

Course Overview for PoCS

Last updated: 2022/08/29, 21:16:11 EDT

Principles of Complex Systems, Vols. 1, 2, & 3D
CSYS/MATH 300, 303, & 394, 2022-2023 | @pocsvox

Prof. Peter Sheridan Dodds | @peterdodds

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



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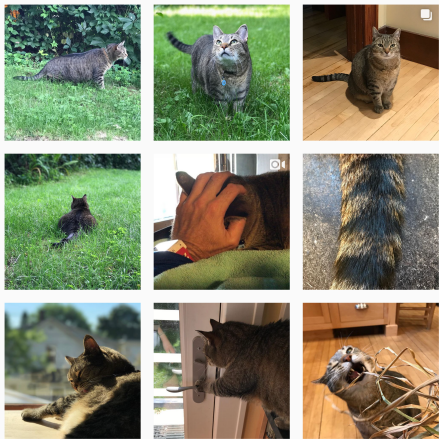
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 On Instagram at [pratchett_the_cat](https://www.instagram.com/pratchett_the_cat) 

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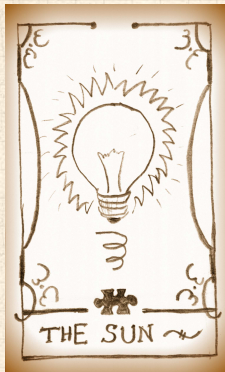


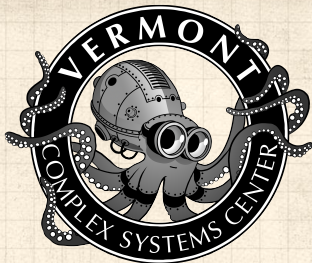
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Describe | Explain | Create | Share | Ethos: Play



vermontcomplexsystems.org 

Vermont Complex Systems Center (2006–):

 Diverse research and teaching portfolio (> 400 papers in 2010–2015).

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-  [Talkboctopus](#)

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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/

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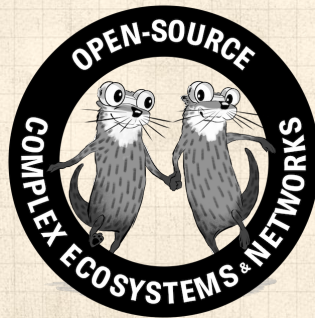
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We're interested in many things:

 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.




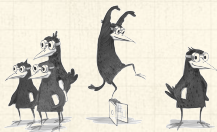
 Graduate Certificate in
Complex Systems and
Data Science




 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> 


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).
-  But really it's the PoCSverse:
Principles of Complex Systems Vols. 1 and 2



Framing (funfully):

Science = Area of study + Instruments of study

 Stars and Telescopes

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Framing (funfully):

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 Stars and Telescopes = Astronomy

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Framing (funfully):

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 Rocks and Hammers

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Framing (funfully):

Science = Area of study + Instruments of study

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Framing (funfully):

Science = Area of study + Instruments of study



Stars and Telescopes = Astronomy



Rocks and Hammers = Geology



Water and Partial Differential Equations

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Framing (funfully):

Science = Area of study + Instruments of study



Stars and Telescopes = Astronomy



Rocks and Hammers = Geology



Water and Partial Differential Equations = Fluid Dynamics

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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

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Science = Area of study + Instruments of study

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-  Rocks and Hammers = Geology
-  Water and Partial Differential Equations = Fluid Dynamics
-  Brains and Giant Imaging Machines = Neuroscience
-  People and Deception

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-  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

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-  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








Framing (funfully):

Science = Area of study + Instruments of study

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-  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









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Science = Area of study + Instruments of study

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-  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

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-  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



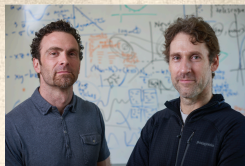
Sandhya Gopchandani



Anne Marie Stupinski



Summer Jang



Chris Danforth

Peter Dodds



Tyler Gray



Aaron Schwartz



Eric Clark



Ben Emery



David Dewhurst



Colin Van Dort



Laura Jennings



Abby Ross
Northfield Mount
Hermon School



Chris Fursting
Data Science
Consultant



Ryan Gallagher
Northeastern
PhD student



John King



Lindsay Ross



Brendan
Whitney



Henry
Mitchell



Sarah Howerter



Kayla Horak
U of Wisconsin



compstorylab.org



Nick Allgaier
Psychiatry
Res Asst Prof



Dylan Kiley
Chobanian Group



Tom McAndrew
CarleInsititute
Research Foundation



Emily Cady
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



Eitan Pechenick
Maine School of
Science & Math



Andy Reagan
Data Scientist
MaxMutual



Sven McCall
Maps, Apple



Lewis Mitchell
Adeladeo Faculty



Jake Williams
Drexel Faculty



Isabel Kloumann
Cornell PhD
Facebook
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Fletcher
Hazlehurst



Sharon Alajalini
Research Scientist
Univ of Pennsylvania



Kameron Harris
U Washington
Postdoc



Paul Lessard
Colorado
PhD student



Suma Desai
Apple
Data Scientist



Mike Iozzy
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PhD student



Garcy Glenn
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LLC London, MS student



Lindsay Van Lier
VCCIP

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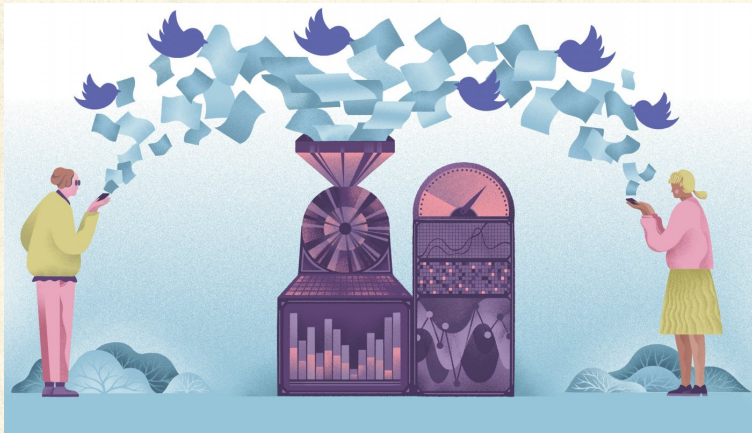


Funding: NSF, NIH, NIDA, NASA, MITRE, James S. McDonnell Foundation, ONR, DARPA, MassMutual, Google, Computer Associates; [YOUR WONDERFUL FUNDING AGENCY HERE]



Outside

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



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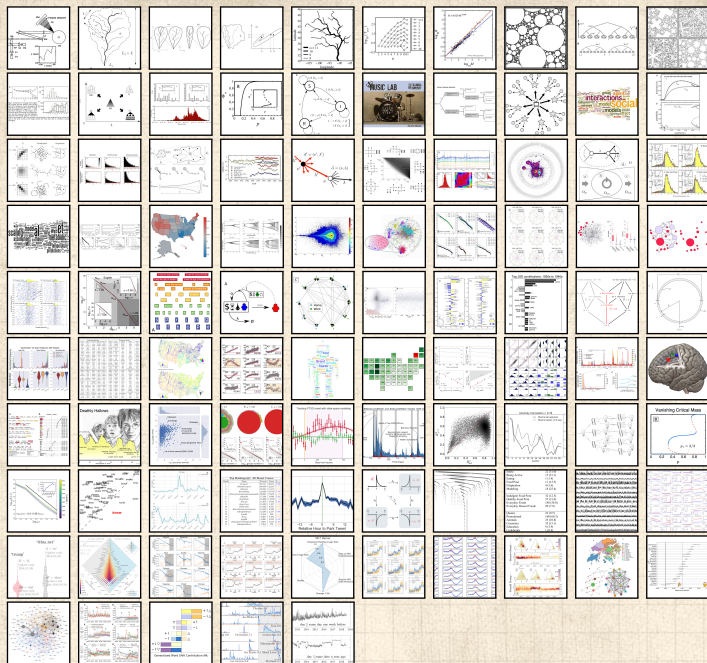
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Basics:

-  Instructor: Prof. Peter Sheridan Dodds
-  Lecture room and meeting times:
Perkins 003, 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/2022-2023pocsverse> 
-  Course Twitter handle: @pocsvox

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Potential paper product:

 The Syllabus .



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Office hours:

 TBD,
The Ether and/or Innovation, fourth floor



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


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


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


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


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


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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 X₃AT_EX , 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 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:

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Yet more super exciting details:



This is Season 18 of Principles of Complex Systems, Vols. 1, 2, & 3D.

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-  All lectures are bottle  episodes .
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- 🧱 Some new clips may be recorded in a pretend studio.
- 🧱 All lectures are bottle  episodes .
- 🧱 Other tropes  will be involved.
- 🧱 Last season's Episodes are here .









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](#) .



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-  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.

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<https://csdsgrads.slack.com/>

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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.



How grading works:

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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 Tuesday, August 31 to Thursday, December 9.
2. Add/Drop, Audit, Pass/No Pass deadline—Monday, September 13.
3. Last day to withdraw—Monday, November 1 (Sadness!).
4. Reading and Exam period—Saturday, December 11 to Friday, December 17.

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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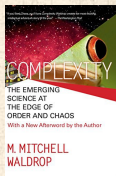
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Popular Science Books:

Historical artifact:



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

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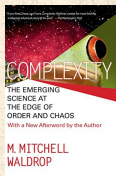
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Popular Science Books:

Historical artifact:



“Complexity: The Emerging Science at the Edge of Order and Chaos” [a](#) [↗](#)
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Shout-out: [Dr. Andrew P. Morokoff](#) [↗](#),
[MBBS PhD FRACS D.Thau \(Bug\)](#) [↗](#)



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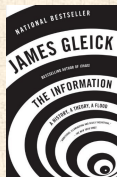
Popular Science Books:



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



“Complexity: A Guided Tour” [a](#) [🔗](#)
by Melanie Mitchell (2009). ^[12]



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

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Books on Complexification:

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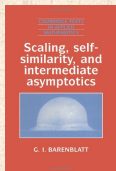
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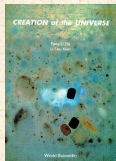
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"Scaling, self-similarity, and intermediate asymptotics" [a](#) [↗](#)
by G. I. Barenblatt (1996). ^[3]



"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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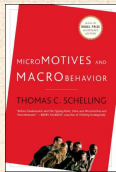
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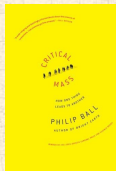
References



“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). ^[10]



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

by Brian Boyd (2010). ^[5]

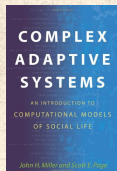


"The Storytelling Animal: How Stories Make Us Human" [a](#) [↗](#)

by Jonathan Gottschall (2013). ^[7]

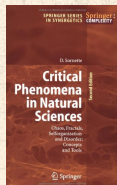


A few textbooky books (dated):



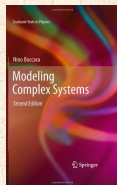
“Complex Adaptive Systems: An introduction to computational models of social life” [a](#) [↗](#)

by Miller and Page (2007). ^[11]



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

by Didier Sornette (2003). ^[15]



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

by Nino Boccara (2004). ^[4]

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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The nature of PoCS:



Transitional from standard coursework to research-focused work.

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The nature of PoCS:



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

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The Complexity Manifesto ;

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 Roles and limits of Data, Theory, and Experiment;

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- Universality and Accidents of History;
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- Elements: Scaling, Surprise, Networks, Robustness, Failure, and Spreading.
- The Theory of Anything: Why Complexify?
- It's all about stories.

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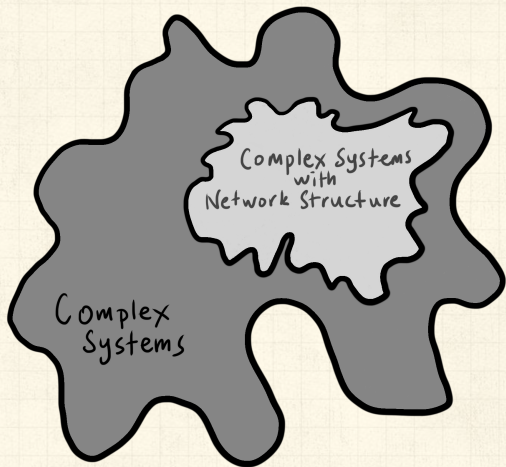
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Complex Systems are the Big Story:



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

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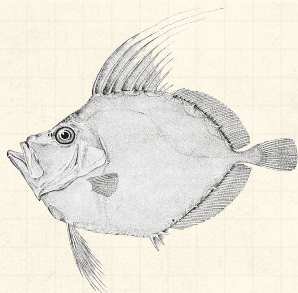
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Cryptolect:

Course mascot:



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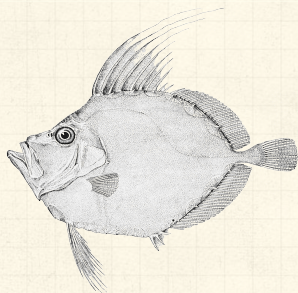
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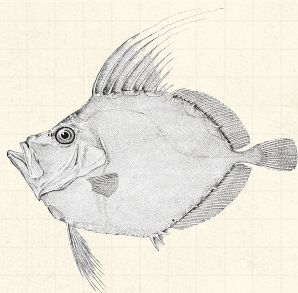
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What's the Story?



What's the John Dory?



What's the John Dory for Rhyming Slang ?

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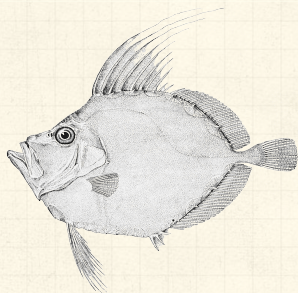
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References



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.

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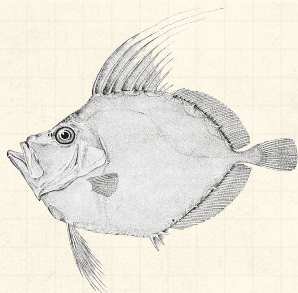
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-  What's the John Dory?
-  What's the John Dory for Rhyming Slang ?
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-  Also: Taxis \Rightarrow Boris Spasskies  \Rightarrow Borises

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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.

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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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.

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References

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.

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Topics:








Collective decision making:

-  Wisdom and madness of crowds.
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-  The role of randomness and chance.
-  Success inequality.
-  The paradox of unpredictable global fame.
-  Bonus knowledge: How to make things spread.



Topics:

Collective decision making:

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

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Topics:

Collective decision making:

-  Wisdom and madness of crowds.
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-  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):



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Allometric scaling in complex systems.

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Allometric scaling in complex systems.



Size distributions of system elements:

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-  Thread of Understanding Sociotechnical Systems.
-  Allometric scaling in complex systems.
-  Size distributions of system elements:
 -  Power-law size distributions.

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-  Thread of Understanding Sociotechnical Systems.
-  Allometric scaling in complex systems.
-  Size distributions of system elements:
 -  Power-law size distributions.
 -  Description and Mechanisms of Becoming.

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-  Size distributions of system elements:
 -  Power-law size distributions.
 -  Description and Mechanisms of Becoming.
-  Robustness of Complex Systems.

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-  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:

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-  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.

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-  Robustness of Complex Systems.
-  Complex networks—how system elements are connected:
 -  Structure, Growth Mechanisms, Processes on Networks.
-  Social Contagion, Voting, Fame and Fate, Stories.

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 -  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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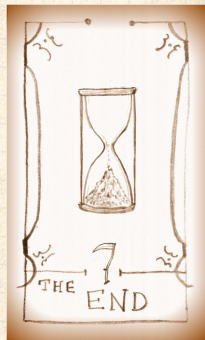
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Projects



Semester-long projects, teams.

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Projects



Semester-long projects, teams.



Develop proposal in first few weeks.

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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.

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Projects

-  Semester-long projects, teams.
-  Develop proposal in first few weeks.
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-  Two talks + written piece.

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Projects

-  Semester-long projects, teams.
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Projects

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Projects

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Projects

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- Academic output (journal papers) resulting from Principles of Complex Systems and Complex Networks can be found here . Add more!












Projects

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- Massive data sets available, including Twitter.
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- 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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