# Course Overview for PoCS

Last updated: 2023/08/22, 11:48:25 EDT

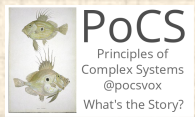
## Principles of Complex Systems, Vols. 1, 2, & 3D CSYS/MATH 6701, 6713, & a pretend number, 2023–2024| @pocsvox


Prof. Peter Sheridan Dodds | @peterdodds

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

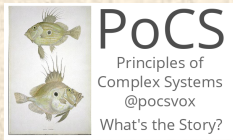










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# Outline

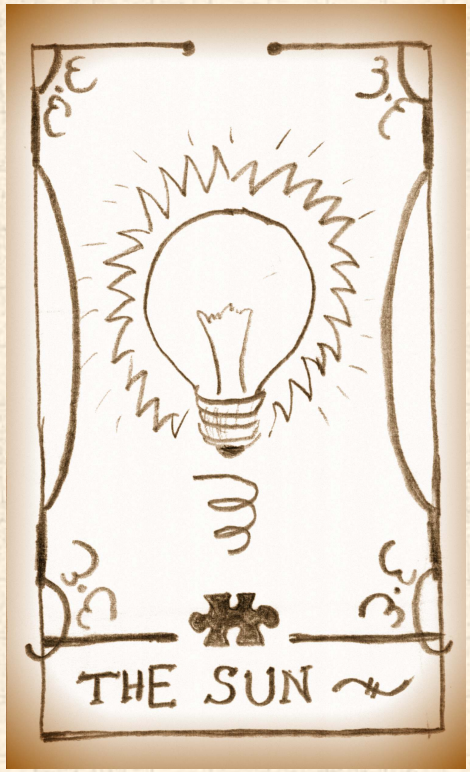




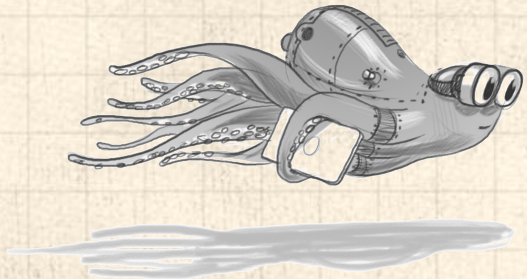
## Orientation

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

## References



Describe | Explain | Create | Share | Ethos: Play



vermontcomplexsystems.org

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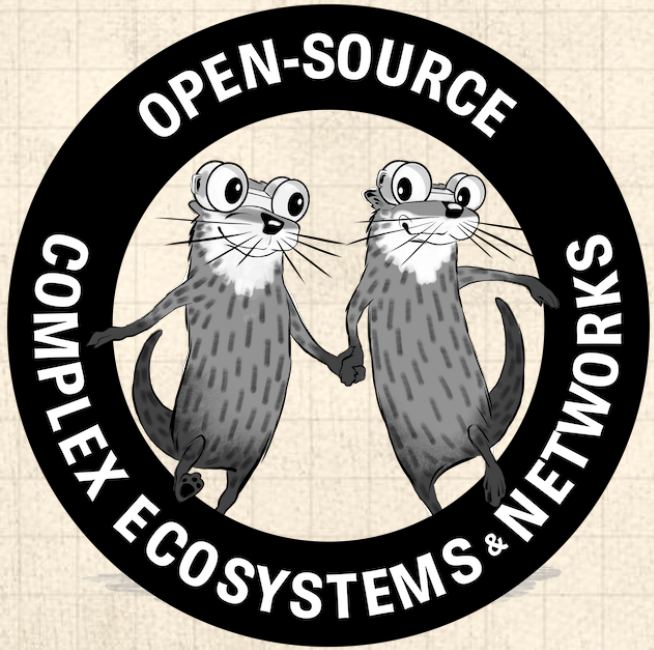
- Talkboctopus

# 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

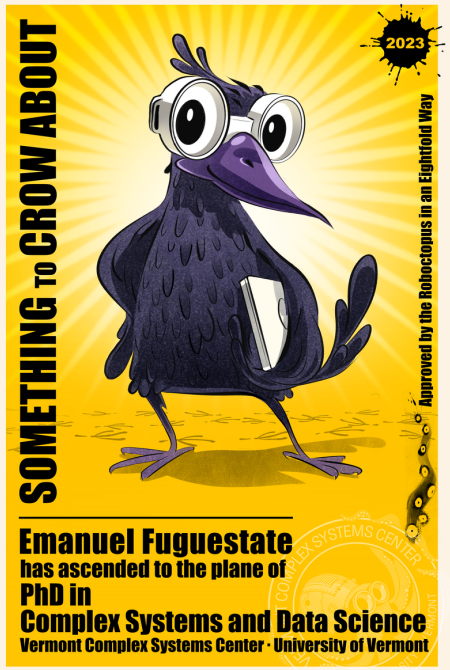
# Leveling up—Scaffolded educational mission:

- 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.
- 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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## Science = Area of study + Instruments of study

- Stars and Telescopes = Astronomy

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## Science = Area of study + Instruments of study

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- Rocks and Hammers = Geology
- Water and Partial Differential Equations

# Framing (funfully):

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# Framing (funfully):





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- Stars and Telescopes = Astronomy
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- Brains and Giant Imaging Machines

# Framing (funfully):





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- Brains and Giant Imaging Machines = Neuroscience
- People and Deception

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- Mathematics and Mathematics

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- People and Deception = Social Psychology
- Mathematics and Mathematics = Pure mathematics

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- Mind and Mind

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- Complex Systems + Data Science

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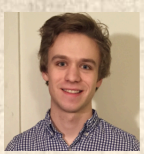
- Complex Systems + Data Science = Postdisciplinary Systems Science


Michael Arnold


Jane Adams


Todd DeLuca


Sophie Hodson


Sandhya Gopchandani

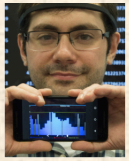

Anne Marie Stupinski


Summer Jiang


Chris Danforth Peter Dodds


Tyler Gray


Aaron Schwartz


Eric Clark


Ben Emery

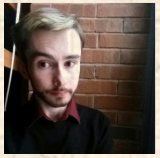

David Dewhurst


Colin Van Oort


Laura Jennings


Abby Ross Northfield Mount Hermon School


Chris Fusting Data Science Consultant


Ryan Gallagher Northeastern PhD student


John Ring


Lindsay Ross


Brendan Whitney


Henry Mitchell


Sarah Howerter


Kayla Horak U of Wisconsin

compstorylab.org


Nick Allgaier Psychiatry Res Asst Prof


Dilan Kiley Chobanian Group


Tom McAndrew Cardiovascular Research Foundation


Emily Cody Data Scientist Adobe

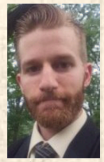

Morgan Frank MIT Media Lab PhD Student


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

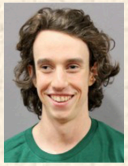

Andy Reagan Data Scientist MassMutual

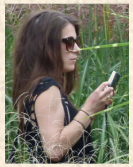

Sven McCall Maps, Apple


Lewis Mitchell Adelaide Faculty


Jake Williams Drexel Faculty


Isabel Kloumann Cornell PhD Facebook Data Scientist


Fletcher Hazlehurst


Sharon Alajajian Research Scientist Univ of Pennsylvania


Kameron Harris U Washington Postdoc


Paul Lessard Colorado PhD Student


Suma Desu Apple Data Scientist


Mike Foley Northeastern PhD student


Darcy Glenn Climate Science UC London, MS student


Lindsay Van Lier VCHIP



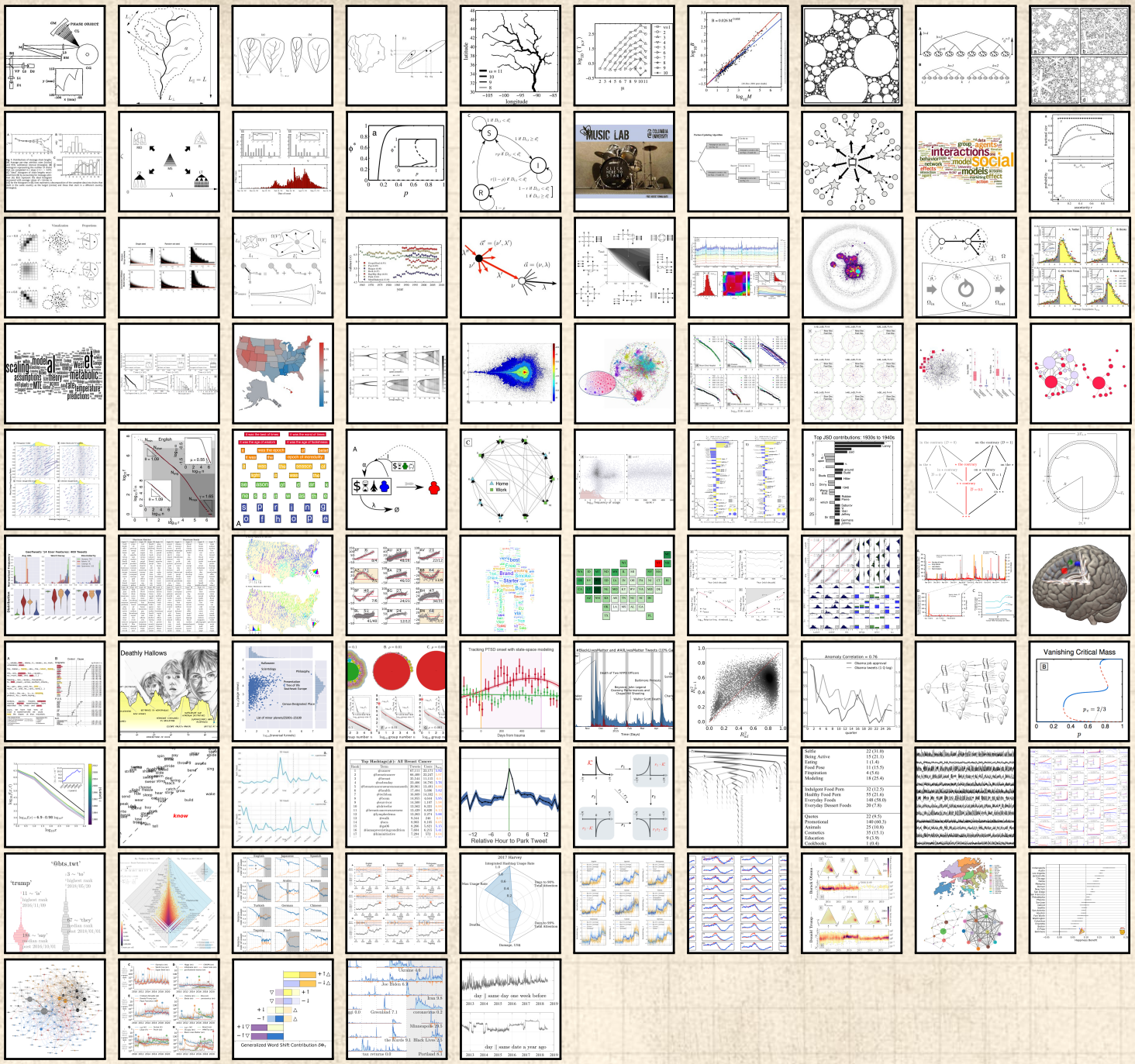
Funding: NSF, NIH, NIDA, NASA, MITRE, James S. McDonnell Foundation, ONR, DARPA, MassMutual, Google, Computer Associates; [YOUR WONDERFUL FUNDING AGENCY HERE]

Outside

## Inside the Lab that's Quantifying Happiness

by Rowan Jacobsen, August 2017.
(Reprinted in UVM Quarterly, 2018.)

Computational Story Lab
++;



# The PoCSverse

## What's the John Dory?

16 of 58

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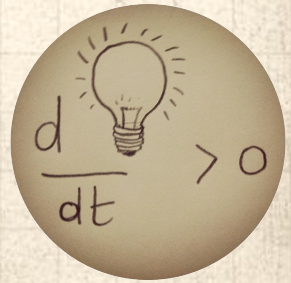

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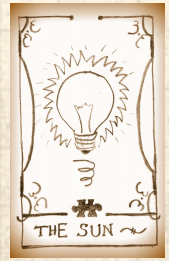
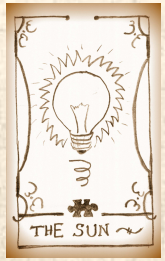


# Basics:



- Instructor: Prof. Peter Sheridan Dodds
- Lecture room and meeting times:
  Mann Hall, 102C, 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/2023-2024pocsverse
- Course Twitter handle: @pocsvox



## Potential paper product:

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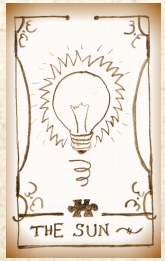

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## Office hours:

- See Teams calendar,
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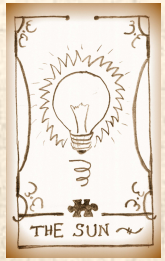

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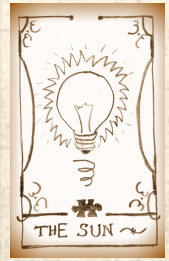
  3. Freeze-dried: Pack-and-go, 3x3 slides per page.







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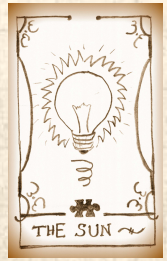

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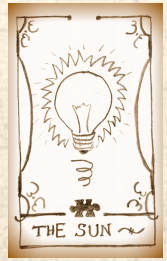

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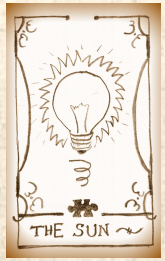

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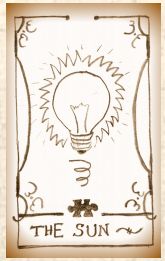

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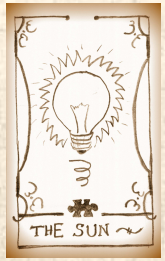

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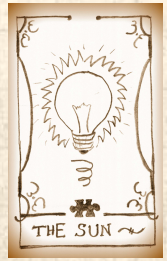
- Brought to you by a frightening melange of XeLaTeX, Beamer, perl, PerlTeX, fevered command-line madness, and an almost fanatical devotion to the indomitable emacs.







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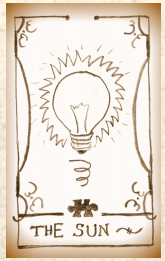
  2. On toast: Flattened for page-turning joy.
  3. Freeze-dried: Pack-and-go, 3x3 slides per page.
- ~~Presentation versions are hyperly navigable: back + search + forward.~~
- Web links look like this.
- References in slides link to full citation at end. [1]
- Citations contain links to pdfs for papers (if available).
- Some books will be linked to on Amazon.
- Brought to you by a frightening melange of XeLaTeX, Beamer, perl, PerlTeX, fevered command-line madness, and an almost fanatical devotion to the indomitable emacs. #totallynormal







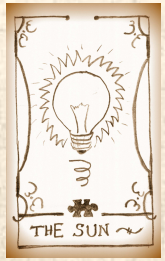
# More super exciting details:



- 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 ...



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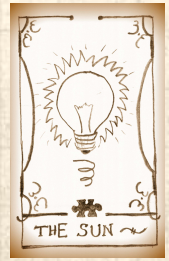

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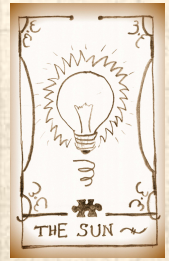

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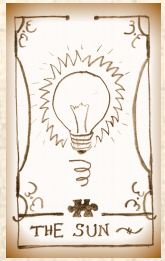

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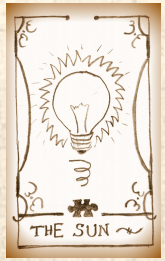

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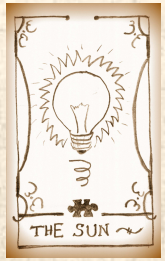

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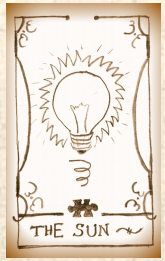

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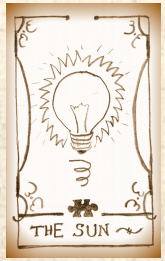

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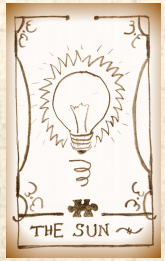

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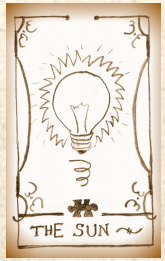
- Some new clips may be recorded in a pretend studio.
- All lectures are bottle episodes.
- Other tropes will be involved.





# 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
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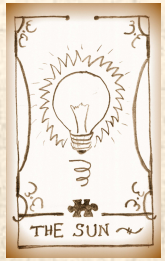

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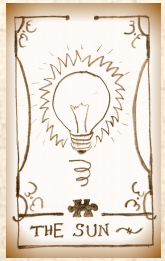
- People have also said nice things about PoCS



# Team PoCS

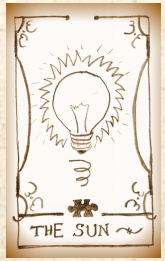
## Microsoft Teams + Slack

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



Microsoft Teams

slack



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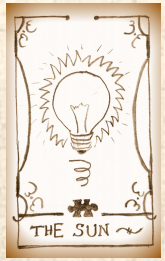

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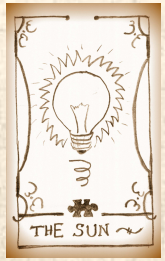

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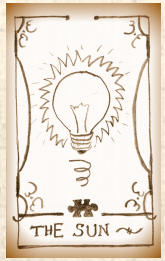
Microsoft Teams slack



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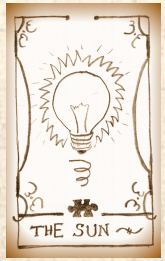

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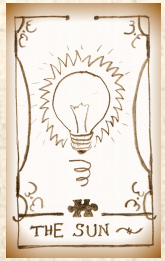
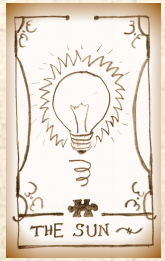


# Grading breakdown:



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

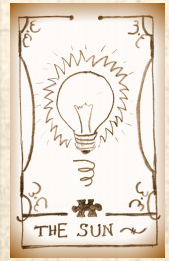


# How grading works:



## 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.

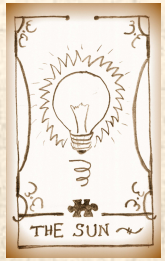


# Important things:

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

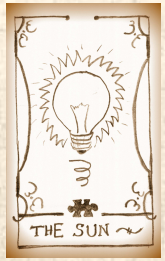




## Orientation

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

## References

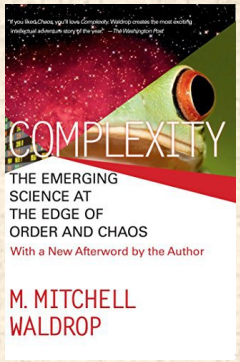


# Popular Science Books:

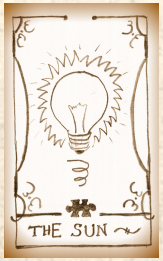




Historical artifact:




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



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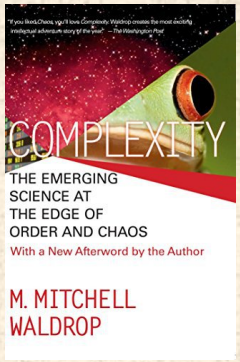


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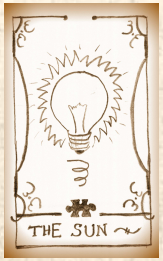
Shout-out: Dr. Andrew P. Morokoff, MBBS PhD FRACS D.Thau (Bug)



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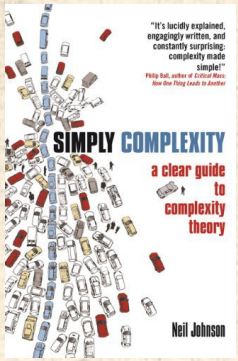
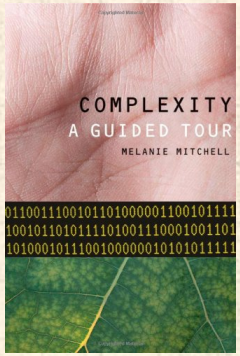
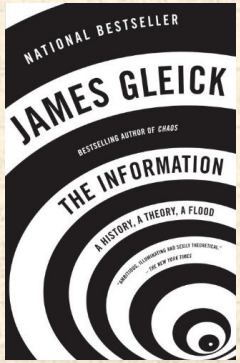


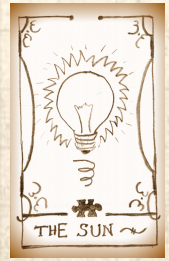

"Simply Complexity: A Clear Guide to Complexity Theory"
by Neil F. Johnson (2009). [9]




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

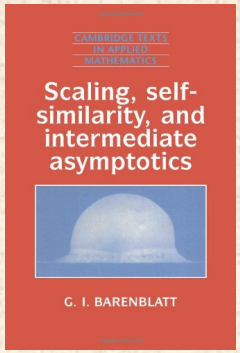



"The Information: A History, A Theory, A Flood"
by James Gleick (2011). [6]

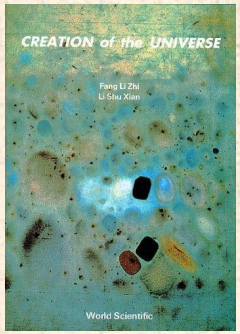


# Books on Complexification:



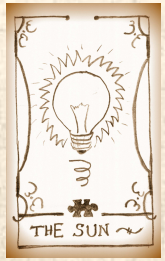



"Scaling, self-similarity, and intermediate asymptotics"
by G. I. Barenblatt (1996). [3]




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

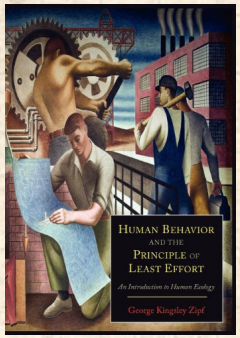
See Freeman Dyson's The Key to Everything.



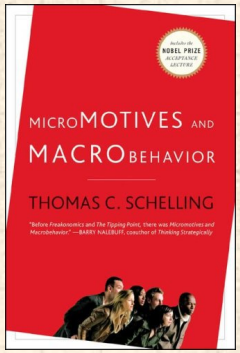
# On complex sociotechnical systems:



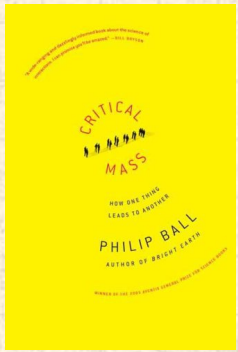




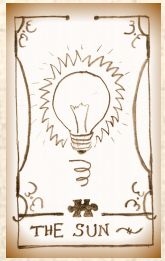

"Human Behaviour and the Principle of Least-Effort"
by G. K. Zipf (1949). [18]




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

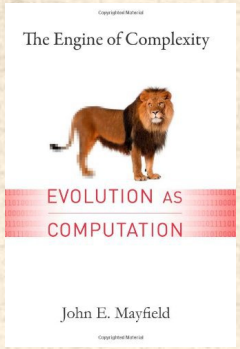



"Critical Mass: How One Thing Leads to Another"
by Philip Ball (2004). [2]

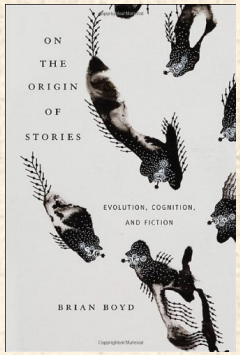


# It's all about algorithms (stories):

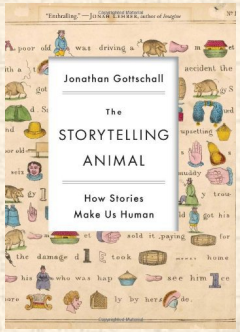




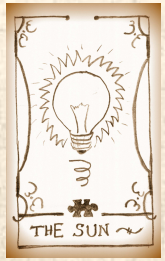

"The Engine of Complexity: Evolution as Computation"
by John E. Mayfield (2013). [10]



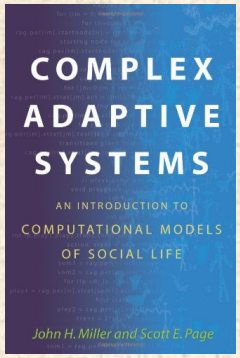

"On the Origin of Stories: Evolution, Cognition, and Fiction"
by Brian Boyd (2010). [5]



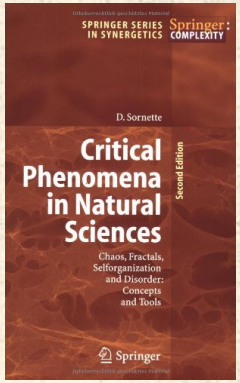

"The Storytelling Animal: How Stories Make Us Human"
by Jonathan Gottschall (2013). [7]



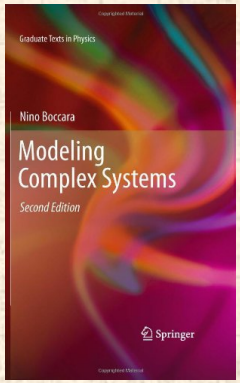
# A few textbooky books (dated):




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

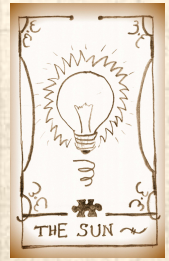



"Critical Phenomena in Natural Sciences"
by Didier Sornette (2003). [15]




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

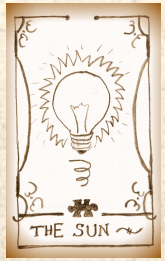
Eventually: "Principles of Complex Systems"



# Centers:

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

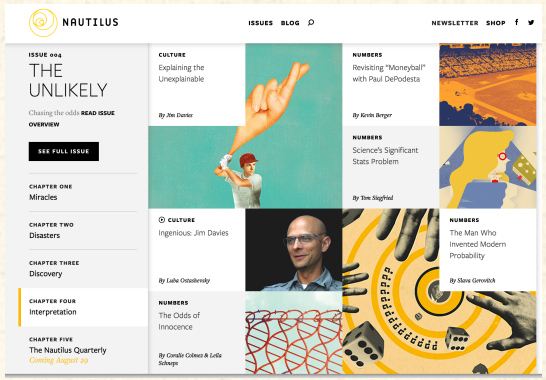


# Other inputs:

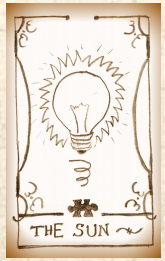


- Complexity Digest:
  http://www.comdig.org
  https://twitter.com/@cxdig




- Nautilus Magazine:
  http://nautil.us/

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



# Outline





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

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# The nature of PoCS:

- Transitional from standard coursework to research-focused work.

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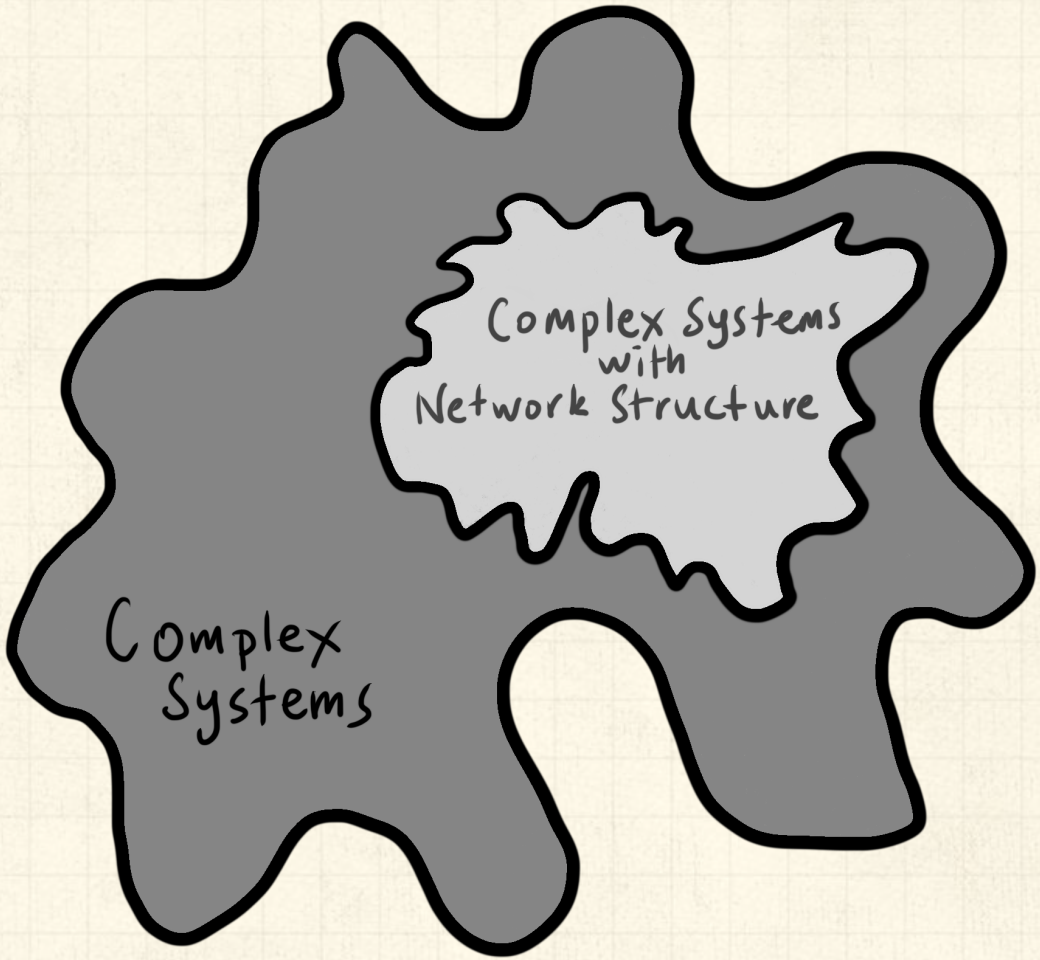
- The Theory of Anything: Why Complexify?
- It's all about stories.



# Complex Systems are the Big Story:




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

# Cryptolect:

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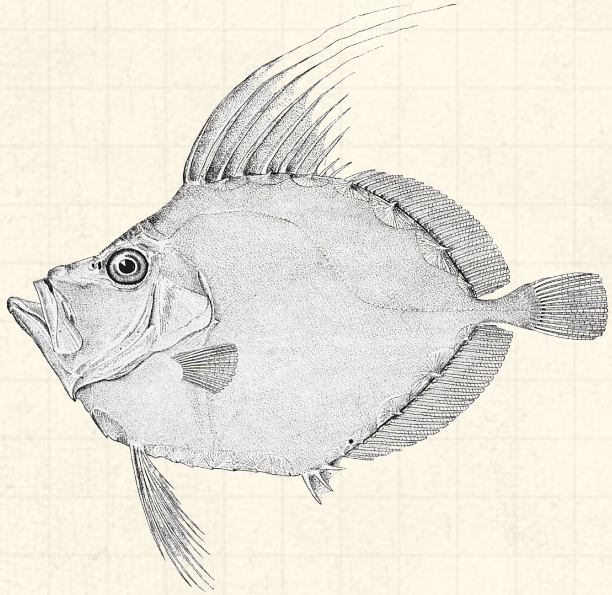

- What's the Story?

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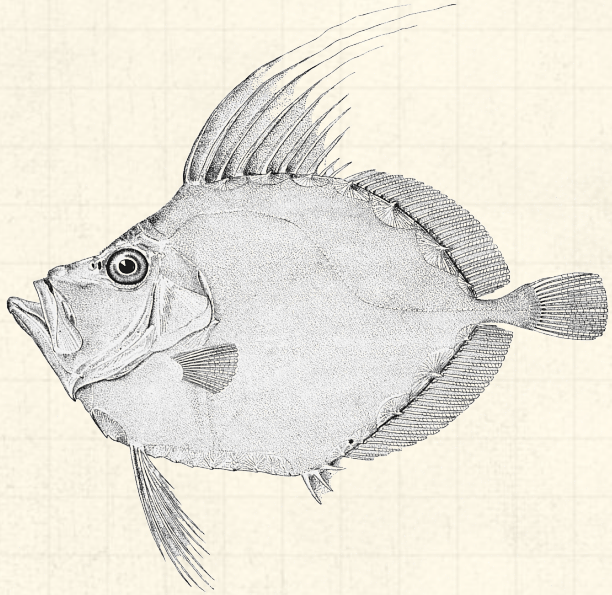

- What's the Story?
- What's the John Dory?

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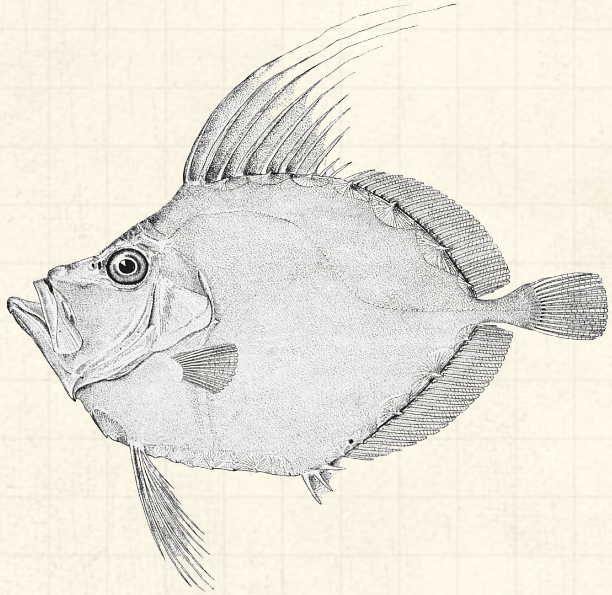

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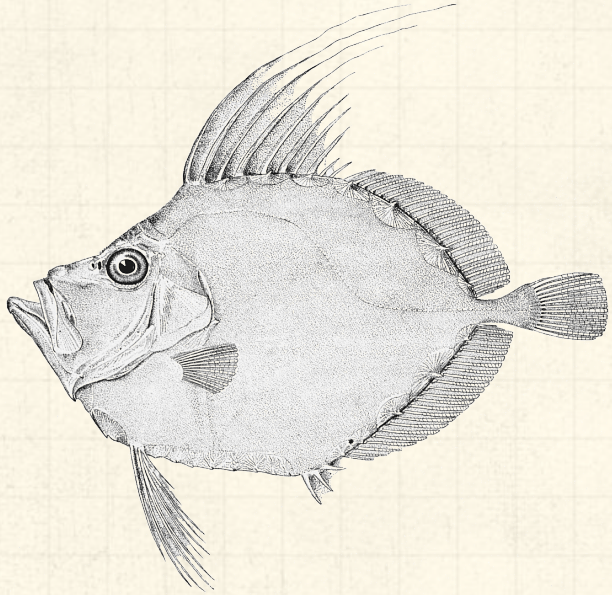

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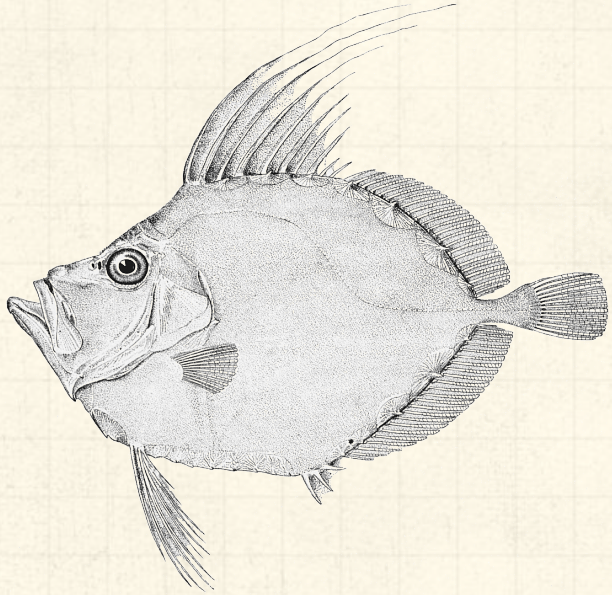

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- Also: Taxis ⇒ Boris Spasskies ⇒ Borises

# Topics:

## Scaling phenomena:

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



# Topics:

## Robustness—Integrity of complex systems:

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

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- How to optimally locate facilities: hospitals, schools, and coffee shops.

## Fundamentals of Complexity:

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



# Topics:



## Complex networks:

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

# Topics:



## Sociotechnical Systems:

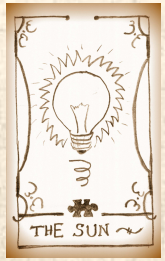
- Biological and social spreading models
- Schelling's model of segregation [13]
- Granovetter's model of imitation [8]
- Collective behavior and synchrony
- Global cooperation from bad actors
- Global conflicts from good actors
- Stories (Homo Narrativus)
- The Sociotechnocene

# Topics:

## Collective decision making:

- Wisdom and madness of crowds.
- Systems of voting.
- The role of randomness and chance.
- Success inequality.
- The paradox of unpredictable global fame.





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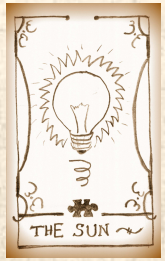

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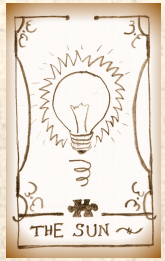

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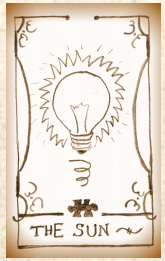
## Large-scale social patterns (maybe):

- Movement
- Cities
- Happiness
- Social media





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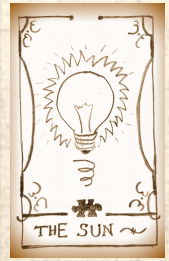
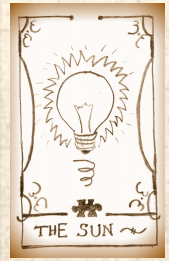


# Season's Narrative Arc (or Places We Will Go):

- Overview of Complex Systems with bonus Manifesto.







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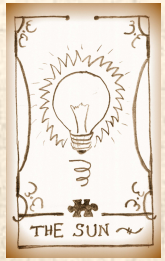

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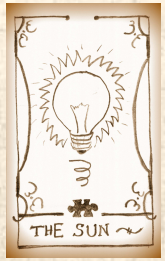

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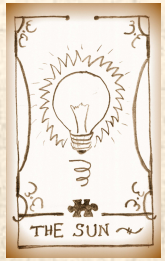

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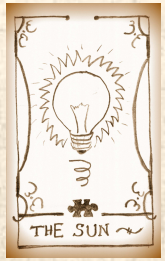

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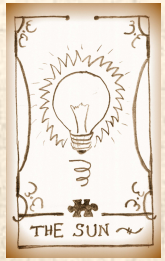

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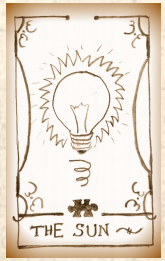
- Robustness of Complex Systems.







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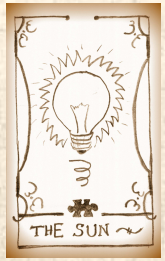
- Complex networks—how system elements are connected:





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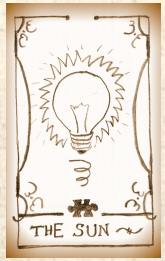
- Complex networks—how system elements are connected:
  - Structure, Growth Mechanisms, Processes on Networks.





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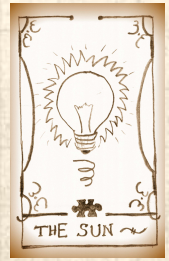

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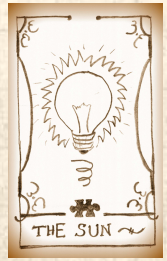
- Complexification: The Theory of Anything and the Rise of Algorithms





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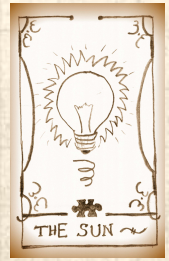

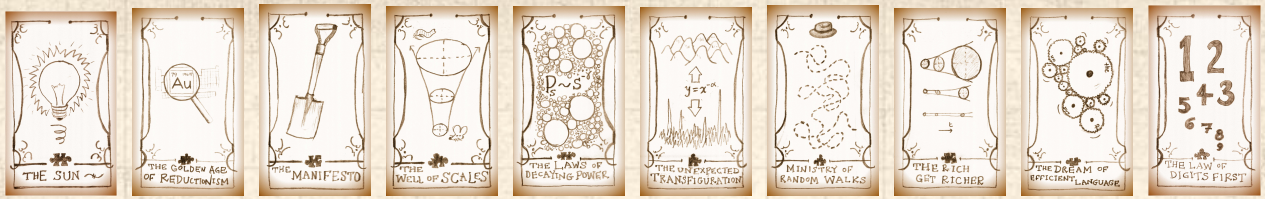
THE SUN
THE GOLDEN AGE OF REDUCTIONISM
THE MANIFESTO
THE WELL OF SCALES
THE LAWS OF DECAYING POWER
THE UNEXPECTED TRANSFIGURATION
MINISTRY OF RANDOM WALKS
THE RICH GET RICHER
THE DREAM OF EFFICIENT LANGUAGE
THE LAW OF DIGITS FIRST


THE SURPRISE OF BEING EARNEST YET PUCKISH
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THE MANY TAILS OF MANY TAILS
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THE THRESHOLDS OF PERCOLATION
THE NETWORKS COMPLEX
THE ELEMENTS OF WEBS
THE BIRDS OF A FEATHER
THE BIRDS OF NOT A FEATHER
THE ARK OF THE RANDOM NETWORK
THE STRANGENESS OF FRIENDS
THE SMALLNESS OF WORLDS
THE THEORY OF SIX DEGREES
THE NETWORKS FREE OF SCALE
CLASSIFIED PHOENIX BIO HAZARD
THE CONTAGION
THE CONFUSION OF CONTAGIONS
THE DISEASE OF RANDOM MIXING
THE UNENDING PANDEMICS
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THE JOHN DORY
THE ADJACENT NARRATIVES
THE STORYTELLERS
THE FATED ASTRAL PATH
THE PATHS OF UNIVERSALITY
THE DEPENDENT PATHS
THE TROUBLES OF BIFURCATING REALITIES
THE UNKNOWN MECHANISM
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THE ORDERS OF STREAMS
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THE SCALING OF BROKEN HIERARCHIES
THE BRAID OR THE BRANCH
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THE CHURCH OF QUARTERLOGY
THE TRUTHICIDE
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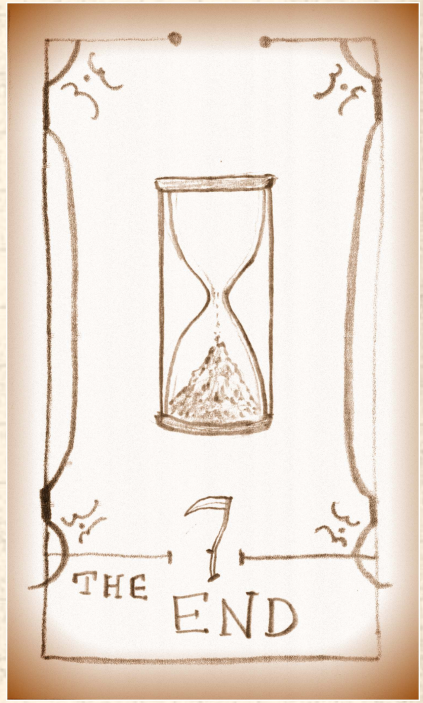
THE FAMILY OF SPHERICAL COWS
THE IMPROBABLE PACHYDERM
THE ILL-SCALING OF ALLOMETRIC BODIES
THE SUPPLY MOST FAIR
THE SUPPLY TO THE MOST
THE DARK ART OF GENERATING FORETHINGS
THE RANDOM SUM OF RANDOMNESS
THE TWO-SIDED WORLDS
THE STORIES AND THE TROPES
THE TRUTH OF DIFFUSION
THE UNVEILING OF HIDDEN POWERS
THE SCRYING FOR THE SHAPES OF THINGS
THE LIMITS OF ORGANIZATIONS
THE OVERCOMING OF CATASTROPHE
THE TROUBLES ILL-FORMED
THE NETWORKS OF MANY ILKS
THE CHAOS OF FETTERED CONTAGION
THE END


THE END

# Outline

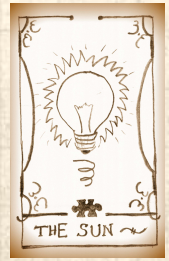




## Orientation

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

## References



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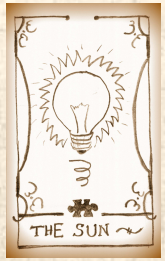

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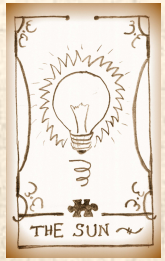

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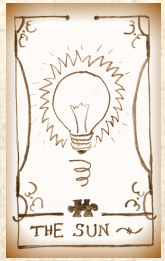

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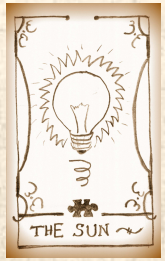

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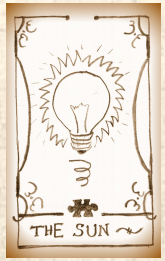

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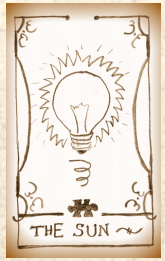

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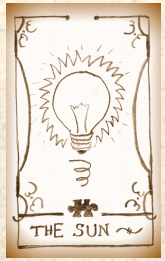

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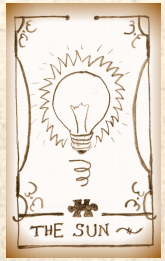

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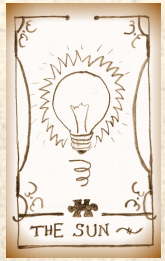
- We'll go through a list of possible projects soon.

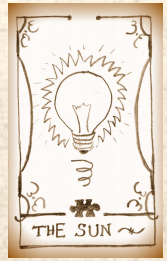


# The narrative hierarchy—Stories and Storytelling on all Scales:

- 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,
- ...



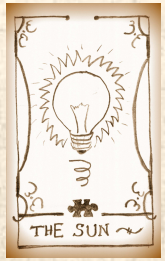




# The Boggoracle Speaks:







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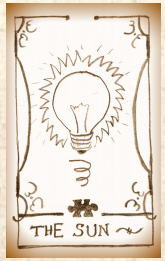

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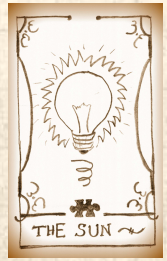

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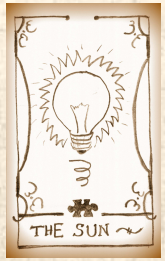

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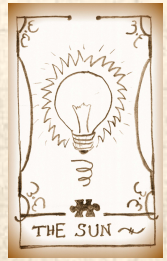

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