A Complex Systems Manifesto

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

Prof. Peter Sheridan Dodds

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

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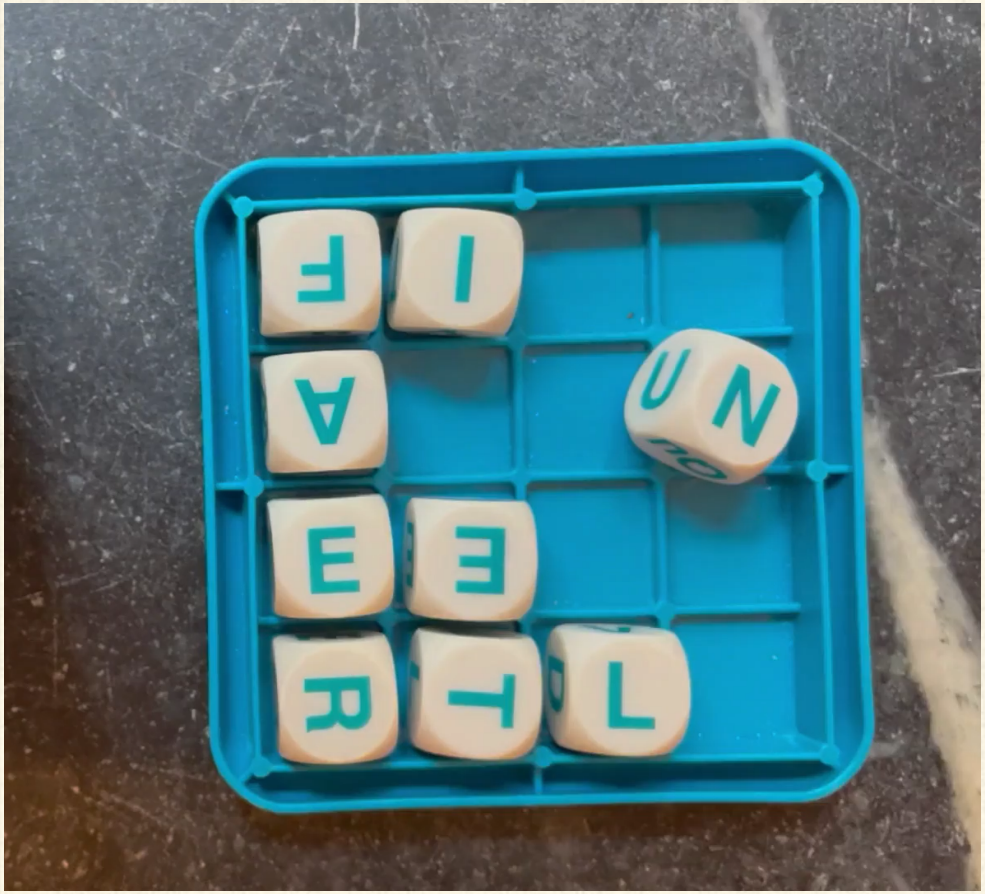
Outline

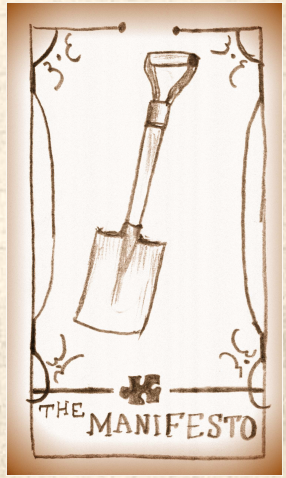
Defining Complexity

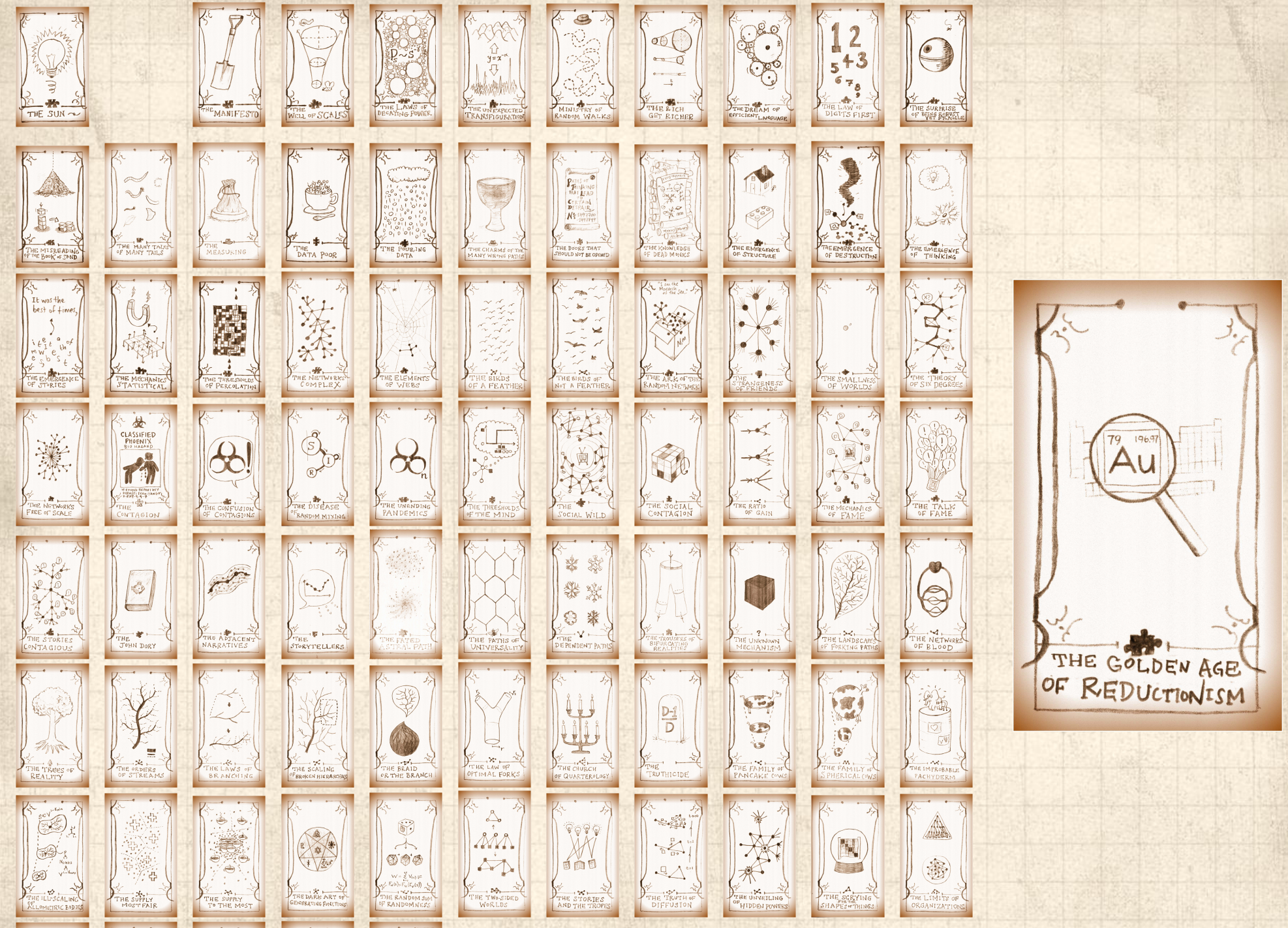
A Manifesto

References

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
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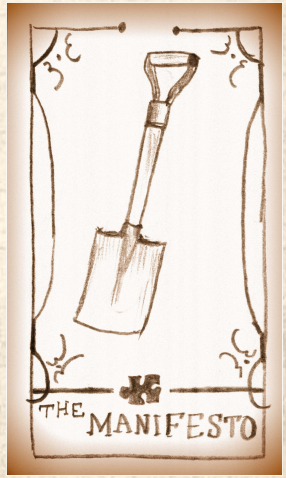
THE MANIFESTO

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:

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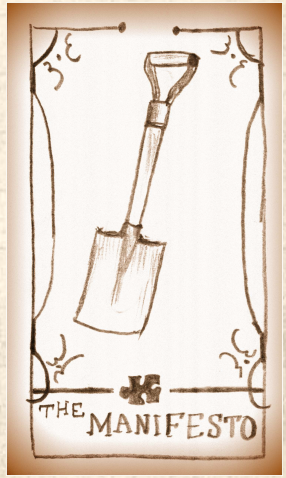

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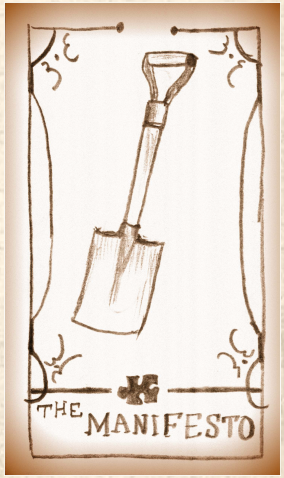

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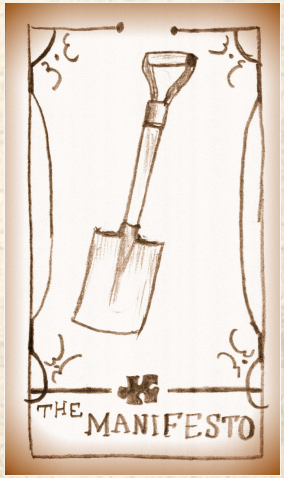

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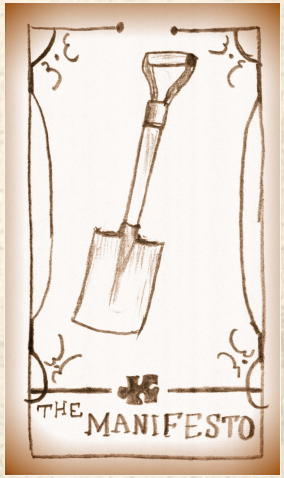

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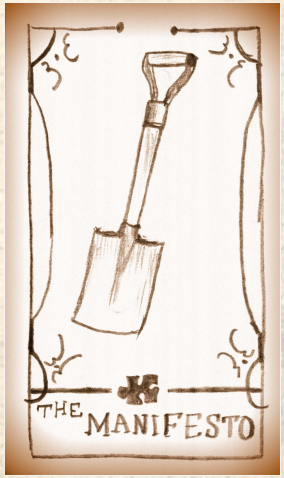
- Explicit distinction: Complex Adaptive Systems.



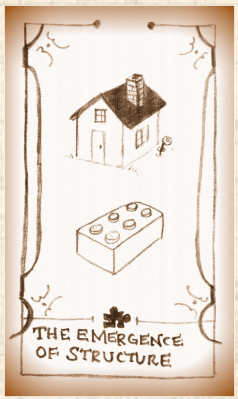
Definitions

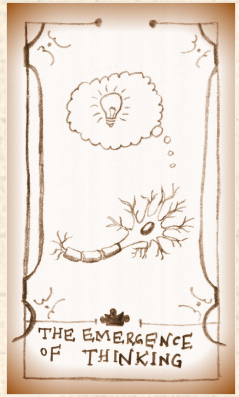
The definition of a Complex System:

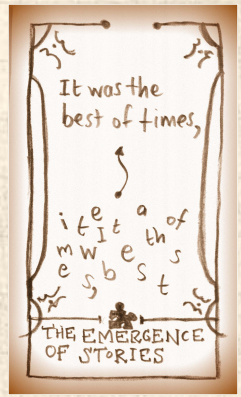
- Distributed system of many interrelated (possibly networked) parts with no centralized control exhibiting emergent behavior.

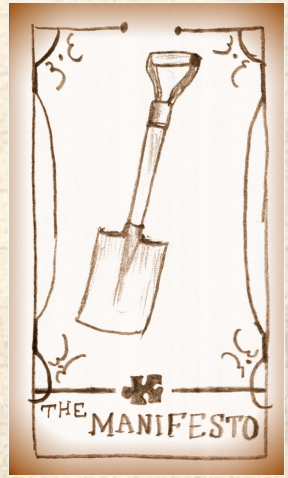
Emergence—'More is Different' [1]:

There's no tornado in a water molecule,
no financial collapse in a dollar bill,
no love in a carbon atom.

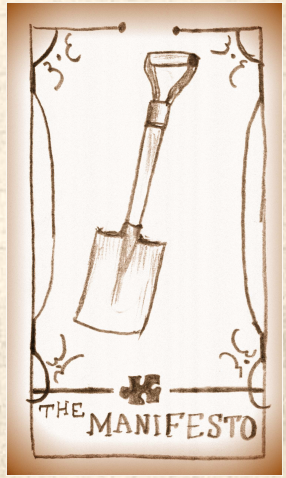








A few other features/aspects of complex systems:



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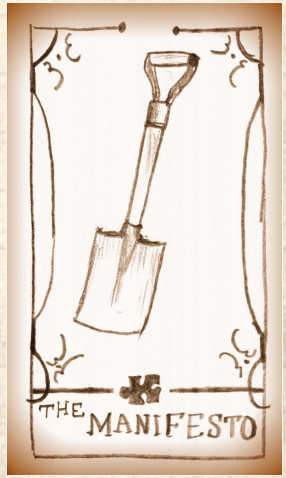

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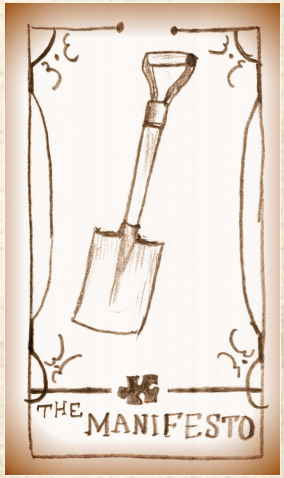

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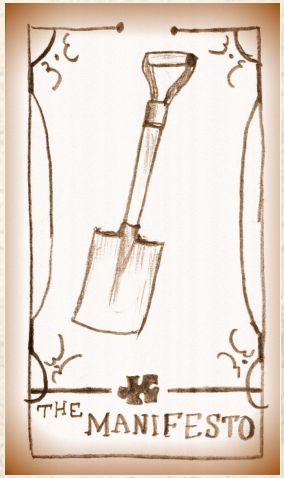

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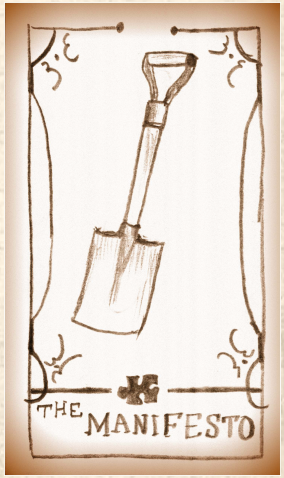
- Memory.



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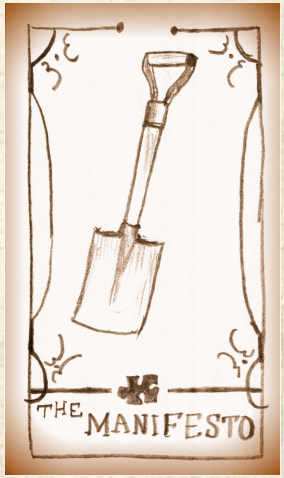

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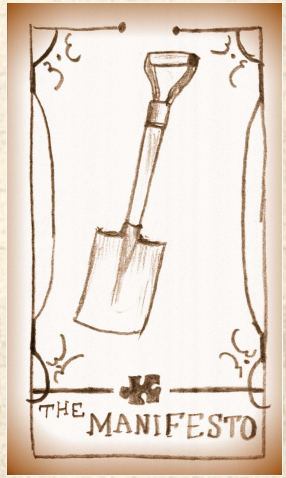
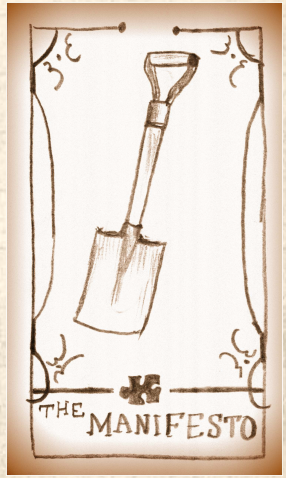
- Modular (nested)/multiscale structure.
- Mechanisms range from being purely physical to purely algorithmic in nature.



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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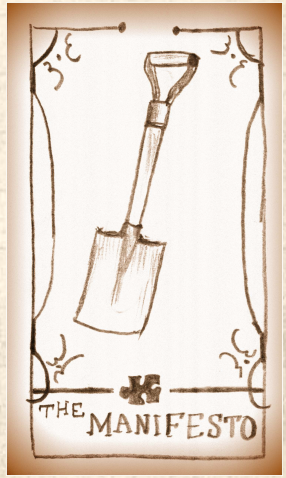
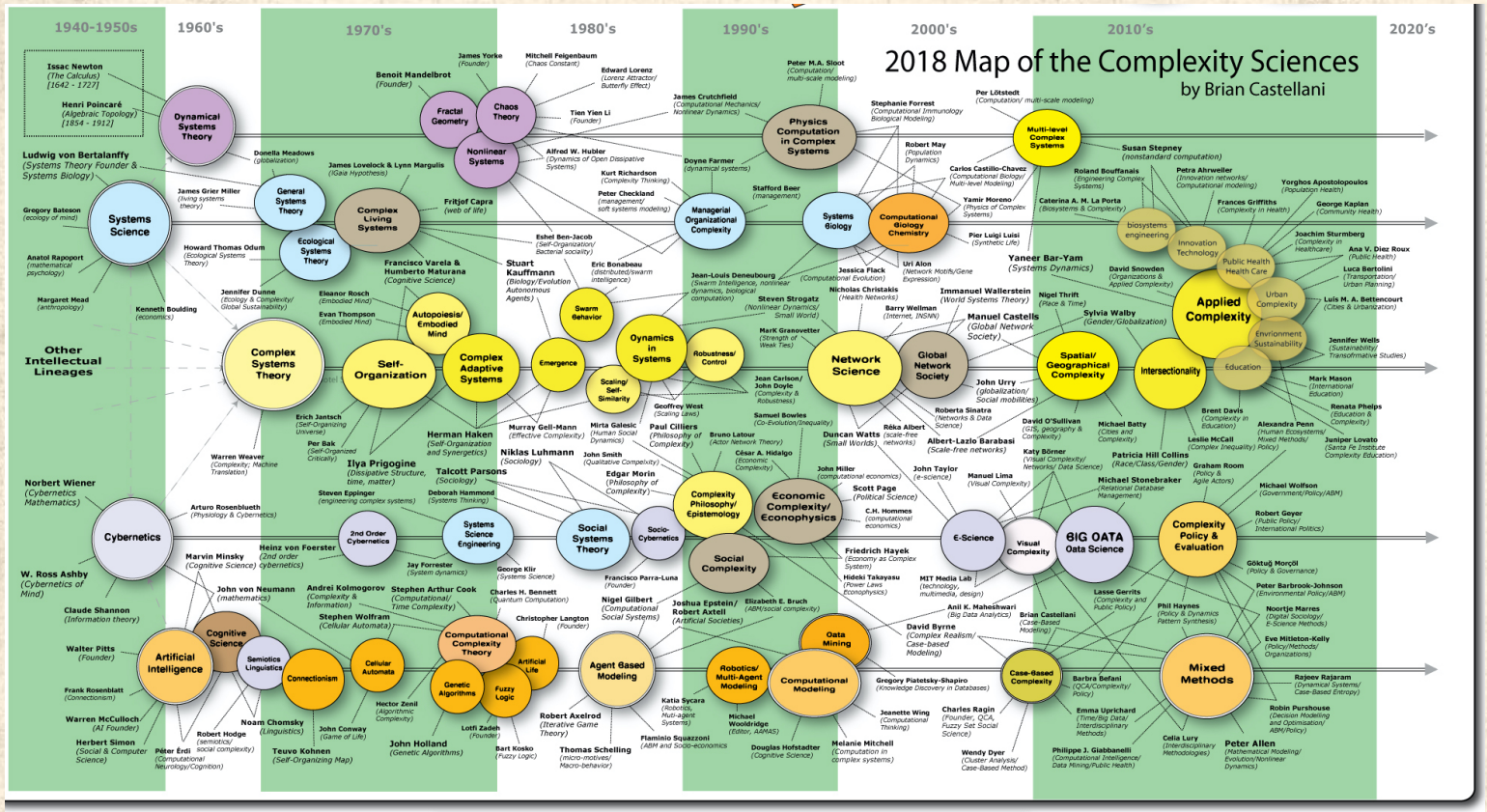
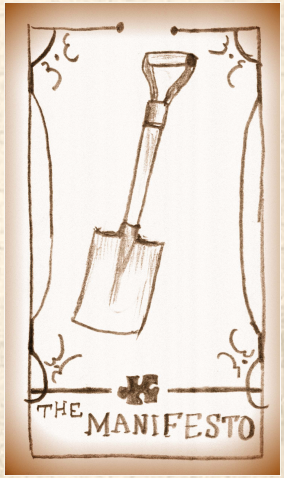


A visualized history of Complex Systemsish fields:

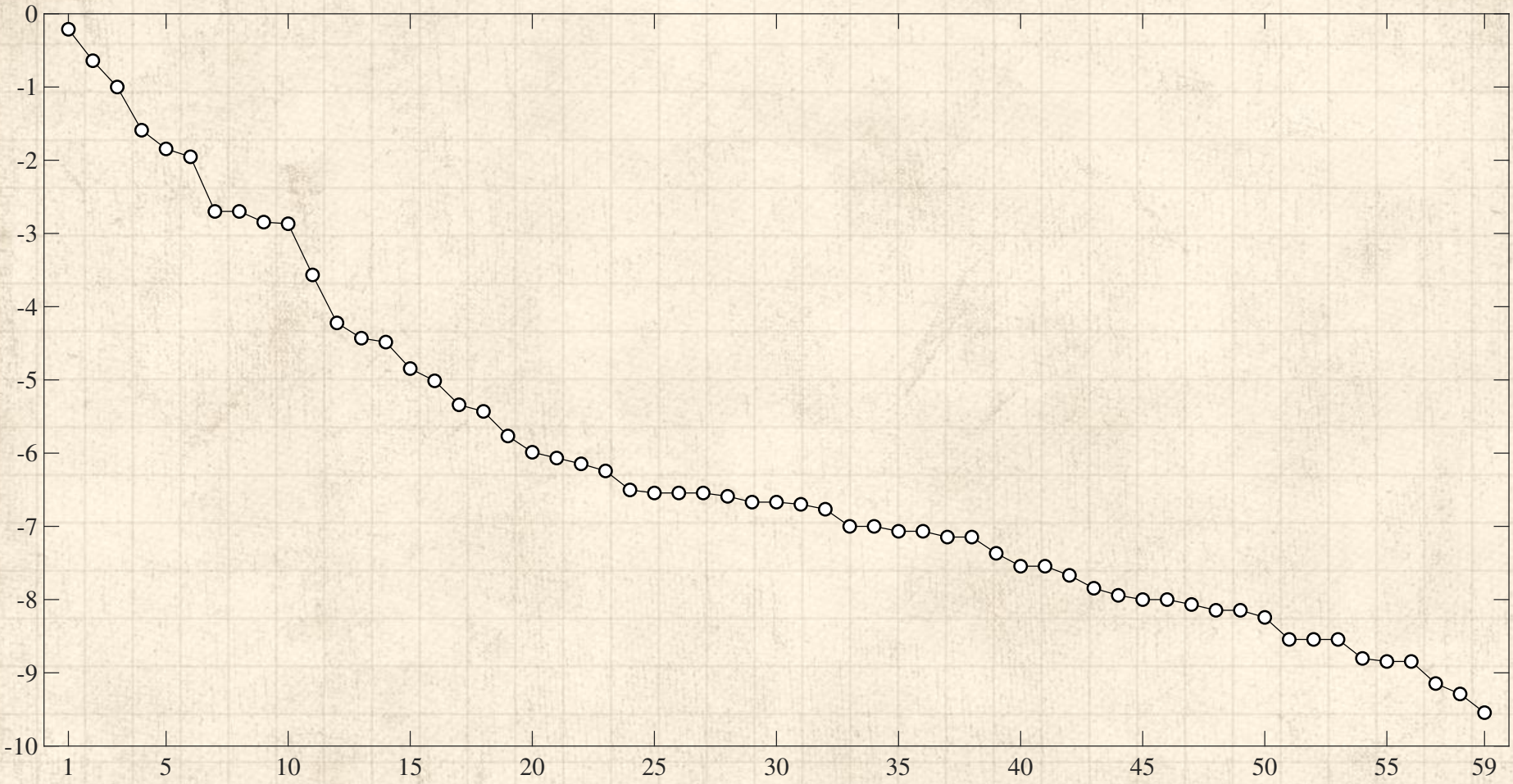


"Complexity Map" by Brian Castellani, Kent State

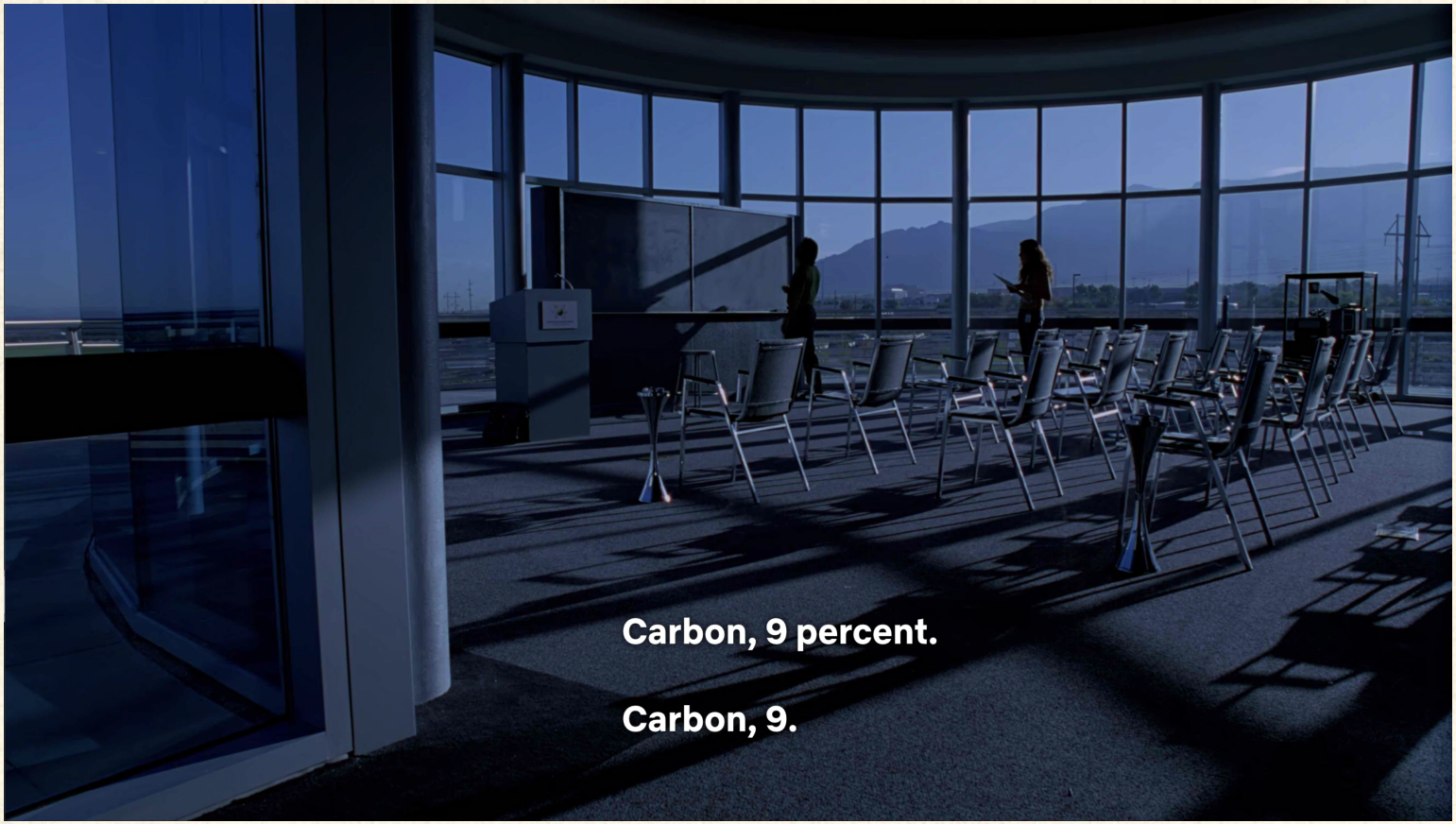
- Online here, at art-sciencefactory.com.
- Complex Systems is bigger than this (e.g., fluid dynamics; more later).

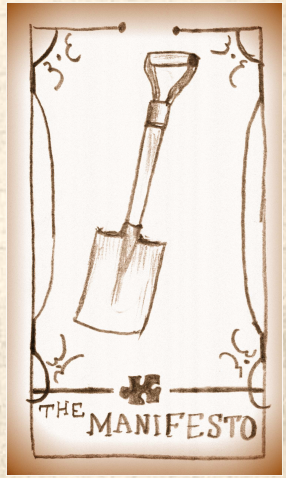


Cryptograph—What's being plotted here?:



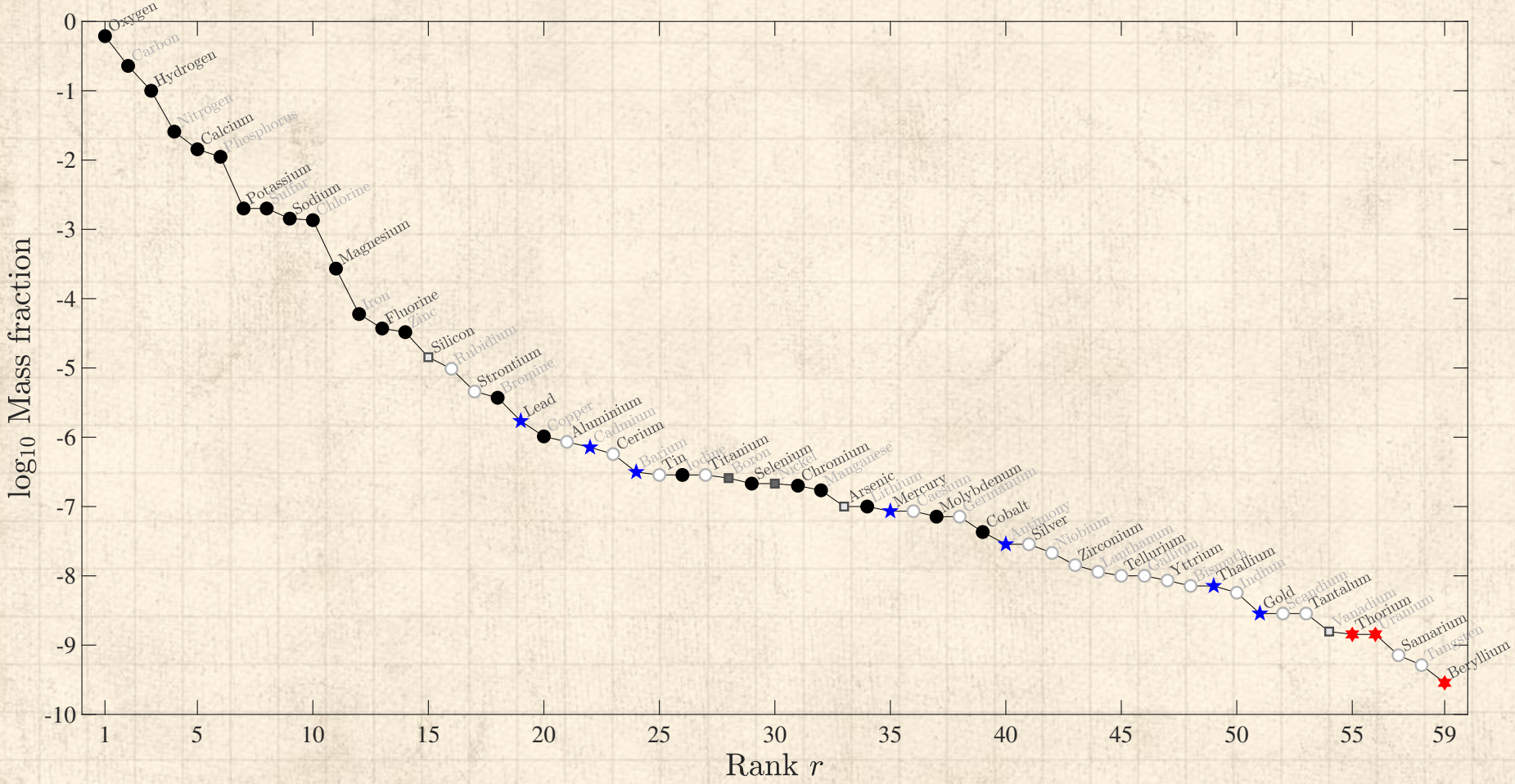
A hint[1]



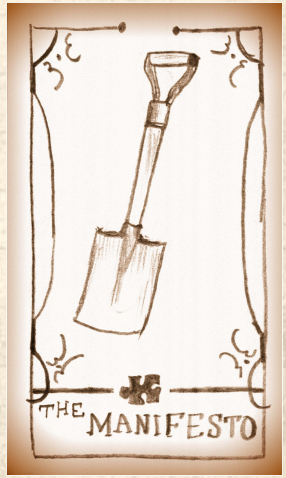


[1] S1E01

Fractional weight of typical human body by atomic species:



Baking soda and vinegar[1]



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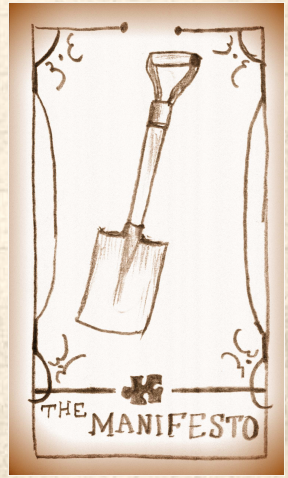

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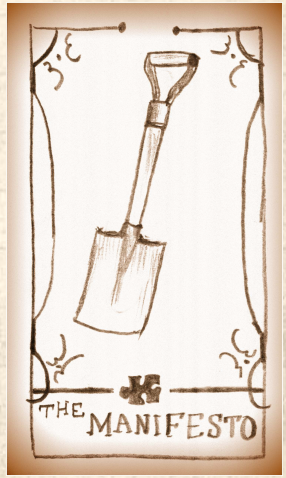

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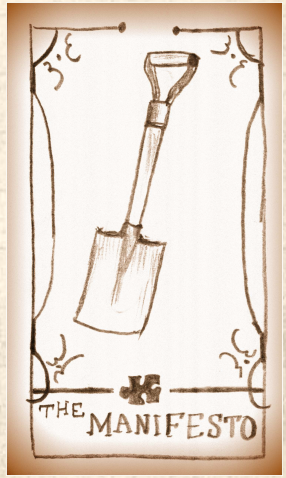

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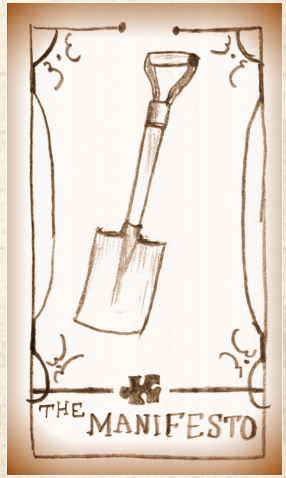

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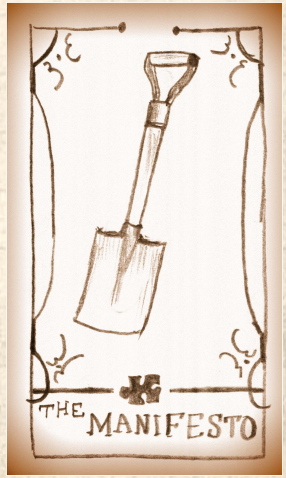

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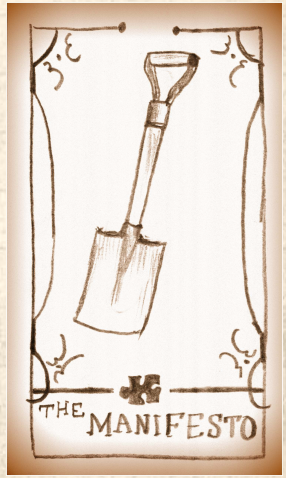

[1] Naturally varies with evilness

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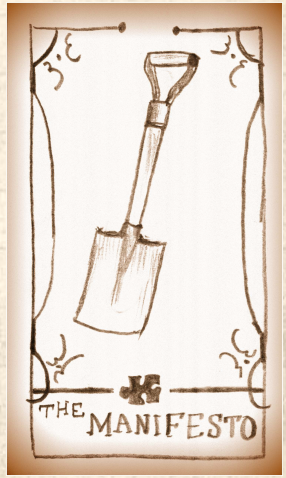

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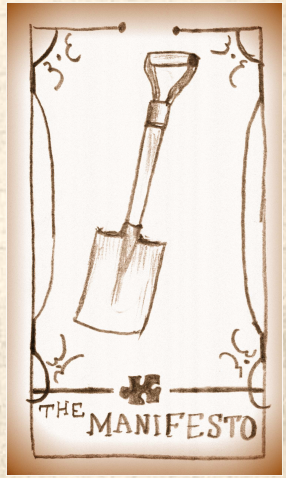
- Could be worse: A box with three packets containing up quarks, down quarks, and electrons.

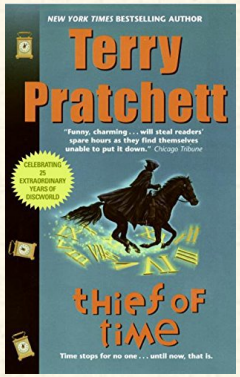


[1] Naturally varies with evilness

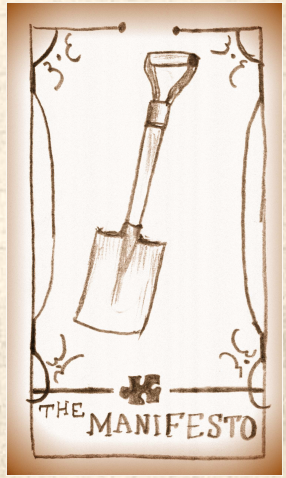
Best to see people as more than some kind of cleverly cooled quark soup:

"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."

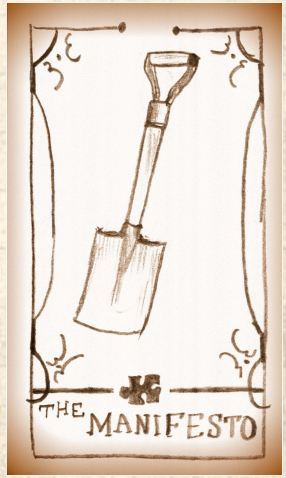
—Susan Sto Helit (who is a "little bit immortal")



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



Or:[1]



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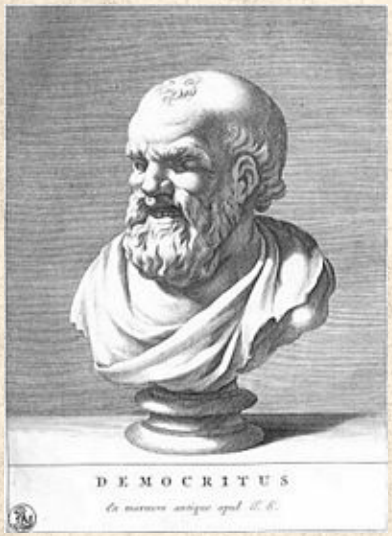
Reductionism:

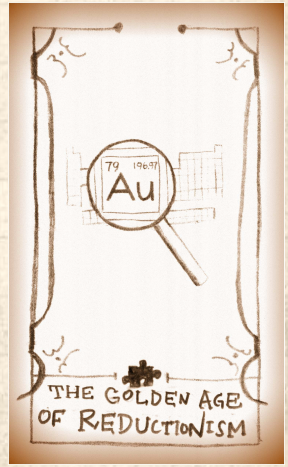


Democritus
(ca. 460 BC – ca. 370 BC)

- 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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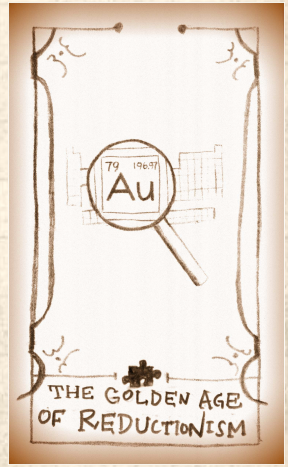

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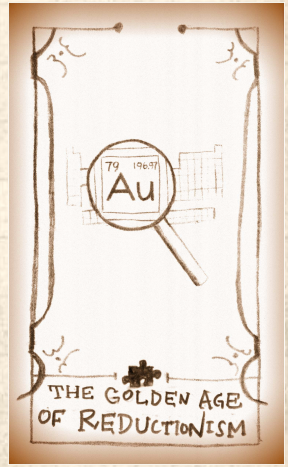

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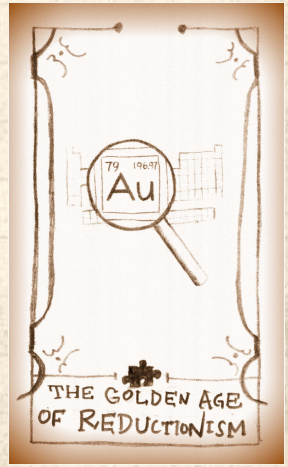

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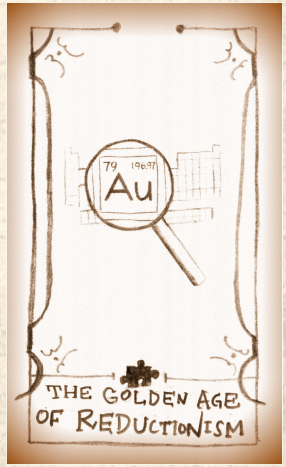

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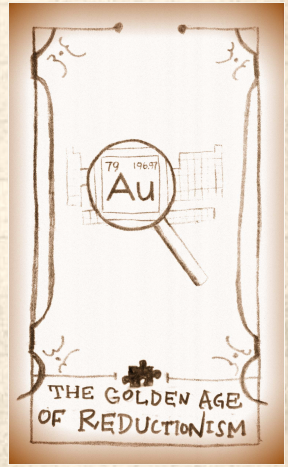

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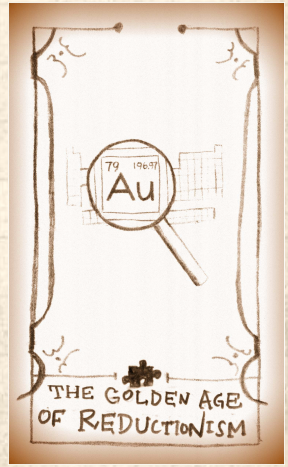

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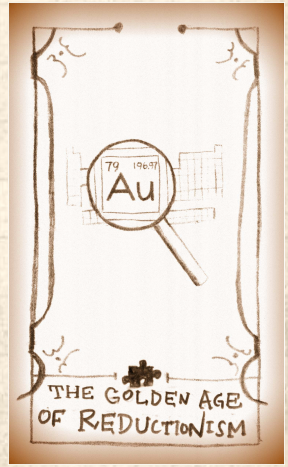
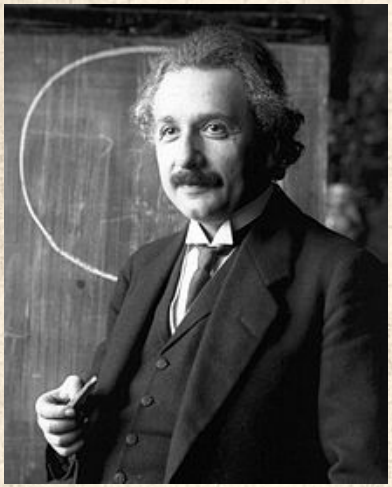
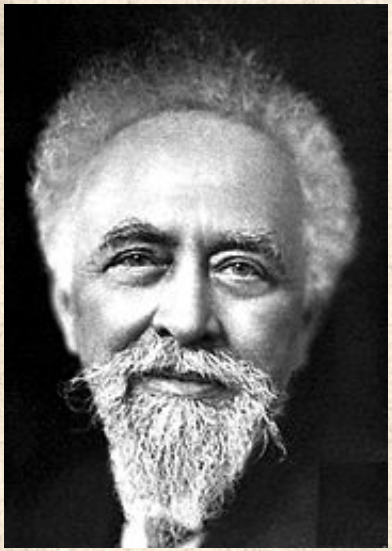
See: epigenetics.





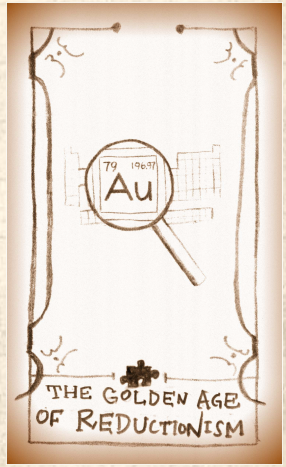
Albert Einstein 1879–1955

- 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

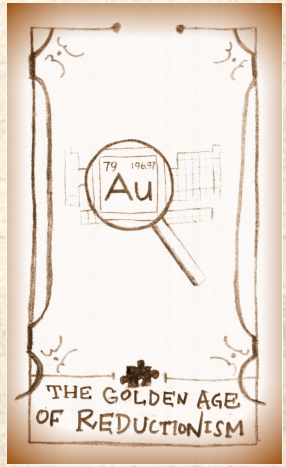
- 1908: Experimentally verified Einstein's work and Atomic Theory.



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?

Snared from brainpickings.org



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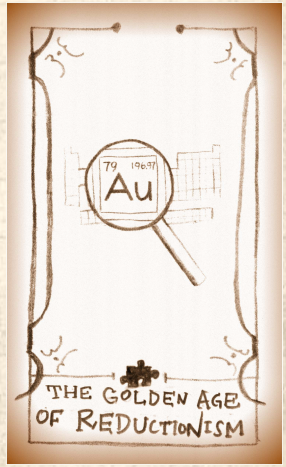

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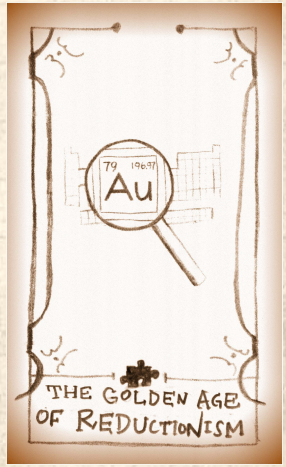

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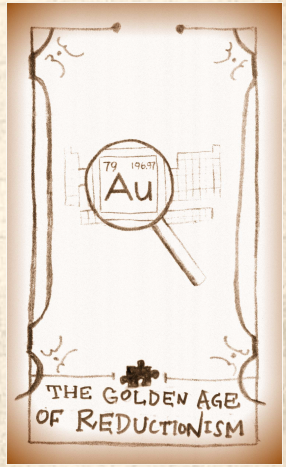
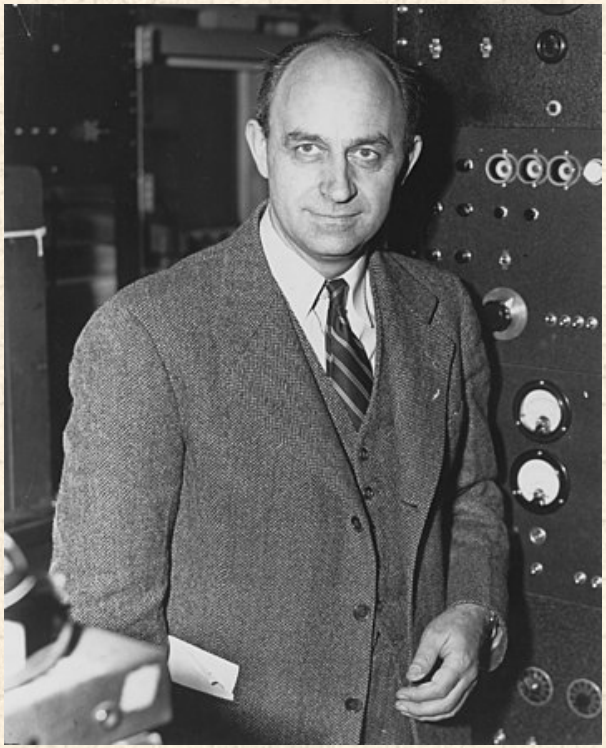
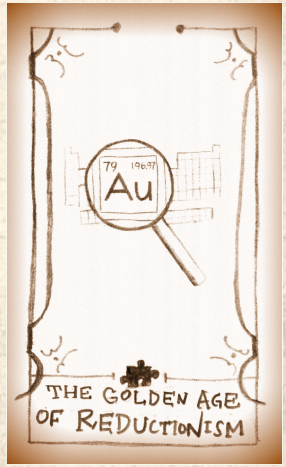


An unpleasantry:

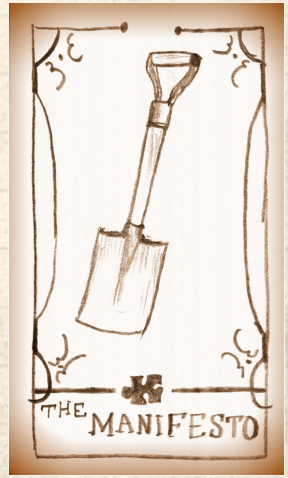
Fermi contained bosons and Bose contained fermions.





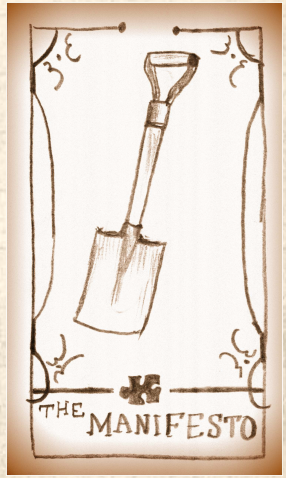
Don't name scientific truths after people.


Manifesto


THE MANIFESTO

The Science of Complex Systems Manifesto:

1. Systems are ubiquitous and systems matter.



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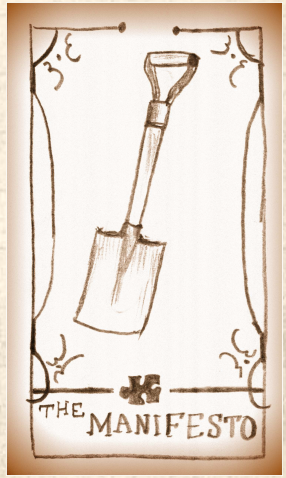

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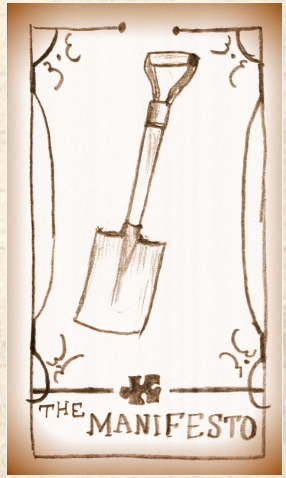

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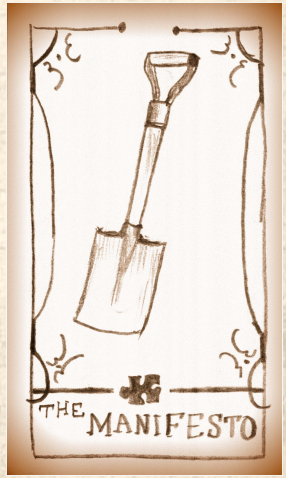

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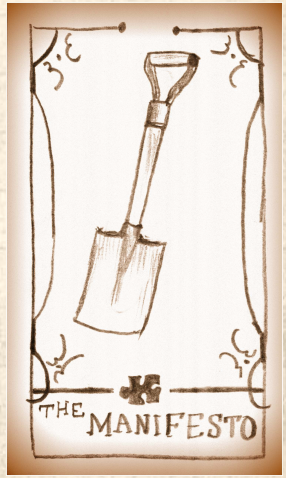

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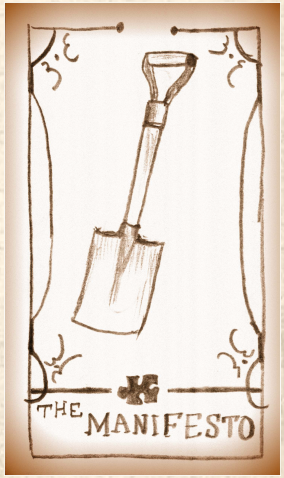

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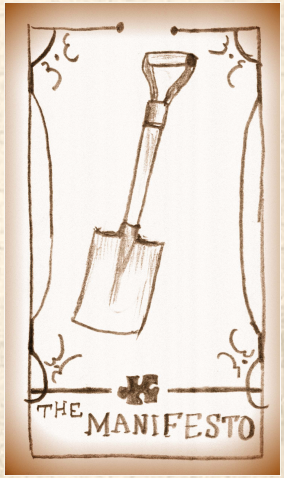

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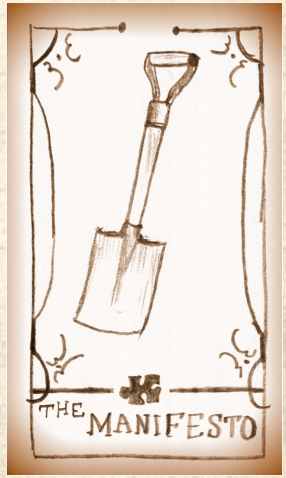

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