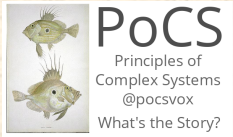
A Complex Systems Manifesto

Last updated: 2021/10/06, 20:26:04 EDT

Principles of Complex Systems, Vols. 1 & 2
CSYS/MATH 300 and 303, 2021–2022| @pocsvox

Prof. Peter Sheridan Dodds | @peterdodds

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



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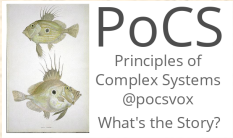
Outline

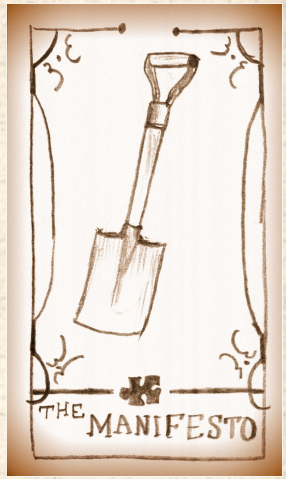
Defining Complexity

A Manifesto

References

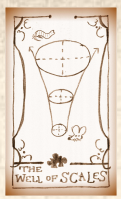


The Boggoracle Speaks:




THE SUN


THE MANIFESTO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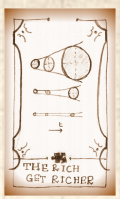
THE LAWS OF DECAYING POWER


THE UNEXPECTED TRANSFIGURATION


MINISTRY OF RANDOM WALKS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THE MANY TAILS OF MANY TAILS


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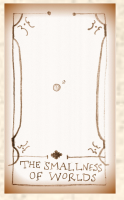
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THE CONTAGION


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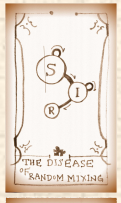
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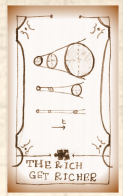
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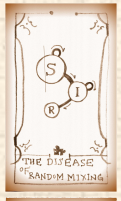
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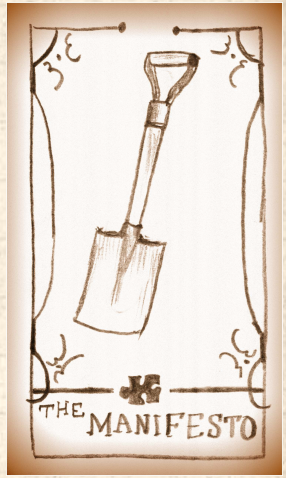
Definitions

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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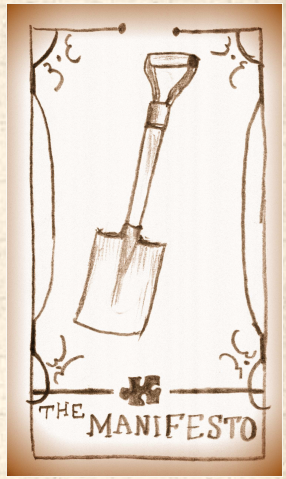
Complicated versus Complex:

- Complicated: Mechanical watches, airplanes, ...



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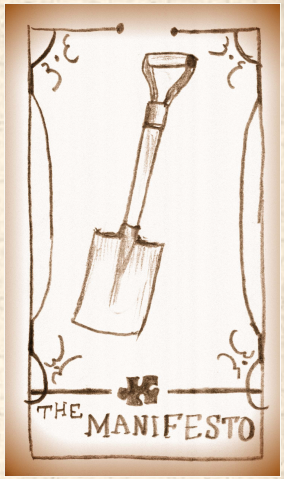

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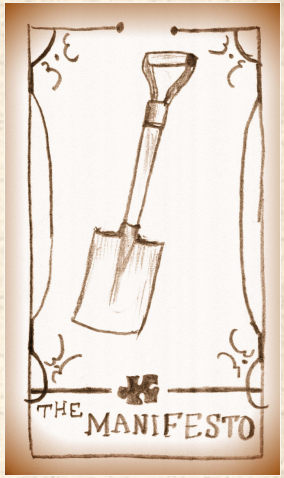

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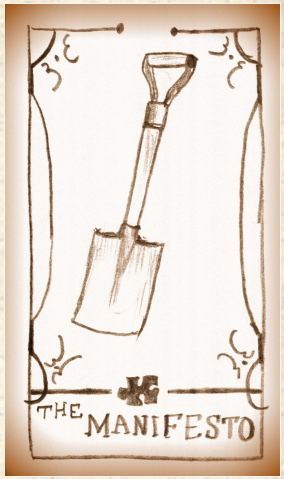

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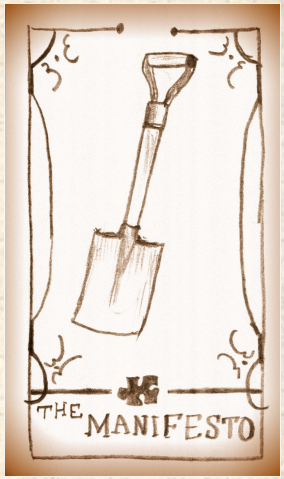
- Explicit distinction: Complex Adaptive Systems.



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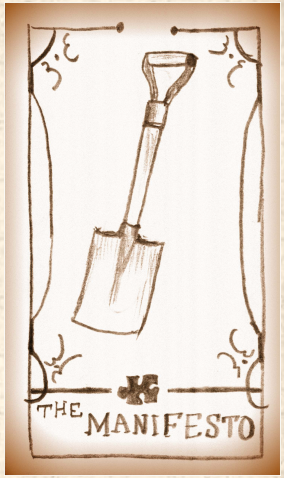
A working definition of a Complex System:

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



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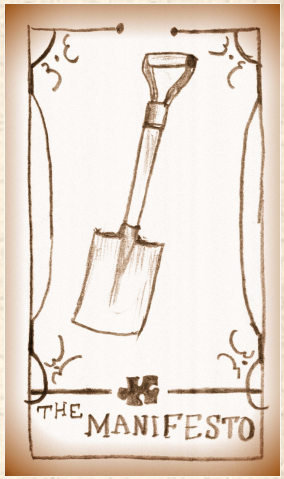

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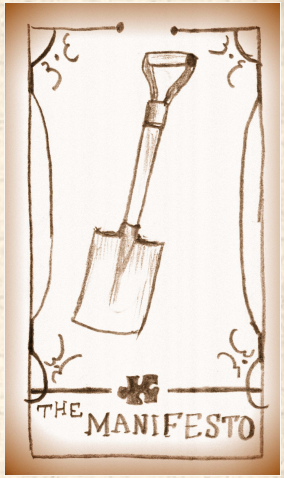

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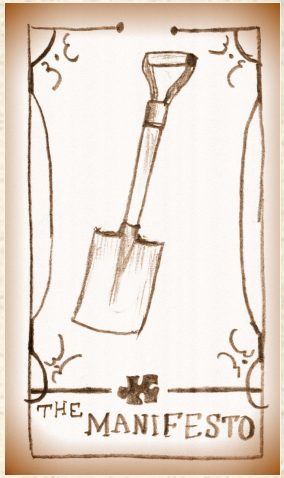

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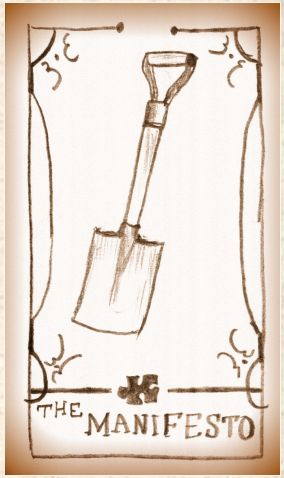

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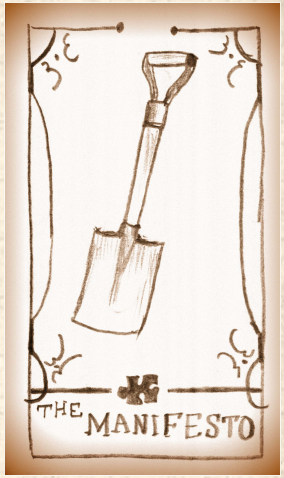

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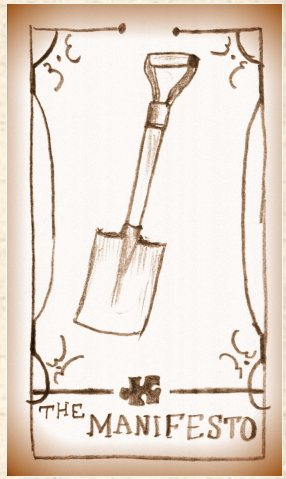
- Modular (nested)/multiscale structure.



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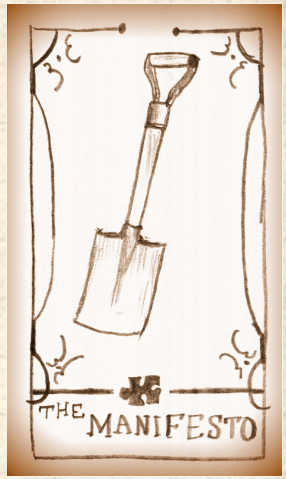
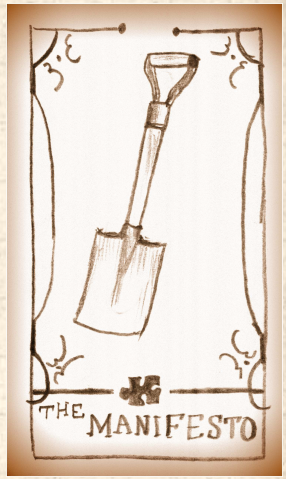
- Modular (nested)/multiscale structure.
- Mechanisms range from being purely physical to purely algorithmic in nature.



Examples of Complex Systems:

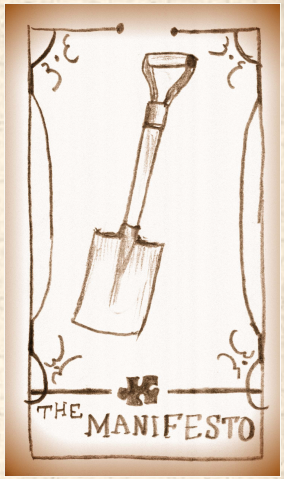
- human societies
- financial systems
- cells
- ant colonies
- fluids, weather systems
- ecosystems
- power grids
- animal societies
- disease ecologies
- brains
- social insects
- geophysical systems
- forests
- Internet + Web

- 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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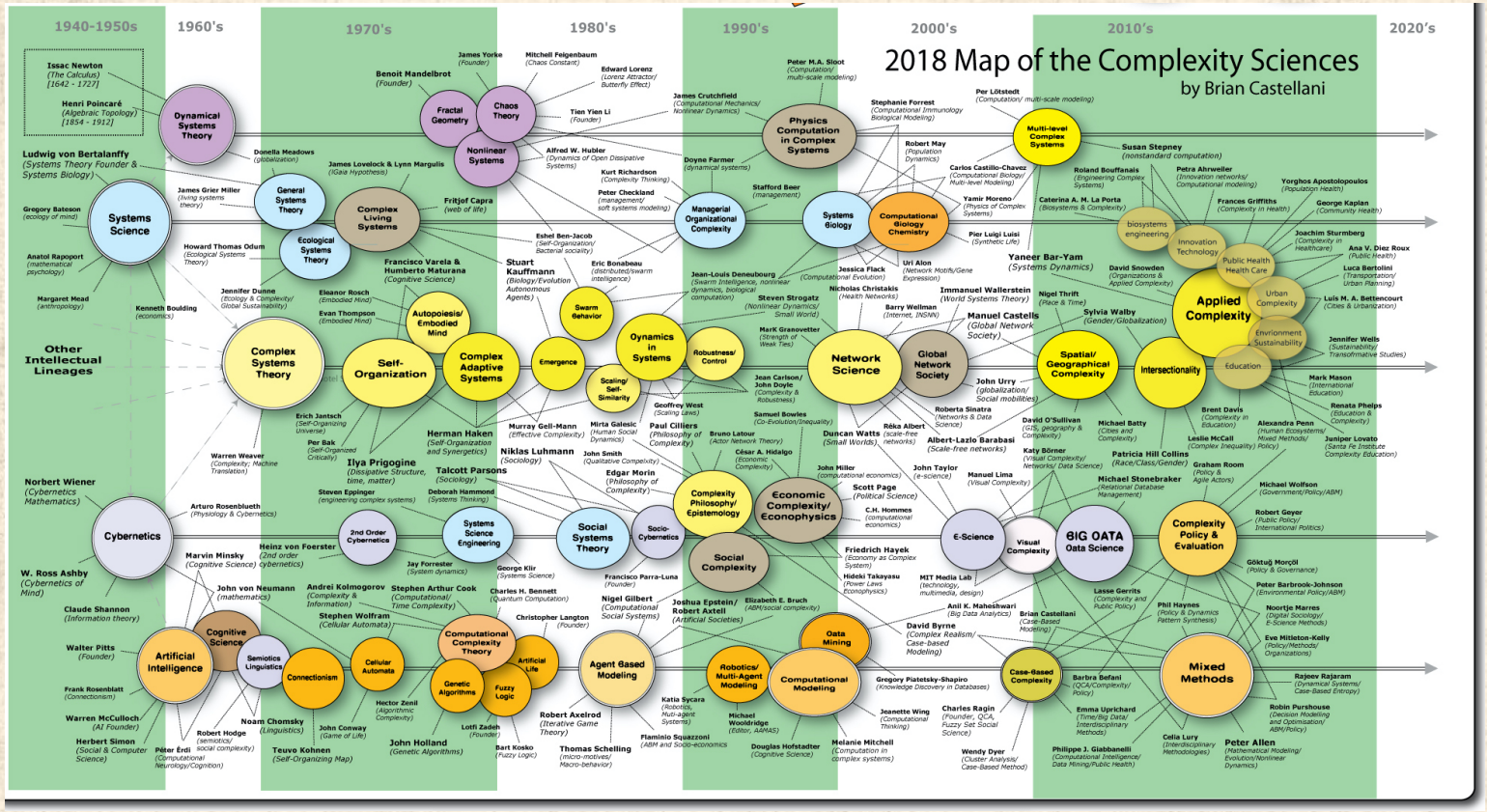
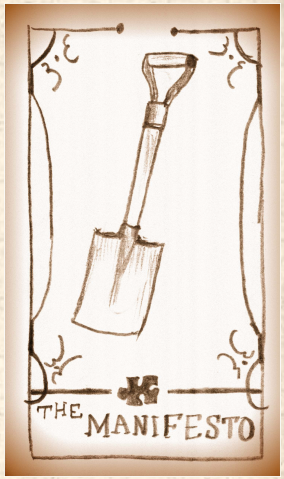
A visualized history of Complex Systemsish fields:

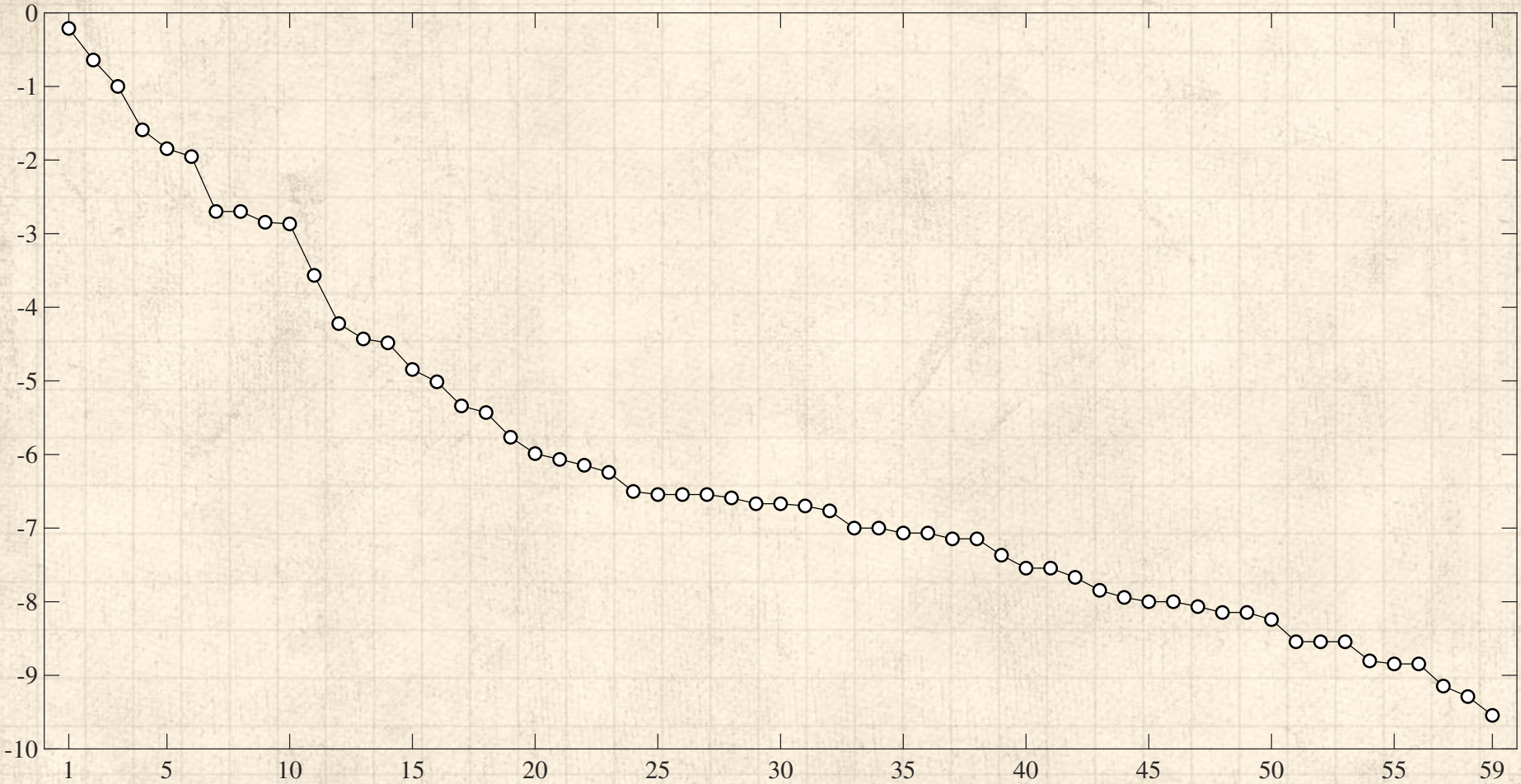


"Complexity Map" by Brian Castellani, Kent State

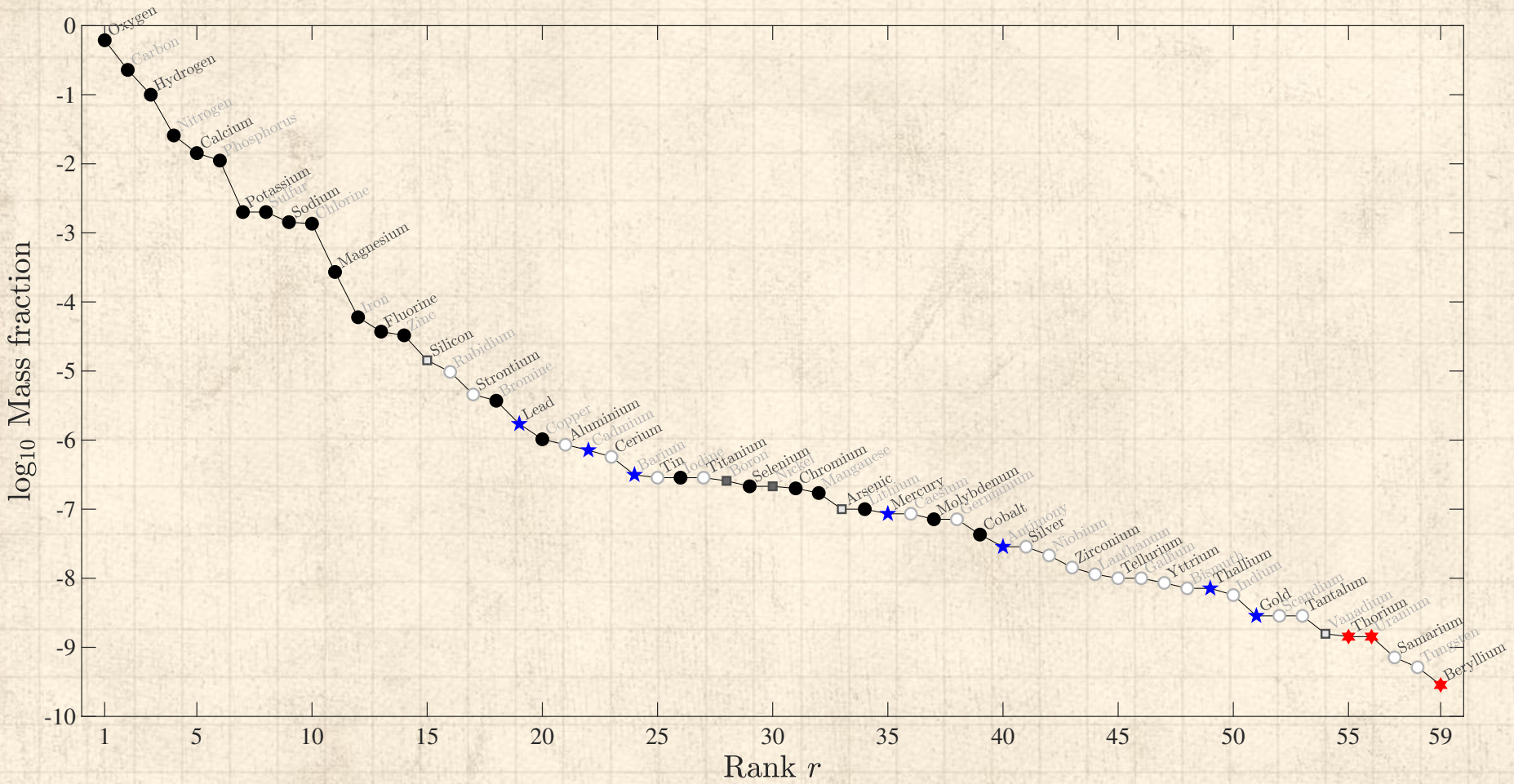
- Online here, at art-sciencefactory.com.
- Complex Systems is bigger than this (e.g., fluid dynamics; more later).



Cryptograph—What's being plotted here?:



Fractional weight of typical human body by atomic species:



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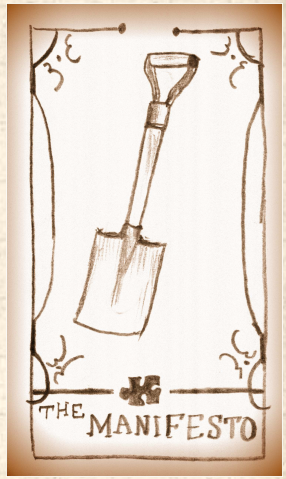

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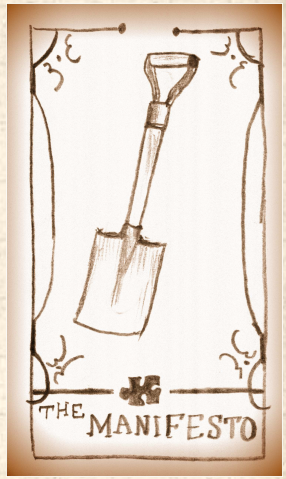

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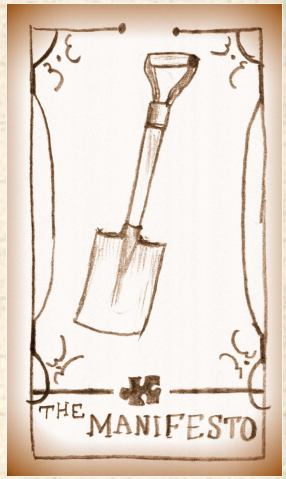

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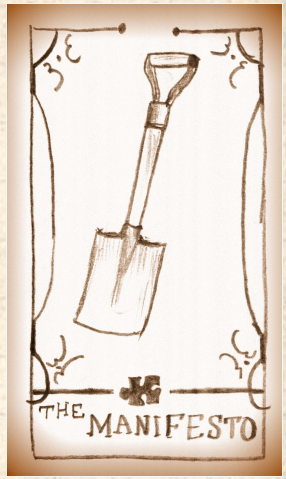
  Oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorous.



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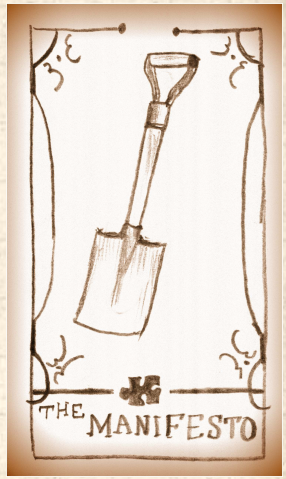
- Next 5 elements make up $\approx$ 0.85%:
  Potassium, sulfur[1], sodium, chlorine, and magnesium.



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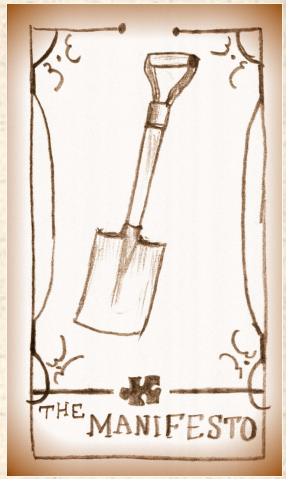

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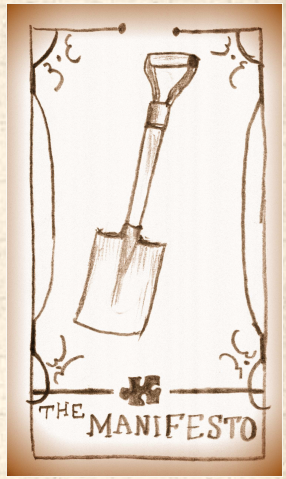
- Written on the box: "Nearly 10^{27} of 29 kinds of pieces!"
- Only in 2014 was bromine shown to be an essential trace element. [4]
- 6 elements make up $\approx$ 99% of the body's elements:
  Oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorous.
- Next 5 elements make up $\approx$ 0.85%:
  Potassium, sulfur[1], sodium, chlorine, and magnesium.
- Remaining 18 necessary elements are trace elements.



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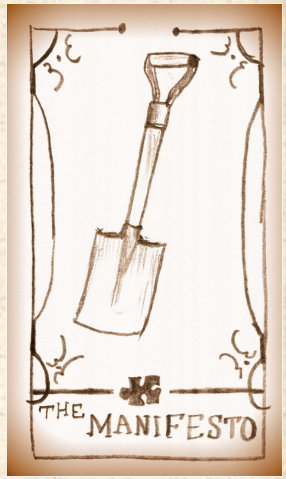
- Could be worse: A box with three packets containing up quarks, down quarks, and electrons.



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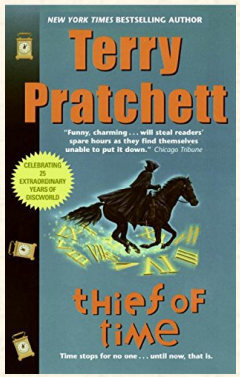
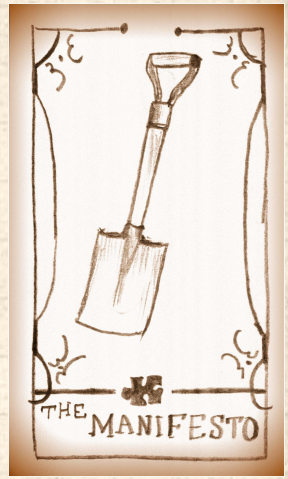
Best to see people as more than some kind of cleverly cooled quark soup:

"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."

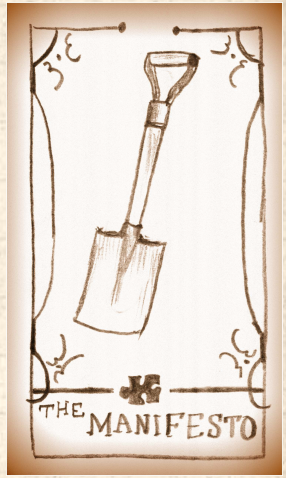
—Susan Sto Helit (who is a "little bit immortal")



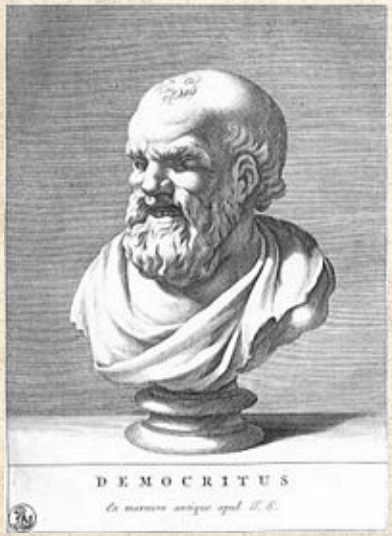
"Thief of Time"
by Terry Pratchett (2002). [5]



Or:



Reductionism:

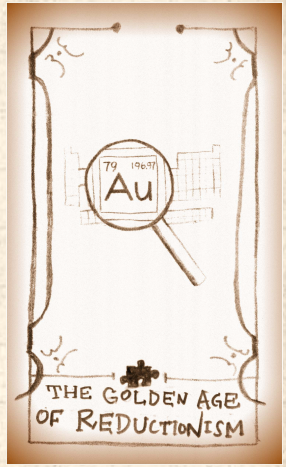


Democritus
(ca. 460 BC – ca. 370 BC)

- 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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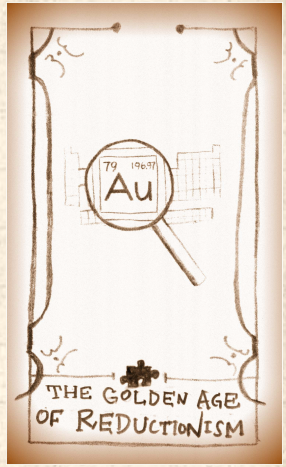

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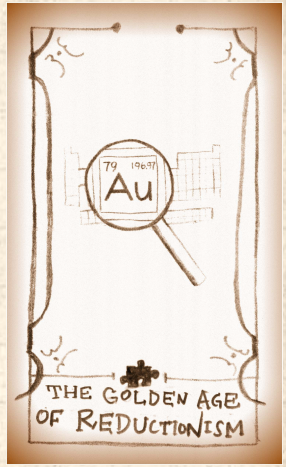

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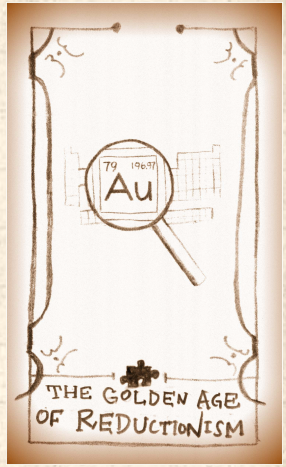

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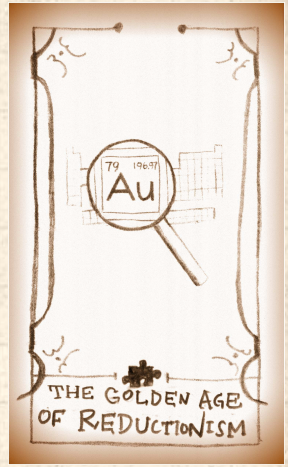

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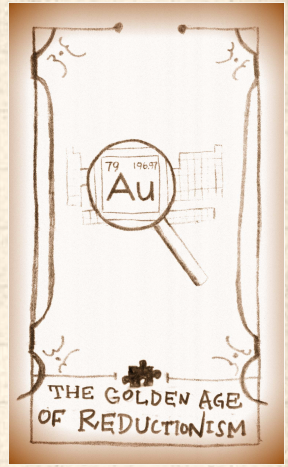

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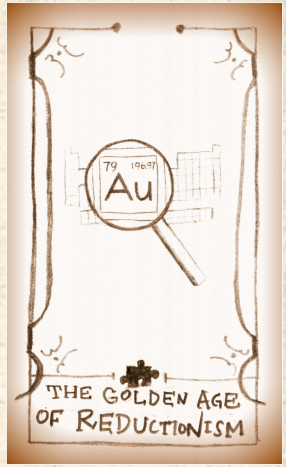

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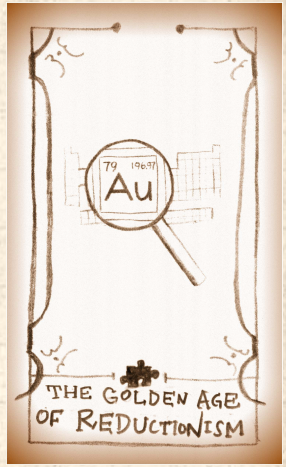
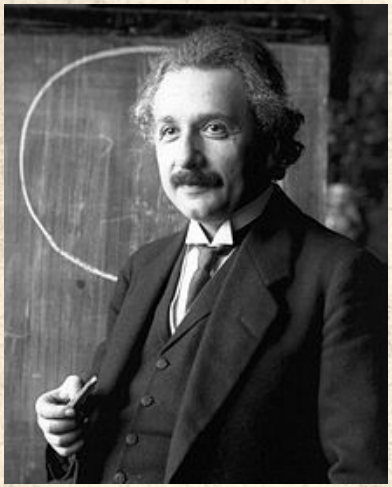
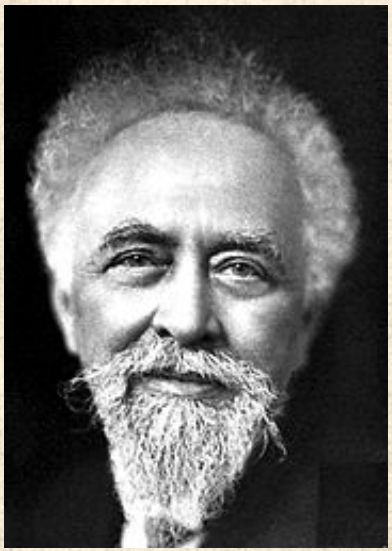
See: epigenetics.



Albert Einstein 1879–1955

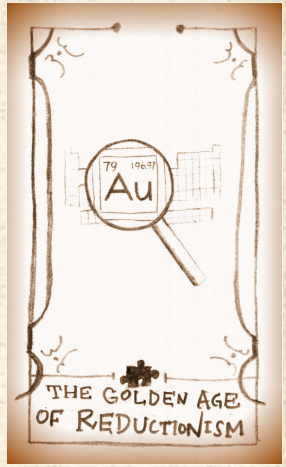


- Annus Mirabilis paper: “the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat” [2, 3]
- Showed Brownian motion followed from an atomic model giving rise to diffusion.



Jean Perrin 1870–1942

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



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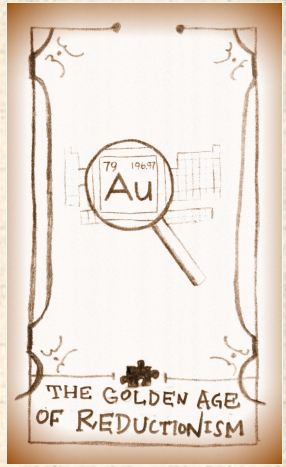

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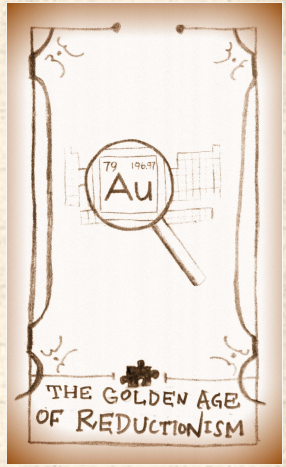

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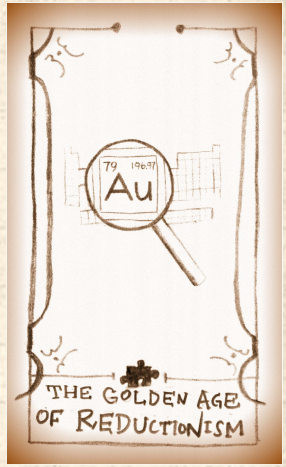

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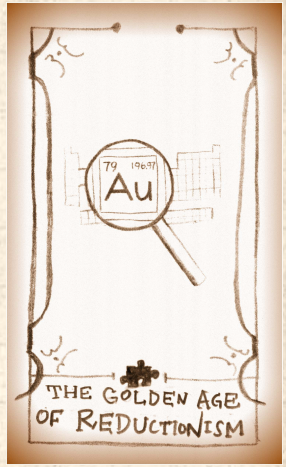

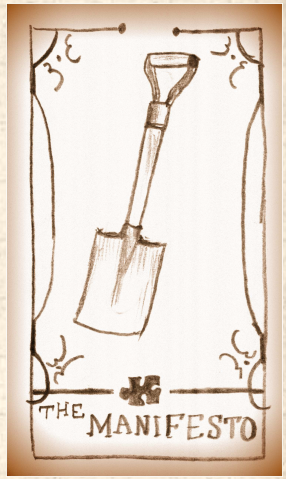

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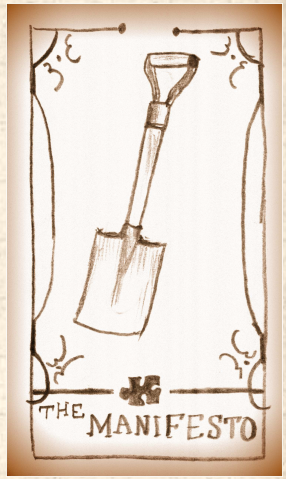

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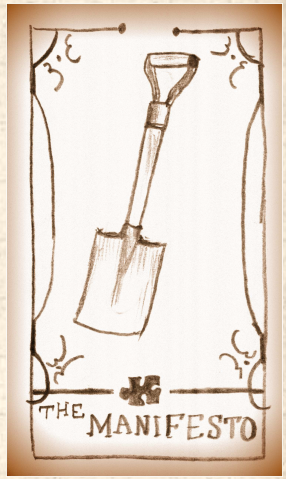

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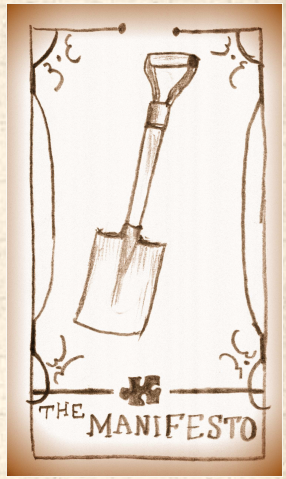

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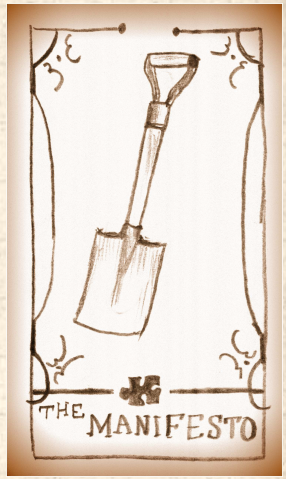

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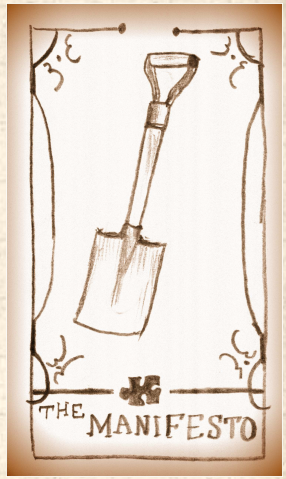

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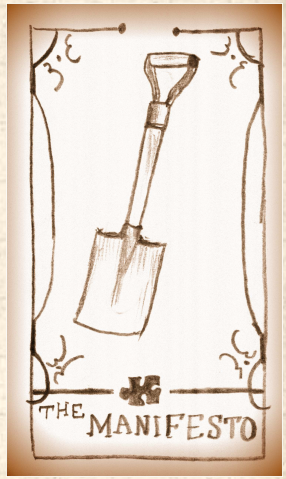

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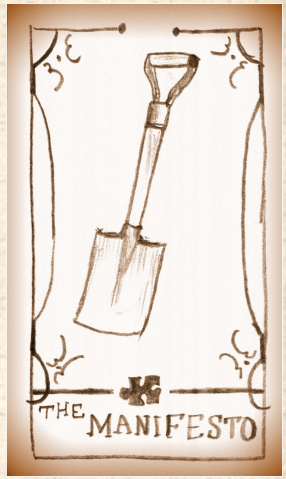

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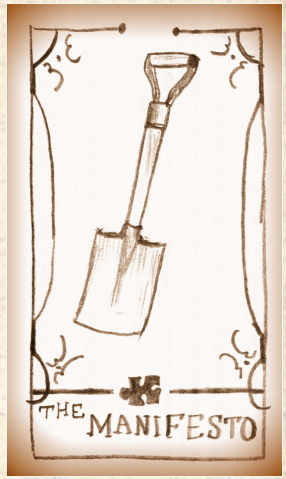

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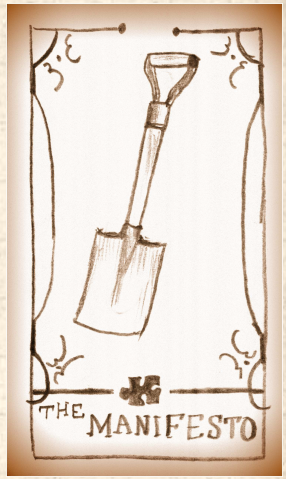

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