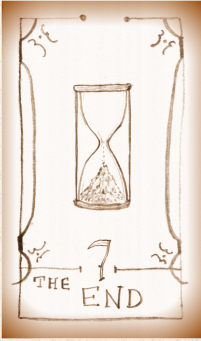
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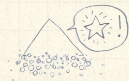



# Projects


-  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,

 ...



## The Boggoracle Speaks:



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