A Complex Systems Manifesto

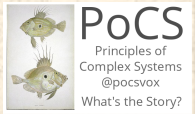
Last updated: 2022/08/28, 08:34:20 EDT

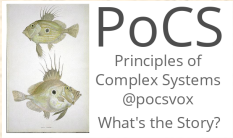
Principles of Complex Systems, Vols. 1, 2, & 3D
CSYS/MATH 300, 303, & 394, 2022–2023| @pocsvox

Prof. Peter Sheridan Dodds | @peterdodds

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





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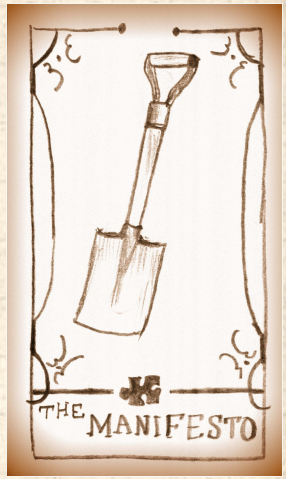
Outline

The Boggoracle Speaks:




THE SUN

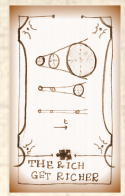

THE MANIFESTO

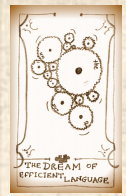

THE WELL OF SCALES


THE LAWS OF DECAYING POWER


THE UNEXPECTED TRANSFIGURATION


MINISTRY OF RANDOM WALKS


THE RICH GET RICHER


THE DREAM OF EFFICIENT LANGUAGE


1 2 5 4 3 6 7 8 9
THE LAW OF DIGITS FIRST


THE SURPRISE OF BEING ROBUST YET FRAGILE


THE MISREADING OF THE BOOK OF SAND


THE MANY TAILS OF MANY TAILS


THE MEASURING


THE DATA POOR


THE POURING DATA


THE CHARMS OF THE MANY WRONG PATHS


THE BOOKS THAT SHOULD NOT BE OPENED


THE KNOWLEDGE OF DEAD MINDS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THE ELEMENTS OF WEBS


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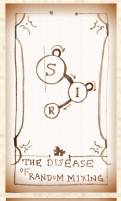
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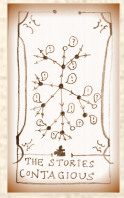
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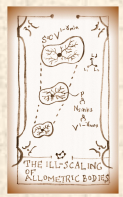
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THE DARK ART OF GENERATING FUNCTIONS


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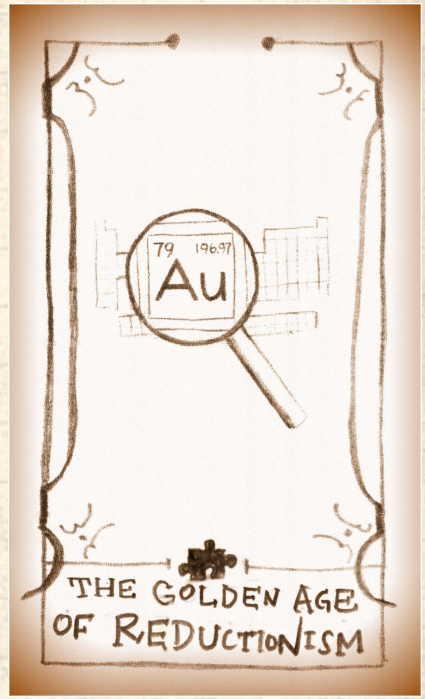
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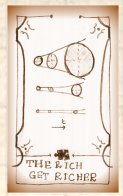
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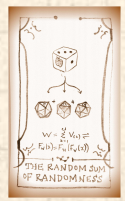
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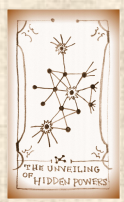
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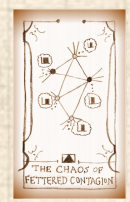
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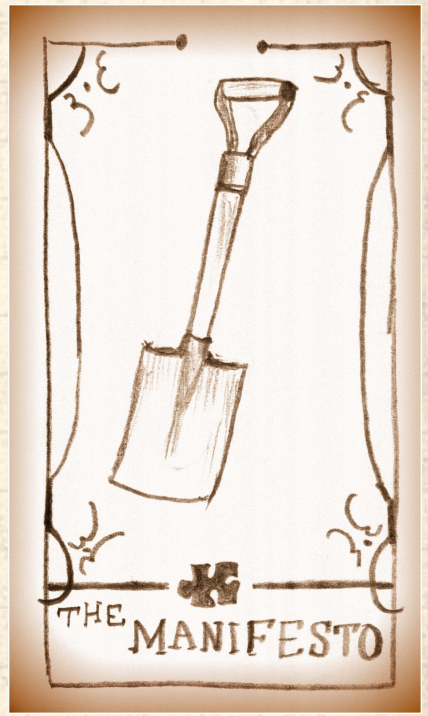
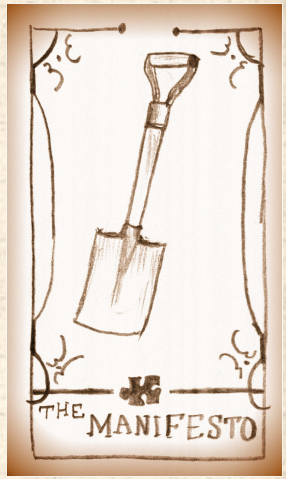

THE MANIFESTO

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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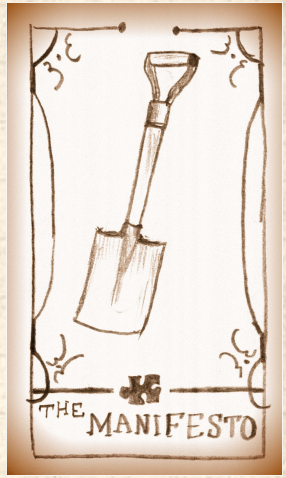
Complicated versus Complex:

- Complicated: Mechanical watches, airplanes, ...



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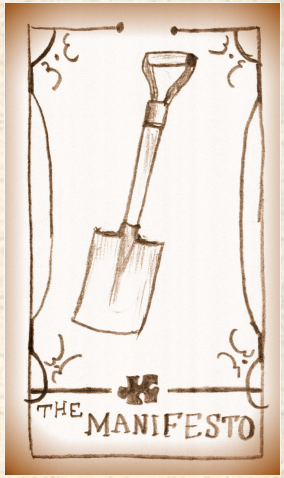

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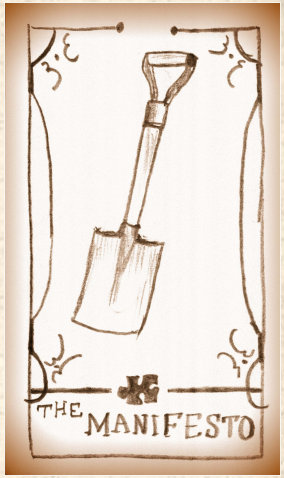

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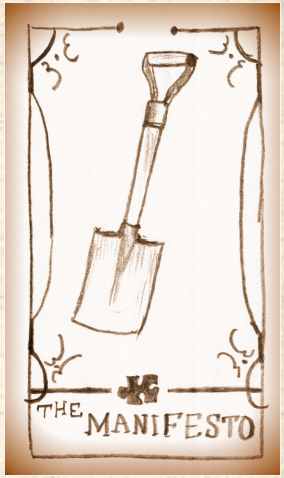

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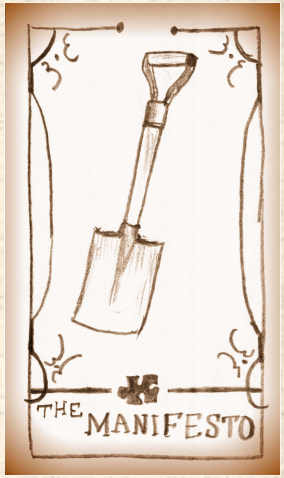
- Explicit distinction: Complex Adaptive Systems.



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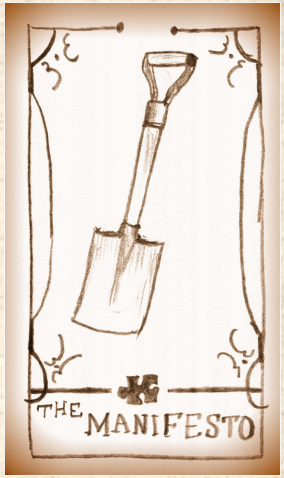
A working definition of a Complex System:

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



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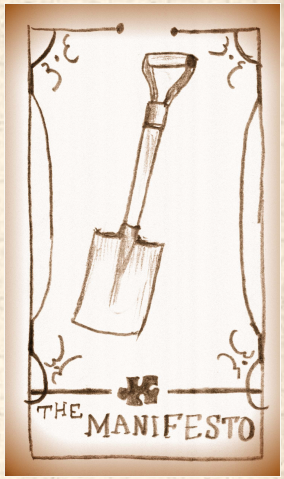

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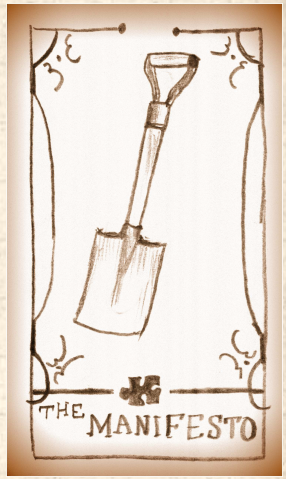

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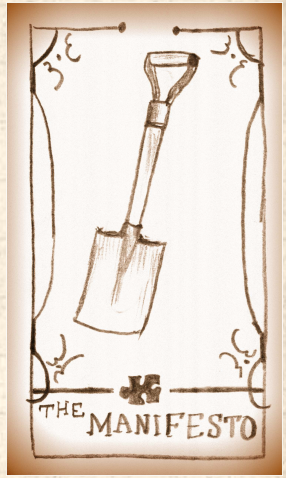
- Presence of feedback loops.



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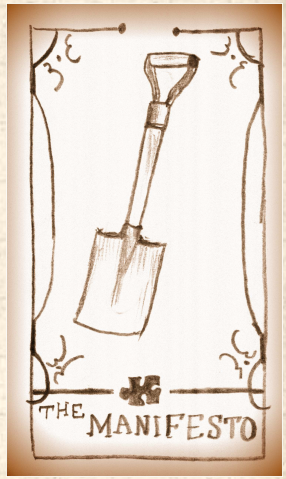

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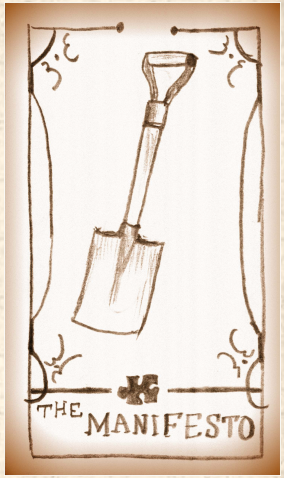

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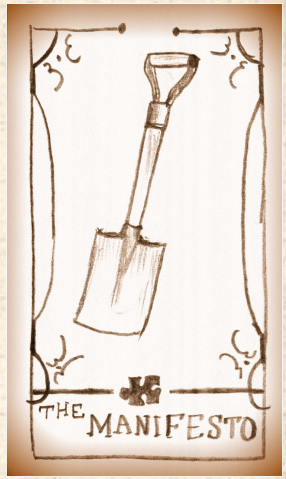
- Modular (nested)/multiscale structure.



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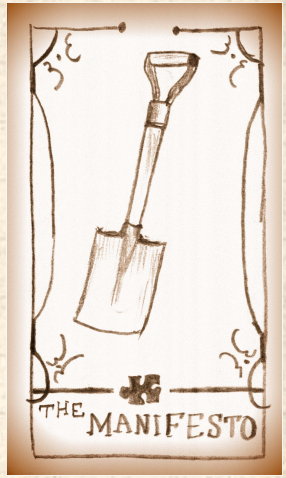
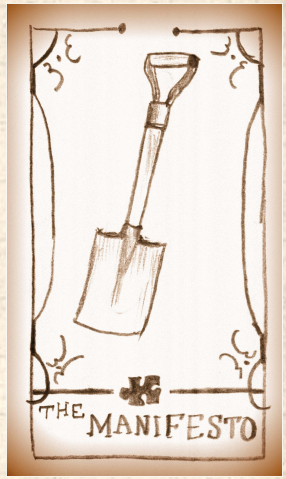
- Modular (nested)/multiscale structure.
- Mechanisms range from being purely physical to purely algorithmic in nature.



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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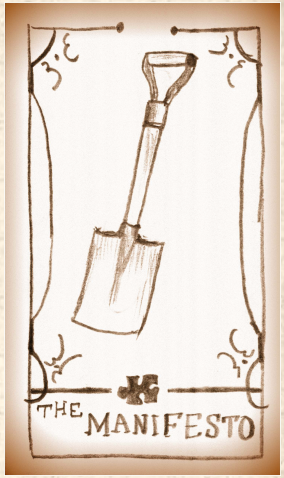
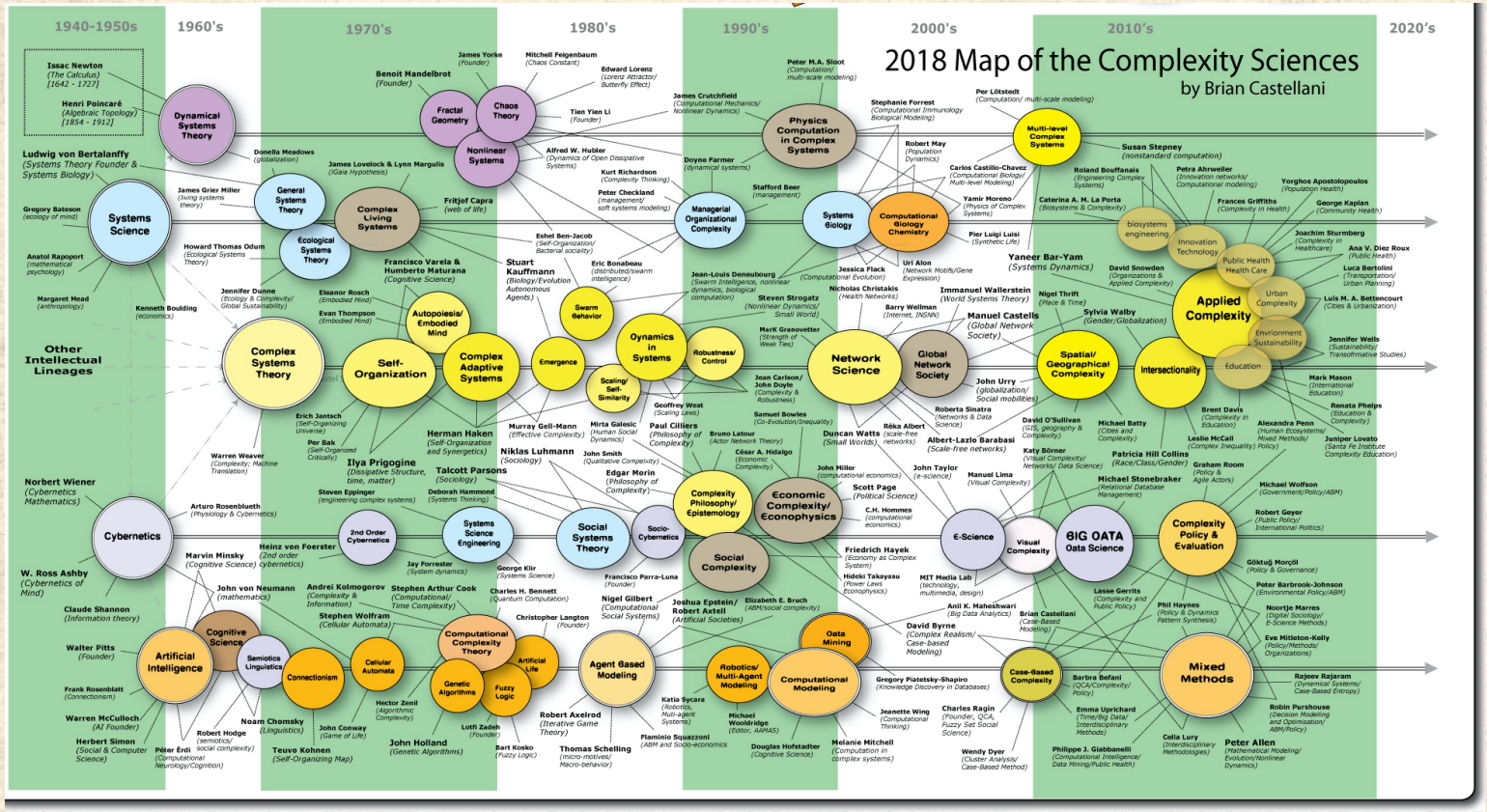
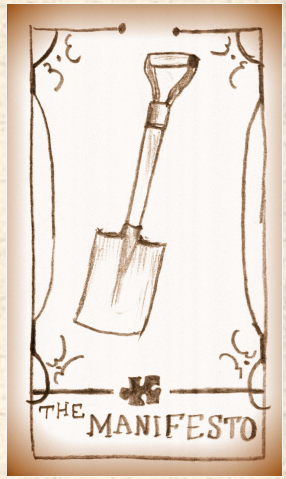


A visualized history of Complex Systemsish fields:

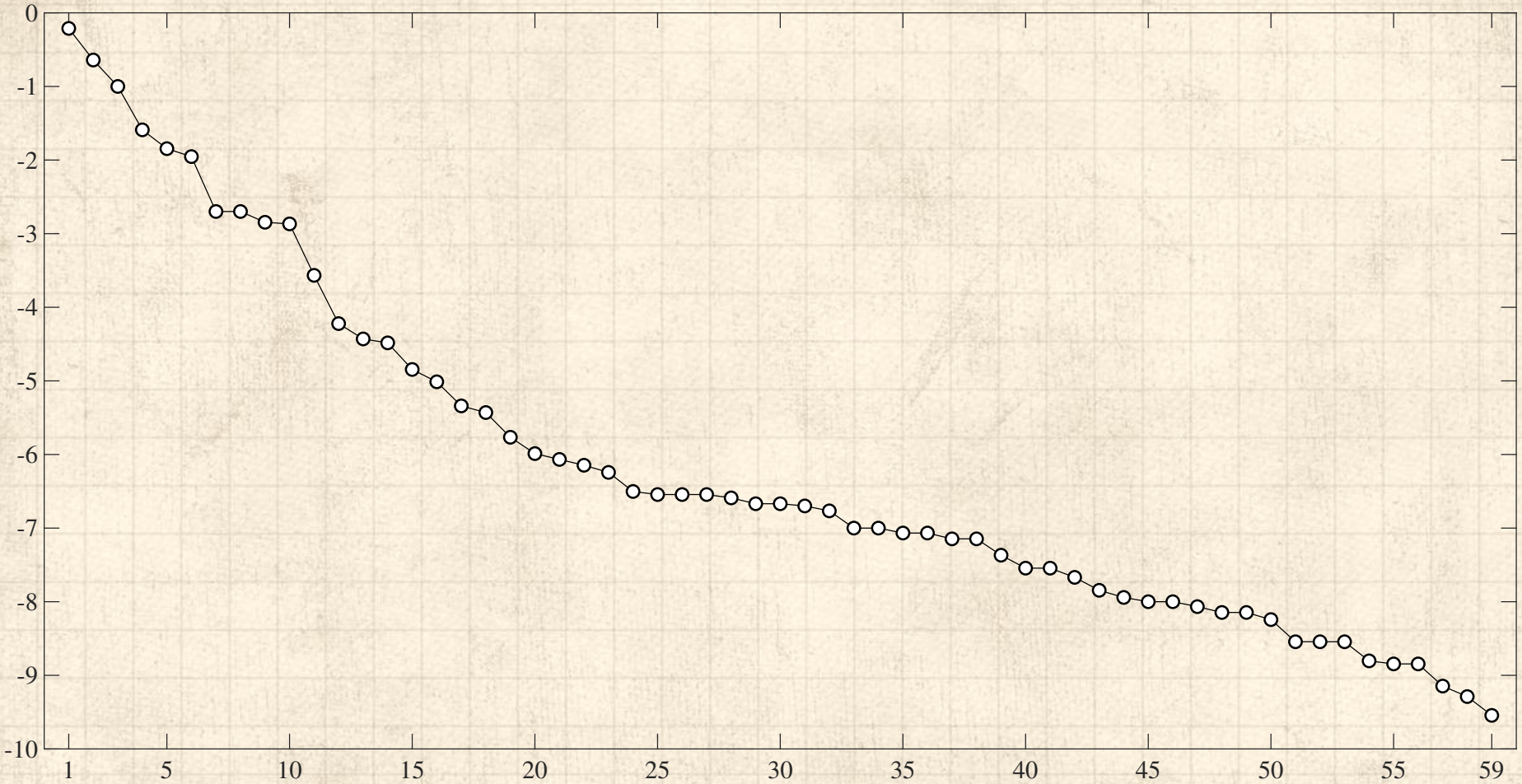


"Complexity Map" by Brian Castellani, Kent State

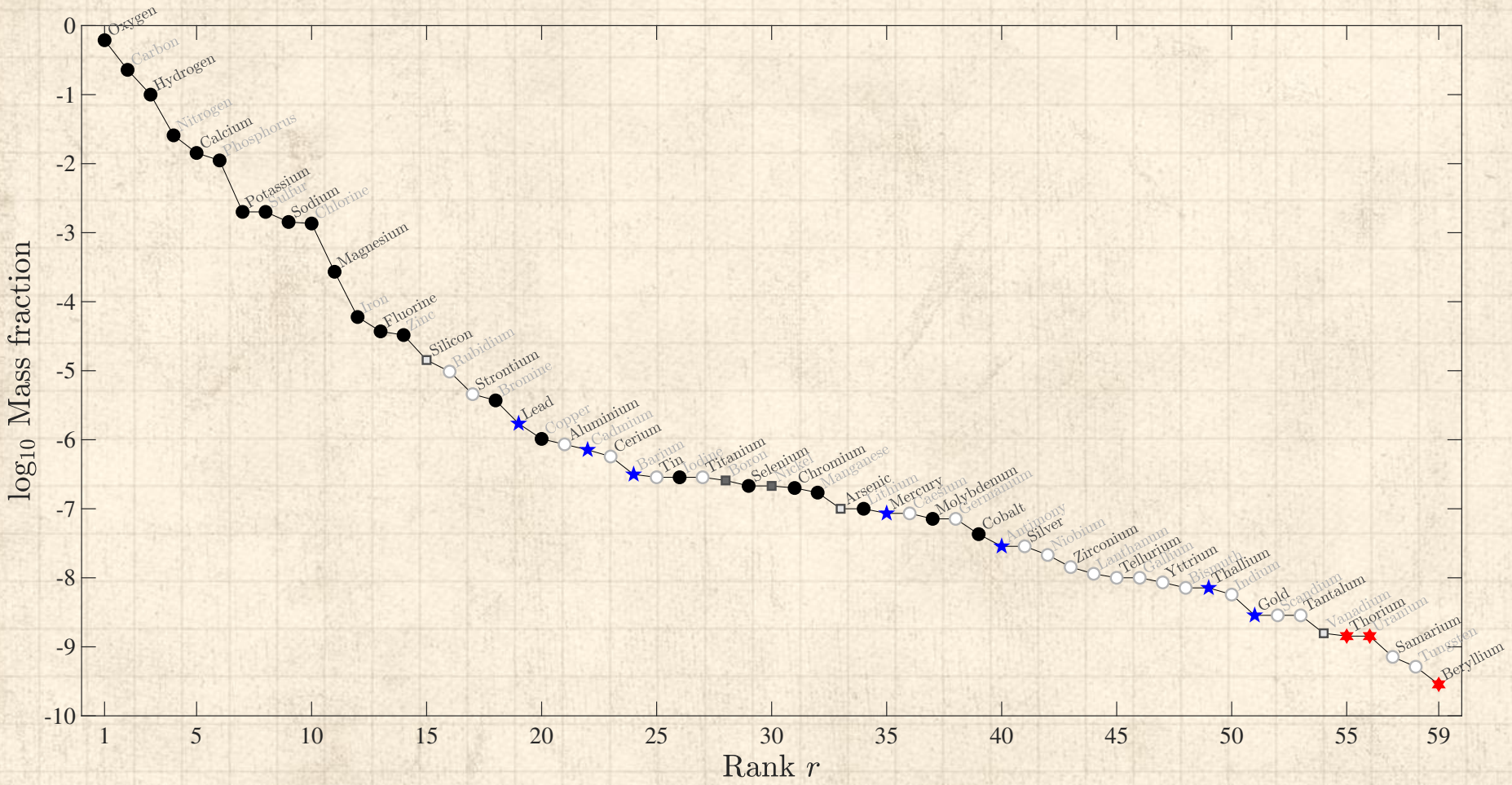
- Online here, at art-sciencefactory.com.
- Complex Systems is bigger than this (e.g., fluid dynamics; more later).



Cryptograph—What's being plotted here?:



Fractional weight of typical human body by atomic species:



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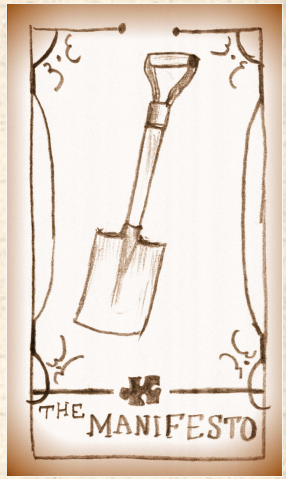

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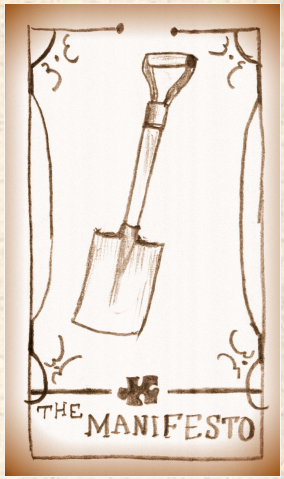

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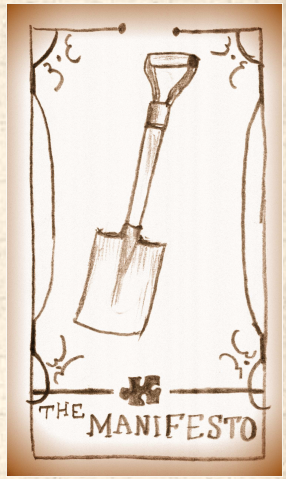
- Only in 2014 was bromine shown to be an essential trace element. [4]



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- Written on the box: “Nearly 10^{27} of 29 kinds of pieces!”
- Only in 2014 was bromine shown to be an essential trace element. [4]
- 6 elements make up $\approx$ 99% of the body’s elements:
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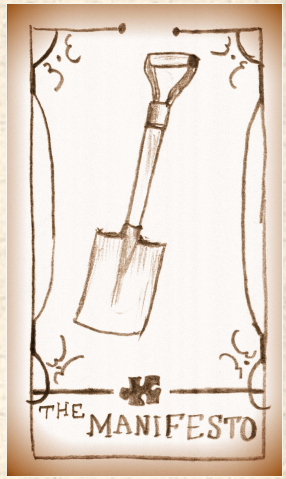

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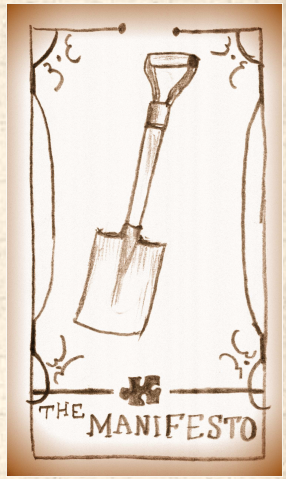

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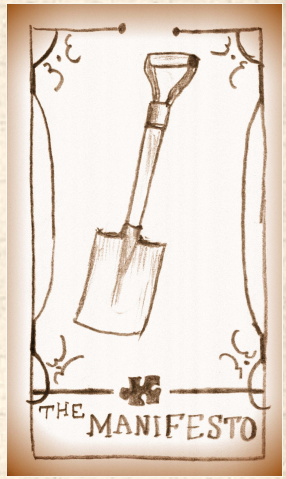

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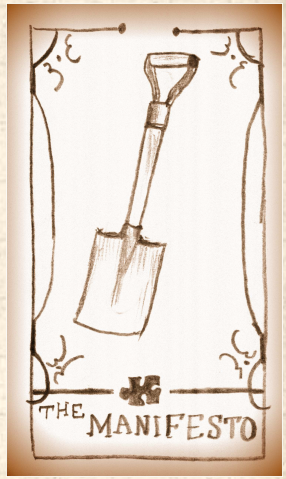

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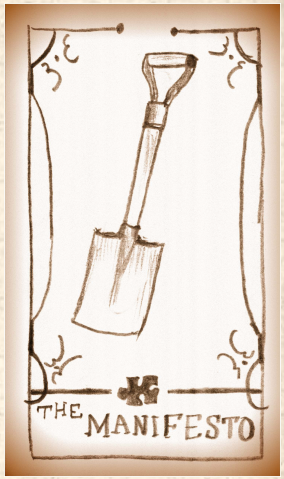
- Could be worse: A box with three packets containing up quarks, down quarks, and electrons.

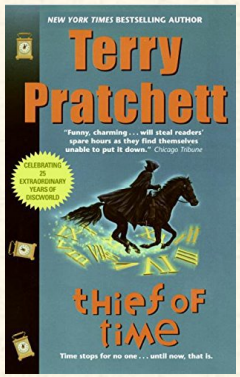


[1] Naturally varies with evilness

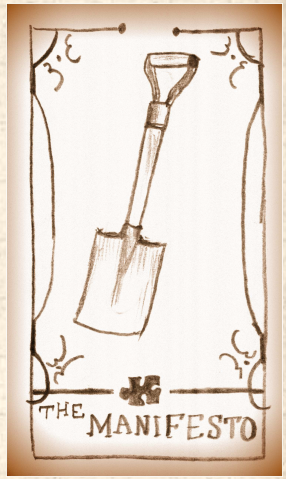
Best to see people as more than some kind of cleverly cooled quark soup:

"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."

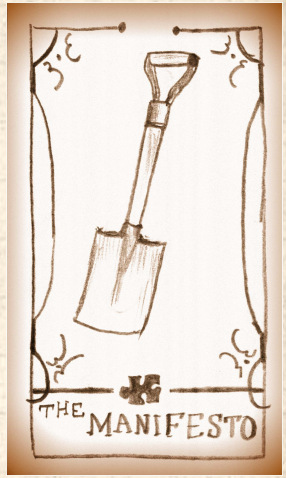
—Susan Sto Helit (who is a "little bit immortal")



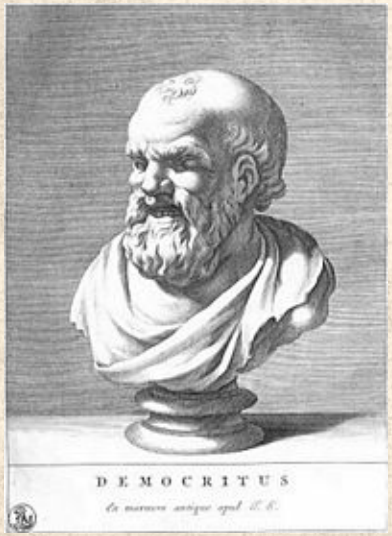
"Thief of Time"
by Terry Pratchett (2002). [5]



Or:



Reductionism:

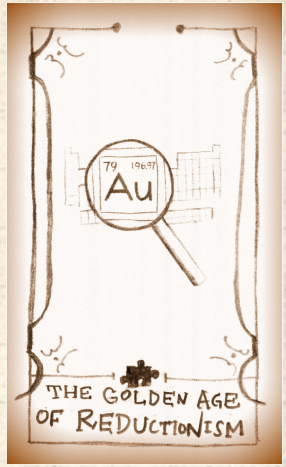


Democritus
(ca. 460 BC – ca. 370 BC)

- 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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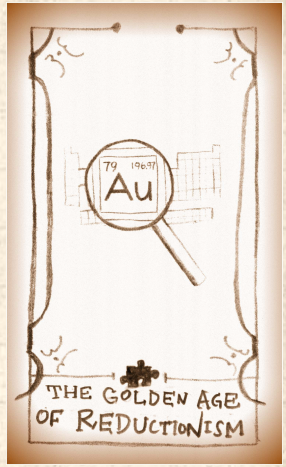

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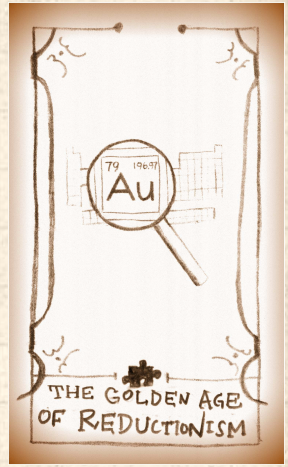

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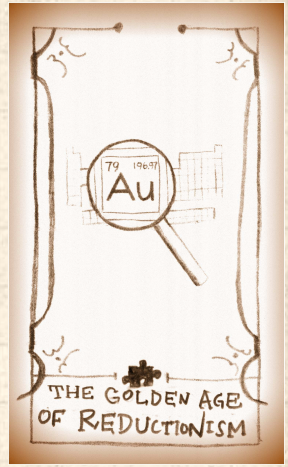

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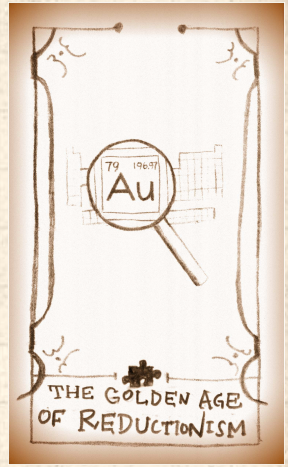

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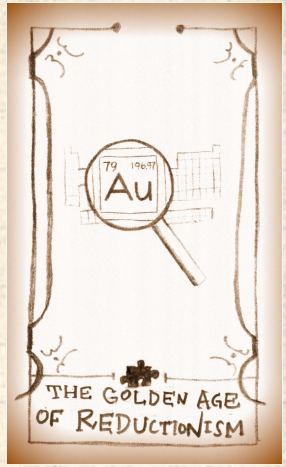

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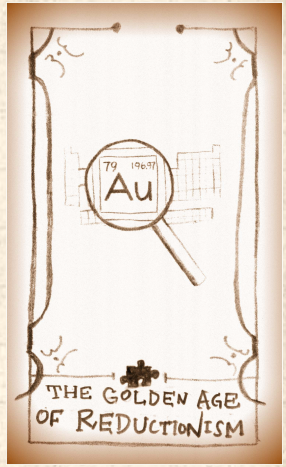

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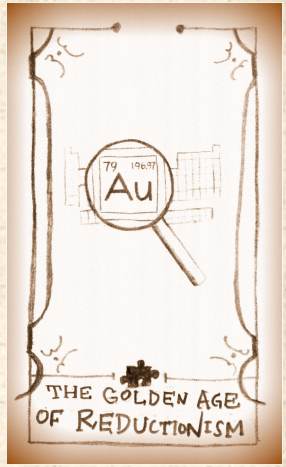
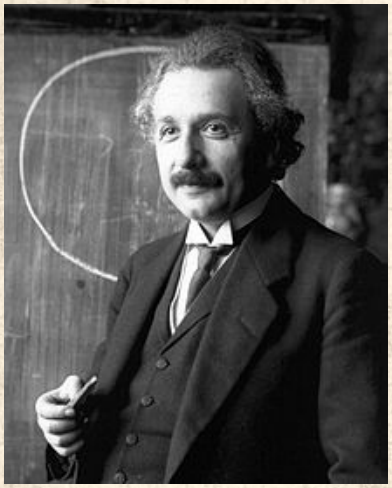
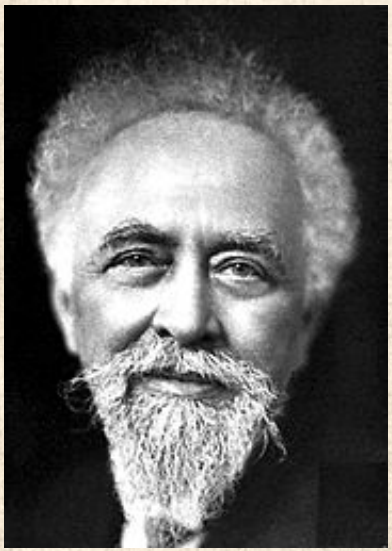
See: epigenetics.



Albert Einstein 1879–1955

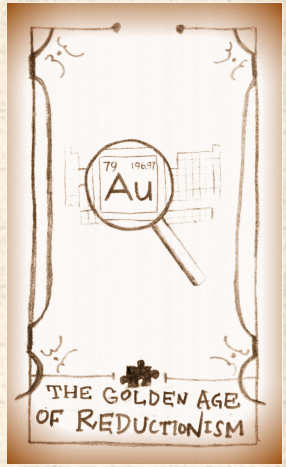


- Annus Mirabilis paper: “the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat” [2, 3]
- Showed Brownian motion followed from an atomic model giving rise to diffusion.



Jean Perrin 1870–1942

- 1908: Experimentally verified Einstein’s work and Atomic Theory.



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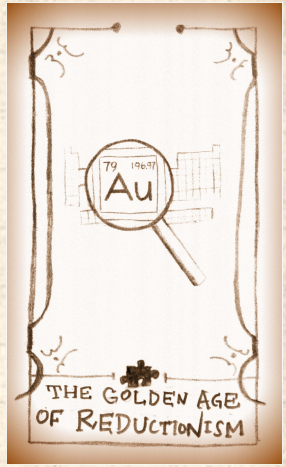

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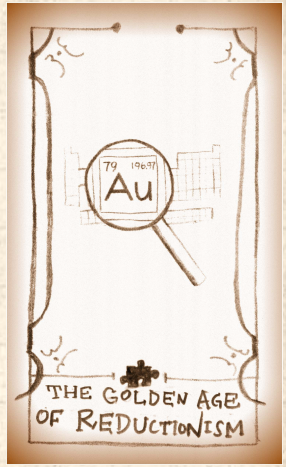

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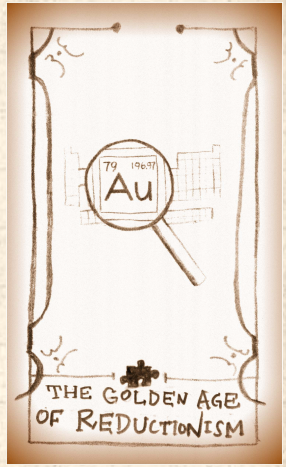

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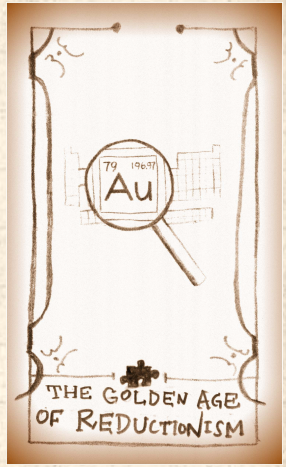
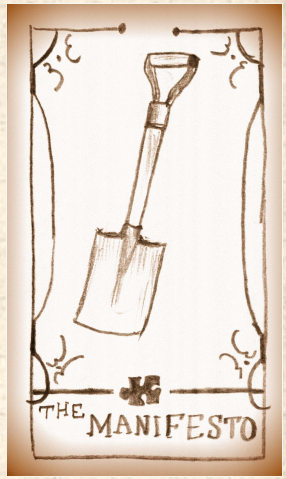


Manifesto



The Science of Complex Systems Manifesto:

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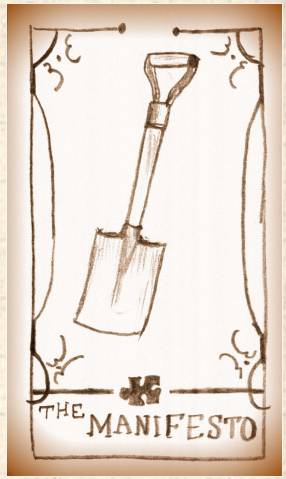

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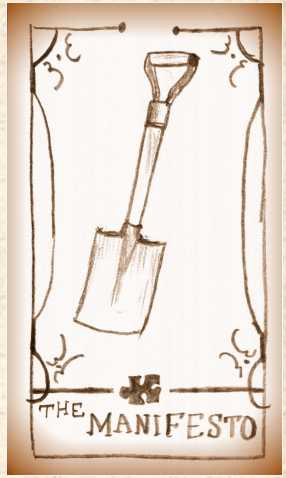

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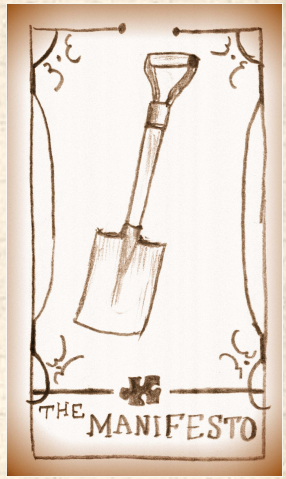

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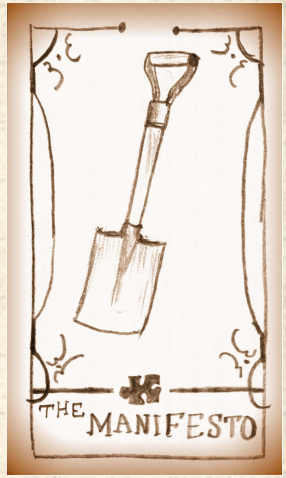

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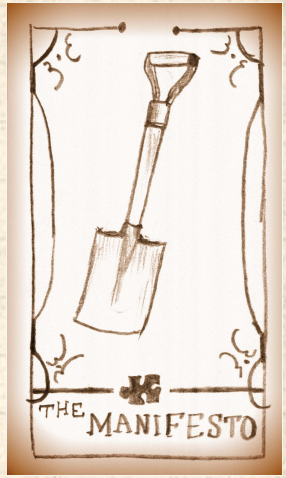

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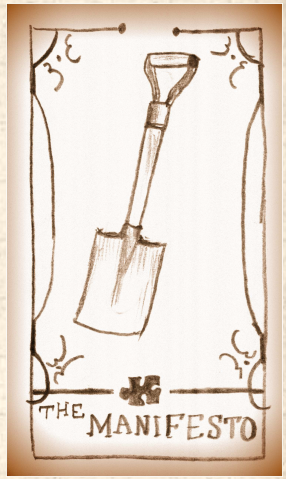

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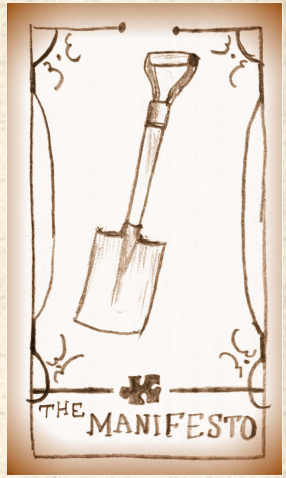

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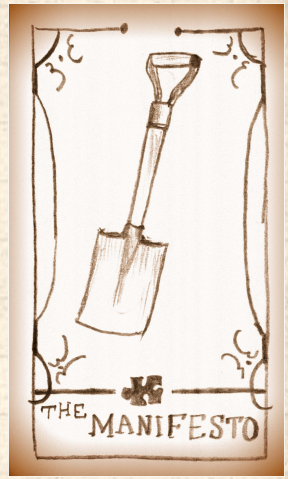

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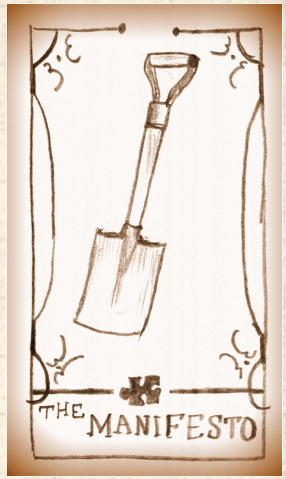

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