

# A Complex Systems Manifesto

## Principles of Complex Systems | @pocsvox

### CSYS/MATH 300, Fall, 2017

Prof. Peter Dodds | @peterdodds

Dept. of Mathematics & Statistics | Vermont Complex Systems Center  
Vermont Advanced Computing Core | University of Vermont



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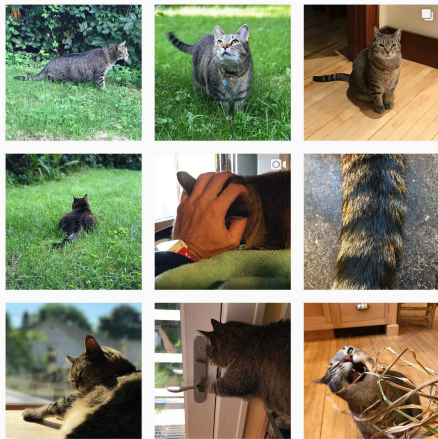
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## Special Guest Executive Producer: Pratchett

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



# Outline

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THE SUN



MANIFESTO



WELL OF SALES



THE LANGUAGE OF RELATING PEOPLE



REINVENTION OF KAREN WALKER



THE EMERGENCY OF TRANSFORMATION



EVERYONE GOT RICHER



THE EMERGENCY OF EFFICIENT LANGUAGE



THE LAW OF DIVINE FIRST



THE SURVIVAL OF THE Fittest PEOPLE



THE MURDER OF THE BANK OF CHINA



THE SURVIVAL OF THE FITTEST



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THE MEAT EATERS OF MOUNTAIN



THE MEASURING



THE DATA POWER



THE ONLINE DATA



THE GENERAL MANY MINDS PEOPLE



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It was the best of times,



THE GENERAL MANY MINDS PEOPLE



THE GENERAL MANY MINDS PEOPLE



THE NETWORK OF COMPLEXITY



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CLASSIFIED PEOPLE



THE CONCEPT OF CONTAGION



THE DISEASE



THE SPREADING OF CONTAGION



THE BIRTH OF GAMES



THE THEORISTS OF THE MIND



THE SOCIAL WILD



THE SOCIAL CONTAGION



THE HUNDREDS OF FAME



THE THREE CONTAGION



THE WINGS OF UNIVERSALITY



THE PERMANENT BING



THE HISTORY OF RESULTS



THE UNKNOWN MECHANISM



THE JOHN DICKY



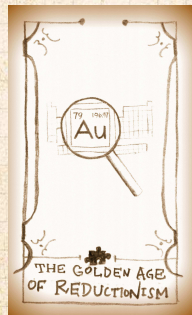
THE SPYING TALKING

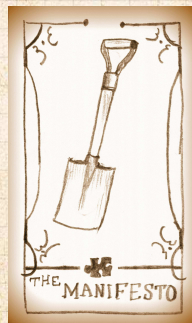


THE ARZACENY MARATIVES



THE END





# Definitions

**Complex:** (Latin = with + fold/weave (com + plex))



**Adjective:**

1. Made up of multiple parts; intricate or detailed.
2. Not simple or straightforward.



## Complicated versus Complex:

- 🧩 Complicated: Mechanical watches, airplanes, ...
- 🧩 Engineered systems can be made to be highly robust but not adaptable.
- 🧩 But engineered systems can become complex (power grid, planes).
- 🧩 They can also fail spectacularly.
- 🧩 Explicit distinction: Complex Adaptive Systems.





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## A while ago: The Wikipedia on Complex Systems:

“Complexity science is not a single theory: it encompasses more than one theoretical framework and is highly interdisciplinary, seeking the answers to some fundamental questions about living, adaptable, changeable systems.”

“Complex systems present problems both in mathematical modelling and philosophical foundations. The study of complex systems represents a new approach to science that investigates how relationships between parts give rise to the collective behaviors of a system and how the system interacts and forms relationships with its environment.”



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## Now:

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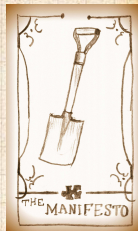


Nino Boccara in *Modeling Complex Systems*:

[3] "... there is no universally accepted definition of a complex system ... most researchers would describe a system of connected agents that exhibits an emergent global behavior not imposed by a central controller, but resulting from the interactions between the agents."

Philip Ball in *Critical Mass*:

[4] "...complexity theory seeks to understand how order and stability arise from the interactions of many components according to a few simple rules."



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## A working definition of a Complex System:

- ☰ Distributed system of many interrelated (possibly networked) parts with no centralized control exhibiting emergent behavior—'More is Different'<sup>[1]</sup>

## Other features/aspects:

- ☰ Explicit nonlinear relationships.
- ☰ Presence of feedback loops.
- ☰ Being open or driven, opaque boundaries.
- ☰ Memory.
- ☰ Modular (nested)/multiscale structure.
- ☰ Mechanisms range from being purely physical to purely algorithmic in nature.

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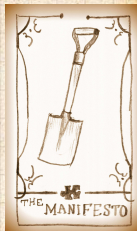


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# Examples of Complex Systems:


 human societies


 animal societies


 financial systems


 disease ecologies


 cells


 brains


 ant colonies


 social insects


 weather systems

 geophysical  
systems

 ecosystems

 Internet + Web

 power grids

 i.e., everything that's interesting ...



# Relevant fields:

- Physics
- Economics
- Sociology
- Psychology
- Information Sciences
- Cognitive Sciences
- Biology
- Ecology
- Geosciences
- Geography

- Medical Sciences
- Systems Engineering
- Computer Science
- ...

i.e., everything that's interesting ...



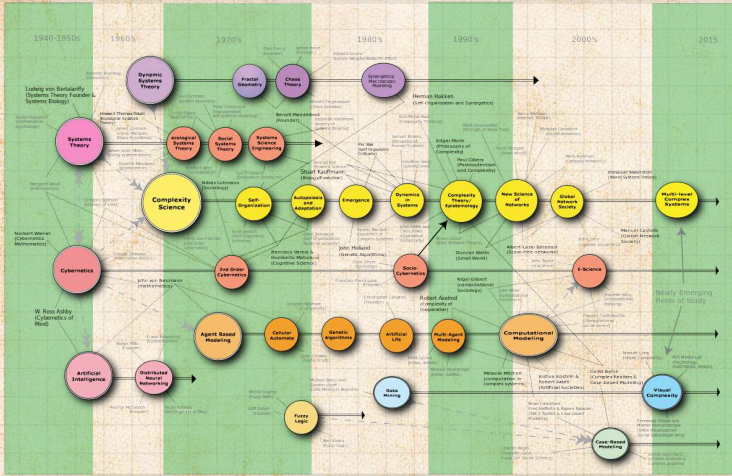


# A visualized history of Complex Systems fields:

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"Complexity Map" by Brian Castellani/Wiki  
Online here: [https://en.wikipedia.org/wiki/Complex\\_systems#History](https://en.wikipedia.org/wiki/Complex_systems#History)






# Reductionism:



Democritus 




(ca. 460 BC – ca. 370 BC)

-  Atomic hypothesis
-  Atom ~ a (not) – temnein (to cut)
-  Plato allegedly wanted his books burned.



John Dalton 

1766–1844

-  Chemist, Scientist
-  Developed atomic theory
-  First estimates of atomic weights

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“Boltzmann’s kinetic theory of gases seemed to presuppose the reality of atoms and molecules, but almost all German philosophers and many scientists like Ernst Mach and the physical chemist Wilhelm Ostwald disbelieved their existence.”

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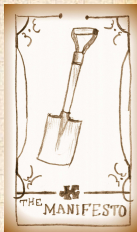


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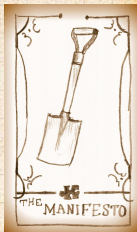


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See: epigenetics ↗.

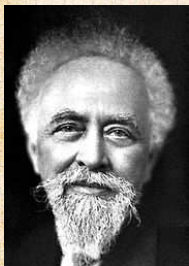


## Albert Einstein 1879-1955




 Annus Mirabilis paper:  “the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat” [4, 5]

 Showed Brownian motion  followed from an atomic model giving rise to diffusion.



## Jean Perrin 1870-1942

 1908: Experimentally verified Einstein's work and Atomic Theory.



## Feynmann:

"If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words?"

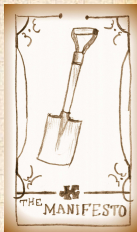


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"I believe it is the atomic hypothesis that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. "In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied."

Snared from [brainpickings.org](http://brainpickings.org)

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# The Science of Complex Systems Manifesto:

1. Systems are ubiquitous and systems matter.
2. Consequently, much of science is about understanding how pieces dynamically fit together.
3. 1700 to 2000 = Golden Age of Reductionism: Atoms!, sub-atomic particles, DNA, genes, people, ...
4. Understanding and creating systems (including new 'atoms') is the greater part of science and engineering.
5. **Universality** : systems with quantitatively different micro details exhibit qualitatively similar macro behavior.
6. Computing advances make the Science of Complex Systems possible:
  - 6.1 We can measure and record enormous amounts of data; research areas continue to transition from data scarce to data rich.
  - 6.2 We can simulate, model, and create complex systems in extraordinary detail.






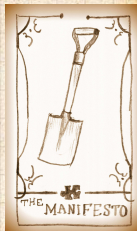
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
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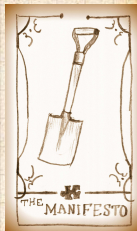
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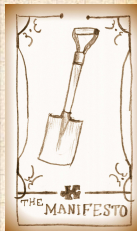
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# Neural reboot (NR):

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It's just better

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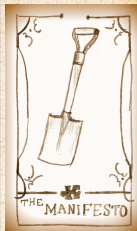
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[pdf](#) 

