

RETURN

Digital human life

Issue 02
Fall 2022

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*"The knowledge imposes a pattern, and falsifies,
For the pattern is new in every moment
And every moment is a new and shocking
Valuation of all we have been"*
—T.S. Eliot, *East Coker*

Mythologies of Moral Arithmetic

At those moments where irreversible decisions are made, lives judged or put to death and revolutions begun, there is somewhere a ledger – physical or ideal – that records negative and positive contributions to our shared belief.

And these beliefs emerge through computation – or a system of rules – that are separate and equally

tangible entries in the ledger. In this way, knowledge is like a spreadsheet containing numerical entries and methods of calculation. Every narrative of change is therefore an account of the history of rapidly changing values and slowly changing rules – the knowledge that imposes a pattern.

In his "archaeological" histories, Michel Foucault describes how depth of knowledge increases over time like stratigraphic sediment in geology. Foucault considers both the visible or surface statements constituting layers of history – *connaissance* – and the underlying calculus – *savoir* – that aggregates the history of events into a consensus belief. In his *History of Sexuality*, Foucault propos-

es that, "truth is to be understood as a system of ordered procedures for the production, regulation, distribution, and operation of statements." The statements are the entries in the ledger of history and the procedures and computations that transmute data into knowledge. Foucault was describing procedures of validation resembling those Walter Benjamin had observed in connection to consensus formation:

(Even if truth should appear in our world, it could not lead to wisdom, because it would no longer have the characteristics which it could acquire only through universal recognition of its validity.

In *The Book of Coming Forth by Day* (also called *The Egyptian Book of the Dead*) the heart of the deceased is weighed on a scale against a feather pulled from the mantle of the Goddess Maat. The heart records the character of its host through a spell inscribed on the back of a nephrite scarab placed in the left ventricle. The weighing ceremony is overseen by the god Anubis. If the beetle-bearing heart should weigh more than the feather it is consumed by the retributive deity Ammit. A terror whose legs are leonine, hind hippopotamus, and jaws crocodilian. The heart carries the sum of virtues and vices and is an indelible ledger upon which life's deeds are recorded. Anubis is an engineer of human destinies.

Long before bank accounts and scorecards, voting machines, and blockchains, there were artifacts that provided the basis for ordered procedures for calculating a moral history of life. The Archangel Michael is often depicted as holding the scales of *psychostasia* – for the weighing of souls: merit as mass. In the *Testament of Abraham*, Abraham asks Michael, "What are these things which we see? ... These things which you see, pious Abraham, are judgment and recompense. And behold, the angel who held the soul in his hand brought it before the judge. And the judge told one of the angels who served him, 'Open for me this book and find for me the sins of this soul.'"

How much does the feather of a God weigh? Who do we go to for a course on divine plumology? Are mythical feathers also made from keratin, in which case, they certainly weigh less than a scarab-sized lump of silicate. The scales look tipped in favor of the celestials. And who appointed Anubis – half Jackal – the judge of moral integrity? Ultimately what are the mechanics of the Universal Ledger

that records our every deed? The Tibetan Buddhists make a claim for optics, as described in the *Bardo Thodol*, on signs of a distant death:

The examination of the signs of death when it is [still] years or months away should be made by scrutinizing the "shadow of one's lifespan," optically projected onto the sky ... [These indications may show that] one will die, or that one will not die, And that the averting [of death] will be possible, or impossible.

The Planetary Ledger

One could make the case, as many geotherists of the 18th and 19th centuries did, that the earth itself is the ultimate ledger of creation and destruction – a layered and spherical archive of planetary transformation. Martin Rudwick, in his fittingly vast history of geology, describes geothery as an effort to explain all the features of the earth. That "rather than accounting for a specific mountain range, for example, it would have to explain in general terms the origin of all mountains and relate them to oceans, volcanoes, fossils, and so on." And most importantly, "a geothery was expected to account for both the origin of the earth and its ultimate end."

The great geological ledgerist of the 19th century was Charles Lyell, who set forth his own geothery in the volumes of the *Principles of Geology* published between 1830 and 1833. Lyell writes, "We often behold, at one glance, the effects of causes which have acted at times incalculably remote, and yet there may be no striking circumstances to mark the occurrence of a great chasm in the chronological series of Nature's archives," and that, "It may undoubtedly be said, that strata have been always forming somewhere, and therefore at every moment of past time nature has added a page to her archives."

Lyell's theory, which we know as uniformitarianism, imagined Earth history as a slow and systematic terrestrial arithmetic of addition and subtraction in which everything is calculated by forces of nature invariant across the sweep of time. A theory that "consists in an earnest and patient inquiry, how far geological appearances are reconcilable with the effect of changes now in progress."

Lyell's earth as time-log found its most enthusiastic reader in the young Charles Darwin escaping the runnels of an ecclesiastical career through exploration on H.M.S Beagle (1831-1836) where he lived in the poop cabin (beneath the aft deck). His room also served as the ship library, provisioned with 400

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volumes. In his *Beagle Diary*, Darwin records,

The principal objects are, first, collecting, observing and reading in all branches of Natural History that I possibly can manage. Observations in Meteorology. — French and Spanish, Mathematics, and a little Classics, perhaps not more than Greek Testament on Sundays. I hope generally to have some one English book in hand for my amusement, exclusive of the above-mentioned branches.

The most influential volume was Charles Lyell's *Principles of Geology*. From Lyell, Darwin derived his understanding of the incremental and decremental impact on the form of the passage of deep time.

Darwin's first monograph, following his zoological account of *The Voyage of the Beagle*, was his 1842 investigation into animate geology — coral reefs. The entire book is a meticulous account of the nearly invisible efforts of tiny organisms writing a huge calcareous geology into history while land subsides.

From the limited depths at which reef-building polypifers can flourish, taken into consideration with certain other circumstances, we are com-

pelled to conclude, as it will be seen, that both in atolls and barrier-reefs, the foundation on which the coral was primarily attached, has subsided; and that during this downward movement, the reefs have grown upwards. This conclusion, it will be further seen, explains most satisfactorily the outline and general form of atolls and barrier-reefs, and likewise certain peculiarities in their structure.

Darwin proposed that small marine polyps powered by photosynthetic symbionts secrete unimaginable quantities of calcium carbonate into their environment. These consolidate into structures around geological features, including volcanic islands. When islands remain visible, we call these features barrier reefs. When the island subsides — because of tectonic motion — the coral first forms a fringing reef, upon further subsidence, a lagoon, and when the island has completely sunk, a circular atoll. The polyps are the fast architects, and the continental shelf, the slow demolition crew. The result is a fast and slow temporal sequence whose visible stages represent the manifold coral forms of the oceans.

The Scientific Scorecard

Foucault, writing on human history, might as well have been describing divine judgment, coral reefs, or the scientific method and its relation to the collective change of rational minds. In this area, the key students of the universal ledger are philosophers of science Karl Popper, Thomas Kuhn, Imre Lakatos, and Paul Feyerabend. And they each had a rather different approach to the statements and ordered procedures that govern the evolution of scientific knowledge.

In the opening statement of his 1934 *The Logic of Scientific Discovery* (rewritten in English in 1959), Karl Popper writes, "A scientist, whether theorist or experimenter, puts forward statements, or systems of statements, and then tests them step by step." It is, according to Popper, the task of the logic of knowledge "to give a logical analysis of this procedure."

In Popper's ledger, there is a foundational asymmetry between positive (verification) and negative (falsification) entries: single experiments can never fully verify a theory, but they can falsify one. A single negative result — presented in the form of a basic refuting statement (e.g., a widely available tool and observation) — will always be heavier than "Maat's feather" and ensure that a theory is rejected. Within the Popperian ledger, theories are

entered in each column, and the rows of entries record those theories surviving refutation. The length of each list provides an index of "fortified" belief.

There were many who decried Popper's method as too unforgiving. A single negative entry effectively erases an entire hypothesis column. Prominent among these critics of "methodological falsificationism" was Imre Lakatos who proposed a more expansive, forbearing belief.

Lakatos gives the example of the anomaly of the perihelion of Mercury which "refutes" Newtonian gravity. Yet for eighty-five years following its observation Newtonian gravity continued to be accepted and used (it still is) without much concern. This anomaly was ultimately explained by Einstein's General Theory of Relativity. Lakatos favored a "sophisticated falsificationism" in which multiple columns were required to compute consensus. A refuting statement in one column (testing one theory) does not erase that column unless another column (a rival theory) contains fewer refuted items. The index of belief is calculated by comparing the maximum score (the smallest number of negative entries) across competing columns. We might think of Lakatos versus Popper as upgrading to more sophisticated spreadsheet software that allows for comparisons across multiple entries in multiple columns.

The third member of the society of scientific actuaries was Thomas Kuhn. In many ways Kuhn is the best and least known. Best known for popularizing the words paradigm and revolution and least known for what he really said. In his 1962 *Structure of Scientific Revolutions*, Kuhn introduces a distinction between periods of normal and revolutionary science. Normal science becomes paradigmatic science when its achievements produce a coherent "language" community structure (of shared belief, method, and models - rule system) that outweigh a community of rivals and when these achievements are open-ended enough to suggest a multitude of new problems to be worked on (not something Popper or Lakatos considered as carefully).

Revolutions are rather like the phase transitions of matter (e.g., liquid to gas) in that they lead to the replacement of one paradigm by another. Kuhn is less interested in the Popperian and Lakatosian ledgers of negative experiments - entries - and more interested in the ledger of paradigms - rules. In terms of scale, Kuhn is writing something like a history of the world (a meta-scientific geotheory) and Popper and Kuhn histories of nations. Kuhn is particularly interested in anomalous observations

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that are seen as incommensurable between theories - observations that are incompatible with one theory and compatible with another. This implies that not everyone agrees at once what an experiment confirms or refutes which tends to throw a spanner into falsificationism. There are endless rounds of persuasion based on the shared belief of each "language" community. And much of Kuhn's interest is in the translators and their methods, or paradigm missionaries, who resolve misunderstandings across his meta-ledgers.

Into this rather sterile laboratory of methodological purity, there arrives an anarchist who brings with him fire. The kind of fire abjured by archivists, historians, and librarians the world over. The fire proscribed in the oath that all who enter Oxford's Bodleian Library must take: "I hereby undertake not to remove from the library, nor to mark, deface, or injure in any way, any volume, document or other object belonging to it or in its custody; not to bring into the Library, or kindle therein, any fire or flame..."

Paul Feyerabend is as close as the philosophy of science has come to a radical, perhaps even heretical, anti-ledgerist. As he writes in his closing statements of *Against Method* from 1975, "even

within science reasons cannot and should not be allowed to be comprehensive and that it must often be overruled, or eliminated, in favor of other agencies." Through a close examination of the history of physical theory Feyerabend concludes that there *need to be* aberrant entries in the ledger, "errors are preconditions of progress."

Feyerabend shows that numerical errors in the cosmology of Copernicus, the optical noise in the observations of Galileo, and mirror/reflection paradoxes in Newton's theory of color hardly mattered. Feyerabend concludes that science is not simply a ledger of Foucault-like *connaissance*-statements and simple summary statistics, but endless *savoir*-rules written and rewritten in the margins in invisible ink. The ledger is not principally an accounting book but an epistemic grimoire.

The Slow Manifold

The primary characteristics of all of these "ledgers" has been (1) the ability to rapidly add or subtract entries - sediments; observations, theories, paradigms - (2) perform some kind of distributed "calculation" that takes into account the full history of observation to reach a temporarily stable position or consensus - paradigm - and (3) over longer timescales allow for these paradigms to change - revolutions.

Over the last several years, working with a few collaborators, I have sought to construct a general mathematical theory of the ledger in relation to stasis and revolution. The concept builds on the idea of the slow manifold in the theory of dynamical systems. Sometimes called a "Lagrangian coherent structure."

The basic idea is that most dynamical systems (systems that change through time, to include planetary systems, economies, politics, ecologies, etc) contain multiple time scales (fast and slow events) and integrate contributions from numerous components. The consequence is the emergence of a center manifold - a unifying structure that changes very slowly and guides the course of its rapidly moving components.

The usual example is the rings of Saturn. We might naively expect a spherical cloud of particles surrounding the planet. Instead, we find planar rings. The rings are attractive and capture particles that pass through them from above and below. And the consequence is the appearance over long periods of time of patterns that change slowly (rings) and patterns that change quickly (the positions of the particles in orbit).

Using these mathematical ideas, we can show that beliefs are subject to the same kinds of dynamical constraints as matter. And that rather than rings, we observe paradigms. And rather than the ultimate gravitational and electromagnetic collapse of the rings we observe revolutions. The Universal ledger is the result of the dynamical laws governing the interplay between determinism and chance in our universe. Small wonder it has provided such an effective template and metaphor for understanding our planet, societies, beliefs, and mythologies. ☺

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