A Complex Systems Manifesto

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Principles of Complex Systems, Vol. 1 | @pocsvox
CSYS/MATH 300, Fall, 2020

Prof. Peter Sheridan Dodds | @peterdodds

Computational Story Lab | Vermont Complex Systems Center
Vermont Advanced Computing Core | University of Vermont

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Outline


THE SUN
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 ROBUST YET FRAGILE
THE MISREADING OF THE BOOK OF SAND
THE MANY TALES OF MANY TAILS
THE MEASURING
THE DATA POOR
THE POURING DATA
THE CHARMS OF THE MANY WRONG PATHS
THE DOORS THAT SHOULD NOT BE OPENED
THE KNOWLEDGE OF DEAD MONKS
THE EMERGENCE OF STRUCTURE
THE EMERGENCE OF DESTRUCTION
THE EMERGENCE OF THINKING
It was the best of times,
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THE MECHANICS STATISTICAL
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
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THE JOHN DORY
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THE FATED ASTRAL PATH
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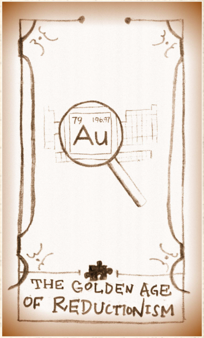
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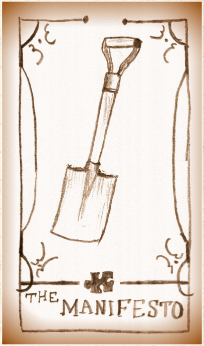
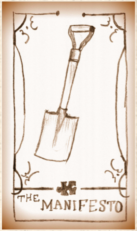

THE MANIFESTO

Definitions

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

Adjective:

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



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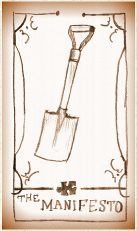

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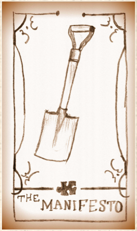

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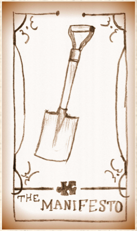

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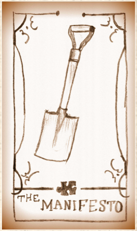

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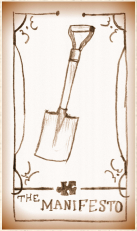
- They can also fail spectacularly.
- Explicit distinction: Complex Adaptive Systems.



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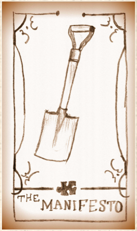
A working definition of a Complex System:

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



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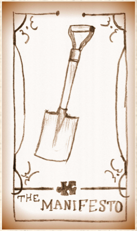

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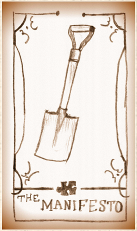

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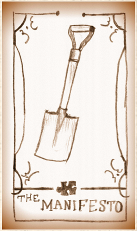

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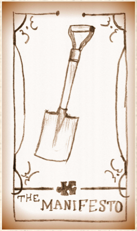

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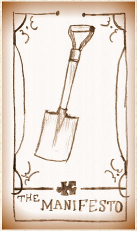

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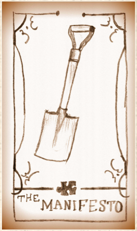

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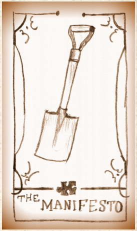
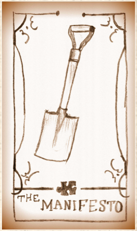
- Modular (nested)/multiscale structure.
- Mechanisms range from being purely physical to purely algorithmic in nature.



Examples of Complex Systems:

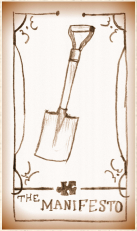
- human societies
- financial systems
- cells
- ant colonies
- fluids, weather systems
- ecosystems
- power grids
- animal societies
- disease ecologies
- brains
- social insects
- geophysical systems
- forests
- Internet + Web

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



Relevant fields:

- Physics
- Economics
- Sociology
- Psychology
- Information Sciences
- Cognitive Sciences
- Biology
- Ecology
- Geociences
- Geography
- Medical Sciences
- Systems Engineering
- Computer Science
- Data Science
- ...



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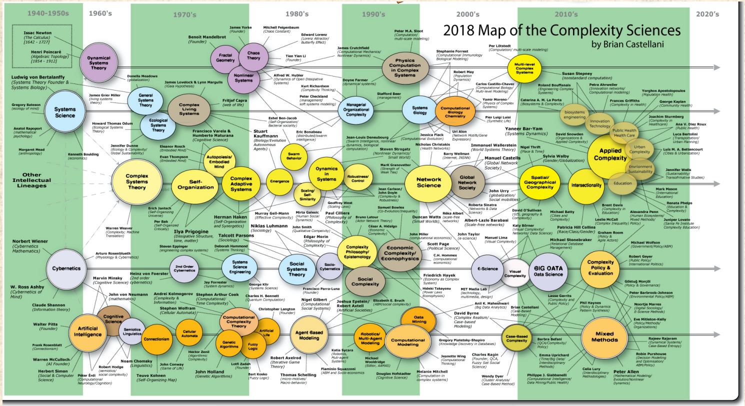
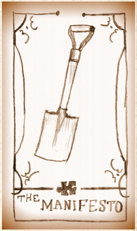
A visualized history of Complex Systemsish fields:

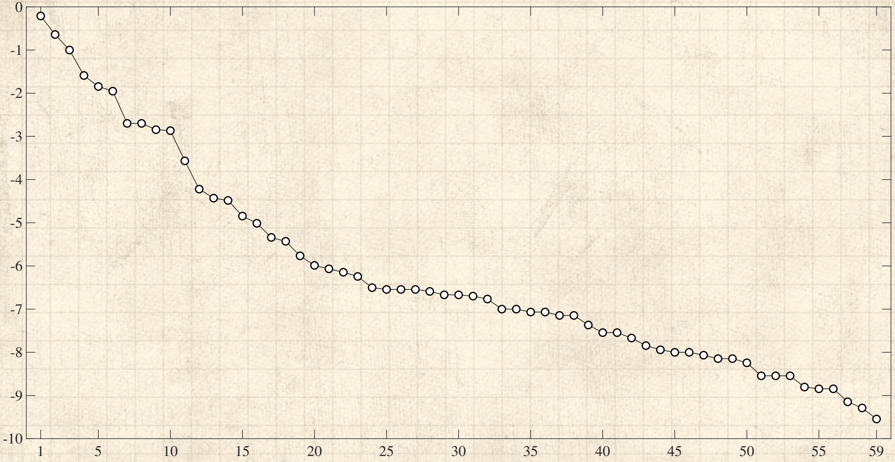


“Complexity Map” by Brian Castellani, Kent State

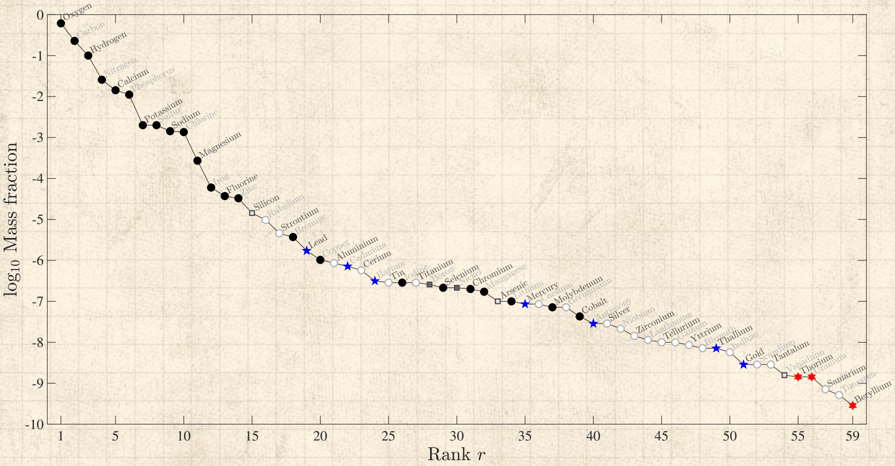
- Online here, at art-sciencefactory.com.
- Complex Systems is bigger than this (e.g., fluid dynamics; more later).



Cryptograph—What's being plotted here?:



Fractional weight of typical human body by atomic species:



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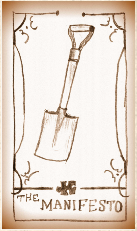

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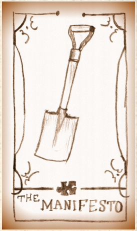

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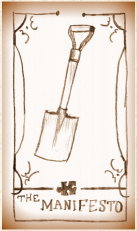

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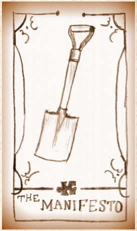

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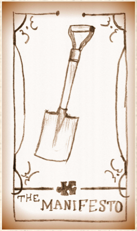

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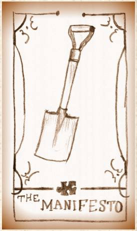

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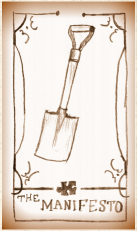

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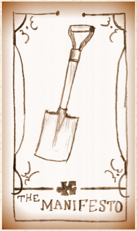
- Could be worse: A box with three packets containing up quarks, down quarks, and electrons.



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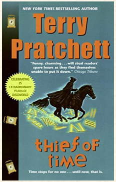
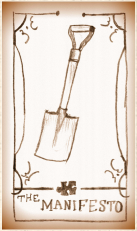
Best to see people as more than some kind of cleverly cooled quark soup:

"It was hard to deal with people when a tiny part of you saw them as a temporary collection of atoms that would not be around in another few decades."

—Susan Sto Helit (who is a "little bit immortal")



"Thief of Time"
by Terry Pratchett (2002). [5]



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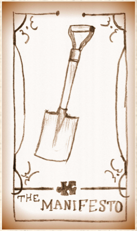
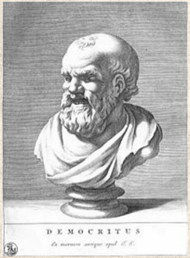


Reductionism:

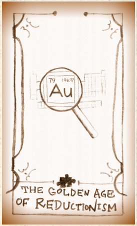


Democritus
(ca. 460 BC – ca. 370 BC)

- Atomic hypothesis
- Atom $\sim$ 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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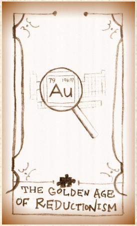
"Boltzmann's kinetic theory of gases seemed to presuppose the reality of atoms and molecules, but almost all German philosophers and many scientists like Ernst Mach and the physical chemist Wilhelm Ostwald disbelieved their existence."



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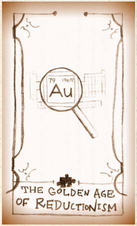

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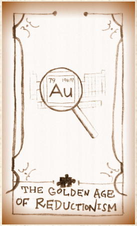

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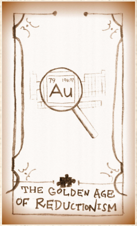

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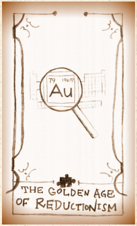

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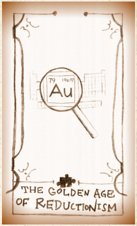

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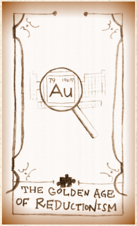
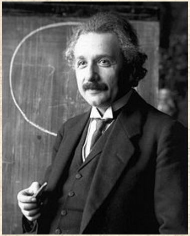
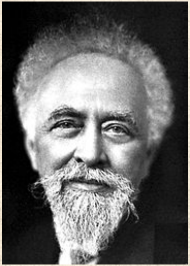
See: epigenetics.





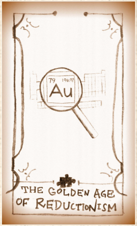
Albert Einstein 1879–1955

- Annus Mirabilis paper: “the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat” [2, 3]
- 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.



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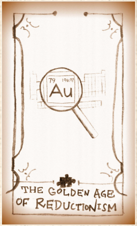
“If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words?



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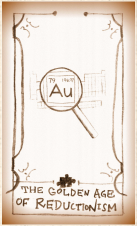

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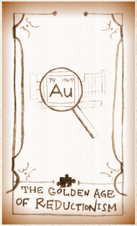

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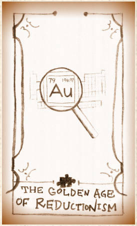
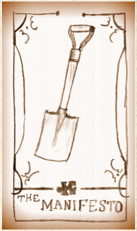



Manifesto


THE MANIFESTO

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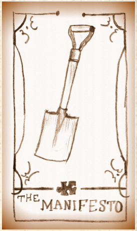

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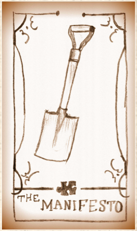

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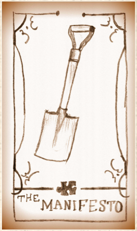

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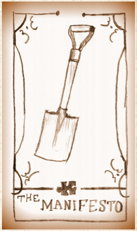

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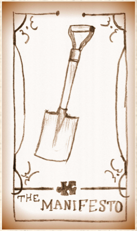

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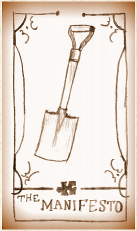

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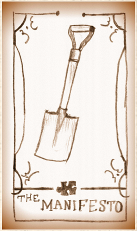

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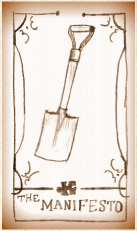

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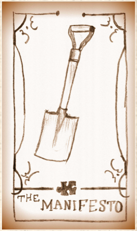

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