

Course Overview for PoCS

Last updated: 2024/09/10, 07:25:32 EDT

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

Prof. Peter Sheridan Dodds

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



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The PoCVerse
What's the John
Dory?
1 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



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The PoCverse
What's the John
Dory?
2 of 59

Orientation

Course Information
Centers, Books, Resources

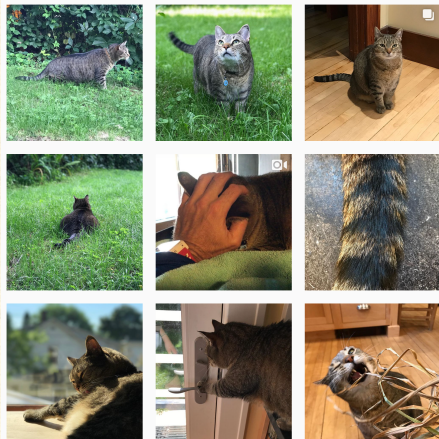
Topics
Narrative Arc



Tarot Cards
Projects

References

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The PoCverse
What's the John
Dory?
3 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Outline

The PoCSverse
What's the John
Dory?
4 of 59

Orientation

Course Information
Centers, Books, Resources
Topics
Narrative Arc
Tarot Cards
Projects
References

Orientation

Course Information
Centers, Books, Resources
Topics
Narrative Arc
Tarot Cards
Projects

References

Orientation

Course Information
Centers, Books, Resources

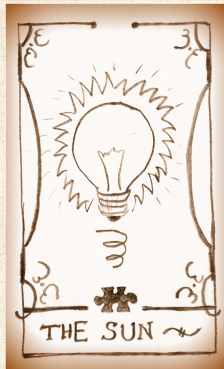
Topics

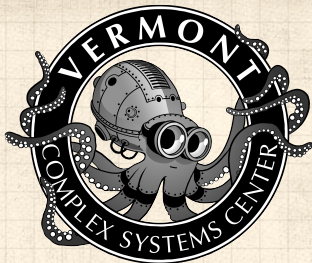
Narrative Arc

Tarot Cards

Projects

References





Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects


References

Describe | Explain | Create | Share | Ethos: Play



vermontcomplexsystems.org 

Vermont Complex Systems Center (2006–):

 Diverse research and teaching portfolio.

Orientation

Course Information

Centers, Books, Resources

Topics



Narrative Arc

Tarot Cards




Projects

References







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-  [Talkboctopus](#) 

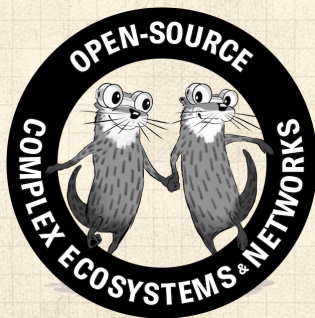
Some Major support:

 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/ 





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

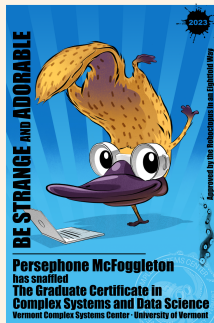


Fall, 2018–: PhD in ~~The Study of Interesting Things~~ Complex Systems and Data Science






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


Dipoloma-posters:




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

The PoCSverse
What's the John
Dory?

13 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc


Tarot Cards

Projects

References

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Science = Area of study + Instruments of study

 Stars and Telescopes = Astronomy

The PoCSverse
What's the John
Dory?

13 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc


Tarot Cards


Projects

References

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 Rocks and Hammers

Framing (funfully):

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 Stars and Telescopes = Astronomy

 Rocks and Hammers = Geology

Framing (funfully):

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Stars and Telescopes = Astronomy



Rocks and Hammers = Geology



Water and Partial Differential Equations

Framing (funfully):

Science = Area of study + Instruments of study



Stars and Telescopes = Astronomy







Rocks and Hammers = Geology



Water and Partial Differential Equations = Fluid Dynamics





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






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-  People and Deception







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-  People and Deception = Social Psychology







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-  People and Deception = Social Psychology
-  Mathematics and Mathematics








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-  Mathematics and Mathematics = Pure mathematics








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-  Mind and Mind









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-  Complex Systems + Data Science

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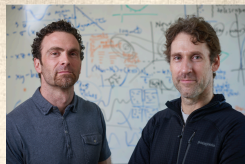
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-  Mathematics and Mathematics = Pure mathematics
-  Mind and Mind = Psychotherapy, Insight meditation, ...
-  Complex Systems + Data Science = Postdisciplinary Systems Science



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



Chris Danforth Peter Dodds



Abby Ross Northfield Mount Hermon School Chris Fusting Data Science Consultant Ryan Gallagher Northwestern PhD student John Ring Lindsay Ross Brendan Whitney Henry Mitchell Sarah Howerter Kayla Horak U of Wisconsin



compstorylab.org



Nick Altaper Psychiatry Res Asst Prof Dylan Kiley Chobanian Group Tom Mylonides Cardiovascular Research Foundation Emily Coody Data Scientist Adobe Morgan Frank MIT Media Lab PhD Student Cathy Bliss UVM Lecturer Mark Ibrahim Data Scientist Insight Ross Luo Dartmouth PhD Cold Region's Research & Engineering Laboratory Eran Pechemek Maine School of Science & Math Andy Seaman Data Scientist MassMutual Sven McCall Maps, Apple



Lewis Mitchell Adelaide Faculty Jake Williams Drexel Faculty Isabel Khouramian Cornell PhD Facebook Data Scientist Fletcher Hazlehurst Sharon Alajajian Research Scientist Univ of Pennsylvania Kamron Harris U Washington Postdoc Paul Lissardi Colorado PhD Student Suma Dixit Apple Data Scientist Mike Foley Northeastern PhD student Darcy Green Climate Science UC London, MS student Lindsay Van Lier VCHIP

The PoCVerse
What's the John
Dory?
14 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects


References



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

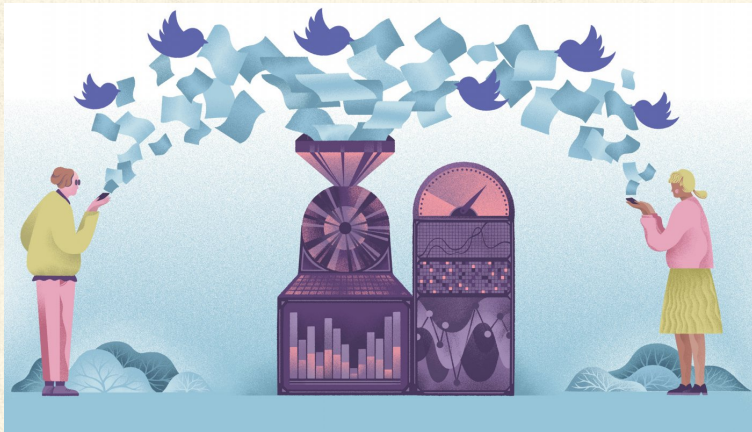


Outside

Inside the Lab that's Quantifying Happiness 

by Rowan Jacobsen, August 2017.

(Reprinted in UVM Quarterly, 2018.)



The PoCVerse
What's the John
Dory?
15 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

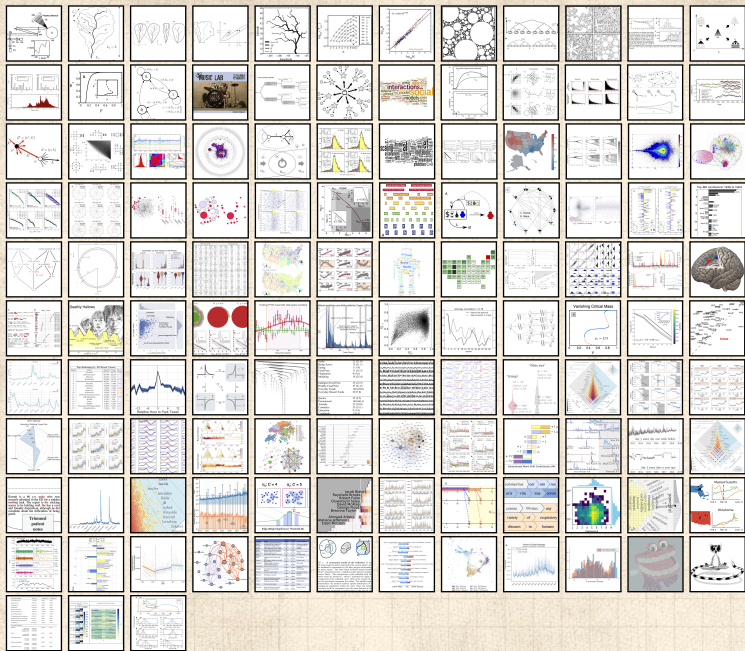
Narrative Arc

Tarot Cards

Projects

References





The PoCVerse What's the John Dory?

16 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

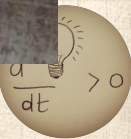
Projects

References





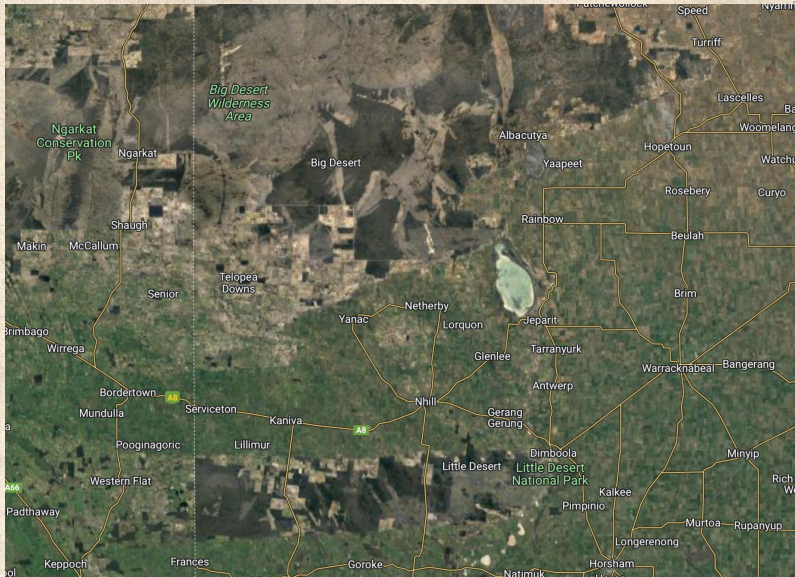
Where  the roads had no names 





Where  the roads had no names 





The PoCVerse
What's the Jhon
Dory?
7 of 59

Orientation

Course Information
Centers, Books, Resources

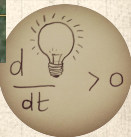
Topics

Narrative Arc

Tarot Cards

Projects

References



Where  the roads had no names 

The PoCverse
What's the John
Dory?

17 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



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Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCSverse
What's the John
Dory?

18 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Basics:



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/2024-2025pocverse> 



Course Twitter handle: @pocsvox



Potential paper product:

 The Syllabus . and a Poster .

The PoCSverse
What's the John
Dory?
20 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects


References



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The PoCVerse
What's the John
Dory?
20 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects


References





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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 Delivery.
2. On toast: Flattened for page-turning joy.
3. Freeze-dried: Pack-and-go, 3x3 slides per page.



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


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Presentation versions are **hyperly navigable**:

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


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


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


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


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Some books will be linked to on Amazon.



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Some books will be linked to on Amazon.



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#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:

The PoCSverse
What's the John
Dory?

23 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Yet more super exciting details:



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The PoCVerse
What's the John
Dory?

23 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc



Tarot Cards

Projects

References



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The PoCverse
What's the John
Dory?
23 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc




Tarot Cards

Projects

References







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Yet more super exciting details:

-  This is Season 20 of Principles of Complex Systems, Vols. 1, 2, & 3D.
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-  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](#) .





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 People have also said nice things about PoCS 



Microsoft Teams + Slack

 Teams = main place for discussions about all things PoCS including assignments and projects.

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc


Tarot Cards


Projects

References






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-  Very good: Install Microsoft and Slack apps on laptops, tablets, phone, cats, dogs. Nothing will go wrong.





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-  Everyone will behave wonderfully.




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.



Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCSverse
What's the John
Dory?
29 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

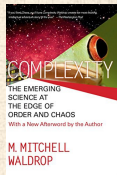
Projects


References



Popular Science Books:

Historical artifact:



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

The PoCverse
What's the John
Dory?
30 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

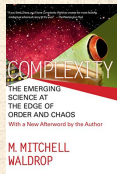
Projects

References



Popular Science Books:

Historical artifact:



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

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



The PoCverse
What's the John
Dory?
30 of 59

Orientation

[Course Information](#)

[Centers, Books, Resources](#)

[Topics](#)

[Narrative Arc](#)

[Tarot Cards](#)

[Projects](#)

[References](#)



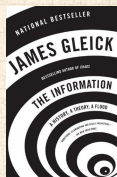
Popular Science Books:



“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]

The PoCVerse
What's the John
Dory?
31 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Books on Complexification:

The PoCverse
What's the John
Dory?
32 of 59

Orientation

Course Information

Centers, Books, Resources

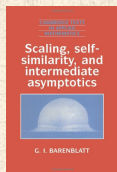
Topics

Narrative Arc

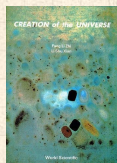
Tarot Cards

Projects

References



“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:

The PoCverse
What's the John
Dory?
33 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

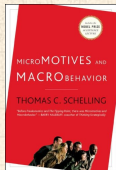
Tarot Cards

Projects

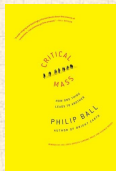
References



“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):

The PoCverse
What's the John
Dory?
34 of 59

Orientation

Course Information

Centers, Books, Resources

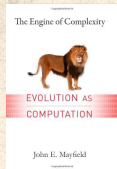
Topics

Narrative Arc

Tarot Cards

Projects

References



“The Engine of Complexity: Evolution as
Computation” [a](#) [↗](#)
by John E. Mayfield (2013). [10]



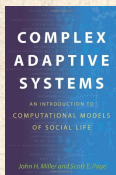
“On the Origin of Stories: Evolution, Cognition, and
Fiction” [a](#) [↗](#)
by Brian Boyd (2010). [5]



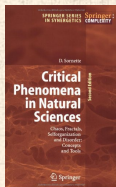
“The Storytelling Animal: How Stories Make Us
Human” [a](#) [↗](#)
by Jonathan Gottschall (2013). [7]



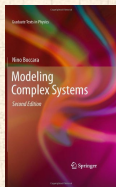
A few textbooky books (dated):



“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”

The PoCVerse
What's the John
Dory?
35 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc


Tarot Cards

Projects

References



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](#) 



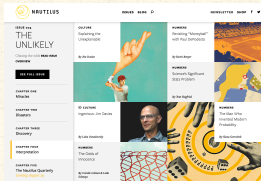
Other inputs:



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 PoCVerse
What's the John
Dory?
37 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCverse
What's the John
Dory?

38 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The nature of PoCS:



Transitional from standard coursework to research-focused work.

The PoCSverse
What's the John
Dory?
39 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The nature of PoCS:



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

The PoCSverse
What's the John
Dory?
39 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

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Major themes:

The PoCSverse
What's the John
Dory?
39 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

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The PoCSverse
What's the John
Dory?
39 of 59

Orientation

Course Information

Centers, Books, Resources

Topics


Narrative Arc

Tarot Cards

Projects


References

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Major themes:

 [The Complexity Manifesto](#) ;

 Complex Systems \equiv Modern, Normal Science;

The PoCVerse
What's the John
Dory?
39 of 59

Orientation

Course Information

Centers, Books, Resources

Topics


Narrative Arc

Tarot Cards





Projects

References


The nature of PoCS:

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-  Complex Systems \equiv Modern, Normal Science;
-  Roles and limits of Data, Theory, and Experiment;


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-  Universality and Accidents of History;

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- The Theory of Anything: Why Complexify?

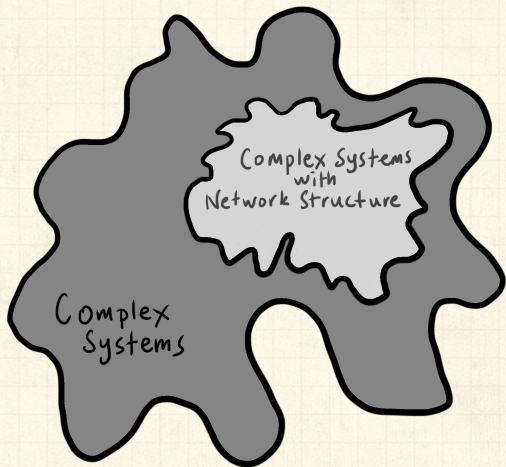
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- Structure and Stories: Micro-to-macro Mechanisms;
- Elements: Scaling, Surprise, Networks, Robustness, Failure, and Spreading.
- The Theory of Anything: Why Complexify?
- It's all about stories.**

Complex Systems are the Big Story:



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

The PoCSverse
What's the John
Dory?

40 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

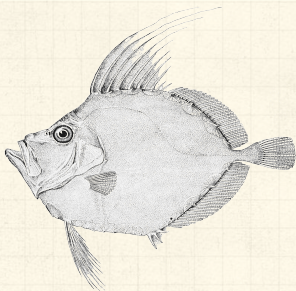
Projects

References



Cryptolect:

Course mascot:



What's the Story?

The PoCSverse
What's the John
Dory?

41 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

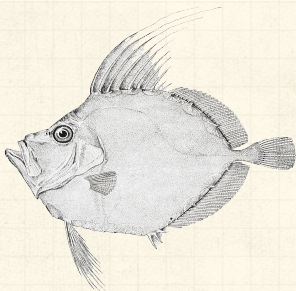
Tarot Cards


Projects


References

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 What's the Story?

 What's the John Dory?

The PoCSverse
What's the John
Dory?

41 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

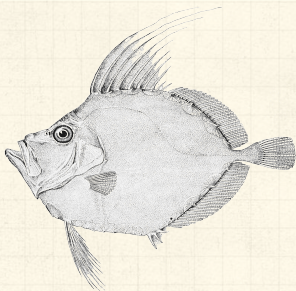
Tarot Cards

Projects

References

Cryptolect:

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What's the Story?



What's the John Dory?



What's the John Dory for Rhyming Slang 

The PoCSverse
What's the John
Dory?

41 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

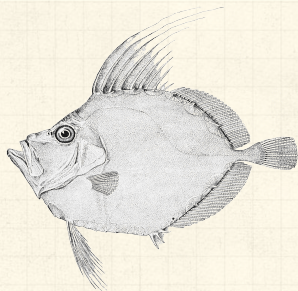
Tarot Cards






Projects

References

Cryptolect:

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-  What's the Story?
-  What's the John Dory?
-  What's the John Dory for Rhyming Slang ?
-  Hemiteleia: beers \Rightarrow Edward Lears \Rightarrow Edwards.

The PoCSverse
What's the John
Dory?

41 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

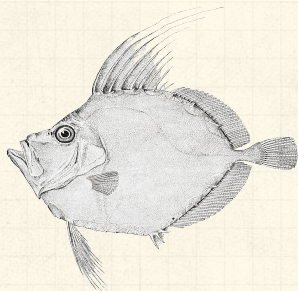
Tarot Cards








Projects

References

Cryptolect:

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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

The PoCverse
What's the John
Dory?

41 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards











Projects

References








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.

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:

The PoCSverse
What's the John
Dory?

44 of 59

Orientation

Course Information

Centers, Books, Resources

Topics









Narrative Arc

Tarot Cards

Projects

References

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:

The PoCSverse
What's the John
Dory?
45 of 59

Orientation

Course Information

Centers, Books, Resources

Topics









Narrative Arc

Tarot Cards

Projects






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.

The PoCSverse
What's the John
Dory?

46 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards







Projects

References



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.



Topics:








Collective decision making:

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-  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.







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



Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCVerse
What's the John
Dory?

47 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards


Projects

References



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



Overview of Complex Systems with bonus Manifesto .

The PoCverse
What's the John
Dory?

48 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc




Tarot Cards

Projects

References



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

-  Overview of Complex Systems with bonus Manifesto .
-  Thread of Understanding Sociotechnical Systems.

The PoCVerse
What's the John
Dory?
48 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc



Tarot Cards


Projects


References



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






 Overview of Complex Systems with bonus Manifesto .

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 Description and Mechanisms of Becoming.












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


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 Complex networks—how system elements are connected:

 Structure, Growth Mechanisms, Processes on Networks.

 Social Contagion, Voting, Fame and Fate, Stories.



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Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCSverse
What's the John
Dory?

49 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Outline

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

The PoCSverse
What's the John
Dory?

51 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



Projects



Semester-long projects, teams.

The PoCVerse
What's the John
Dory?

52 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



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Semester-long projects, teams.



Develop proposal in first few weeks.

The PoCSverse
What's the John
Dory?

52 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References



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May range from novel research to investigation of an established area of complex systems.

The PoCSverse
What's the John
Dory?
52 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc





Tarot Cards

Projects

References



Projects

-  Semester-long projects, teams.
-  Develop proposal in first few weeks.
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The PoCSverse
What's the John
Dory?
52 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc







Tarot Cards

Projects

References










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-  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,

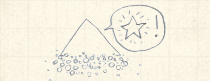
 short paper, essay,

 long paper,

 chapter,

 book,

 ...



Orientation

Course Information

Centers, Books, Resources



Topics

Narrative Arc

Tarot Cards


Projects

References

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References V

The PoCSverse
What's the John
Dory?
59 of 59

Orientation

Course Information

Centers, Books, Resources

Topics

Narrative Arc

Tarot Cards

Projects

References

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