

Records Across Nature, Life, and Mind

The persistence layer of collapse in nature, life, and mind

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Abstract

Records are the persistence layer that turns isolated resolutions into cumulative history. This paper argues that durable, informative, non-destructively readable traces of resolved outcomes—records—are a missing middle layer in explanations that rely on memory, inheritance, or learning. We formalize a minimal definition of record and embed it in a constraint-guided resolution cycle: collapse under constraint selects an outcome, writes records, produces residue, and updates constraints for the next resolution. The same structural logic operates across physics, biology, and mind. These roles are constitutive of collapse as a cumulative process: without records there is no cumulative objectivity, no inheritance, and no learning. In physics, redundant records drive inter-observer consensus; in thermodynamics, entropy is read as the residue of pruning; in biology, genomes and inherited structures function as records that become constraints on future phenotypes; in mind, memory, belief, and externalized symbols shape perception and coordination. We list three portable, falsifiable signatures—redundancy-driven consensus, neutrality-delayed resolution, and constraint-sweep hysteresis—that connect this record logic to measurable behavior across domains.

Keywords: records; persistence; constraint-guided collapse; cumulative dynamics; accessibility; objectivity; entropy; inheritance; update

1. Introduction

Modern explanations frequently rely on an implicit persistence assumption: outcomes leave traces and those traces matter. Measurements become public facts, organisms inherit structure, and minds learn. Yet these effects are often treated as downstream details of dynamics rather than as the mechanism that makes dynamics cumulative. This paper isolates the shared spine: records.

The central claim is methodological and structural: records are not merely descriptions of what happened; they are the persistence layer that turns isolated resolutions into history. Once records are treated as first-class, several recurring confusions clarify: objectivity no longer requires metaphysical stipulation; entropy and time acquire a unified reading as record accumulation; evolution becomes inheritance of constraint-bearing memory rather than blind sampling; and probability becomes conditional on accessibility defined by record history.

Scope. Records are not incidental outputs of collapse; they are constitutive of collapse as a cumulative process. The resolution cycle—constraint $\rightarrow$ collapse $\rightarrow$ record $\rightarrow$ update—is the foundational kernel of the broader framework (Jones, 2025), and the record operation is the hinge on which the cycle turns: collapse produces records, and update requires them. Without records, collapse still fires, but the cycle does not close. This paper isolates that operation and shows what the system looks like when it is present and when it is absent. The paper therefore functions as structural anatomy of the kernel rather than a new standards document or a secondary bridge between domain papers. The claim is structural-interpretive: records are what make collapse cumulative rather than punctual, and this role is constitutive, not incidental. Nothing here replaces thermodynamics, evolutionary biology, or cognitive science; it offers a shared structural reading of the persistence role that each discipline already relies on.

2. Core definitions

2.1 Record (operational)

Let X denote a realized outcome (e.g., a measurement result, phenotype, chosen action). A variable R is a record of X if it satisfies:

- (i) informativeness: $I(X; R) > 0$ (R carries nonzero mutual information about X ; Cover & Thomas, 2006),
- (ii) durability: R persists across subsequent resolution steps at the relevant scale, and
- (iii) non-destructive readability: R can be accessed without erasing X at the relevant scale.

The third clause is operational: it is scale-relative and regime-dependent. In quantum settings it aligns with the practice of reading environment fragments; in biology it aligns with heritable and embodied traces; in mind it includes neural memory and externalized artifacts. The key point is causal: a record is information with constraint power.

2.2 Resolution cycle (formal notation)

The operational definition above can be embedded in a general resolution cycle. We model system evolution as repeated, constraint-conditioned resolution of structured potential. A minimal discrete form is:

$$(\Omega, K) \rightarrow C^K(\Omega, K) = x^* \rightarrow (R, S, T) \rightarrow K' = U(K, x^*, R)$$

where Ω is a structured possibility space; K is the active constraint set; C^K is collapse/selection under K ; x^* is the realized outcome; R are records written by that outcome; S is residue (entropy-like remainder); T is record-time (a ledger index of sequential resolution); and U is the update map that incorporates records into subsequent constraints.

2.3 Redundancy and independence

A record is redundant when many fragments encode the same outcome. Let $Y_1, \dots, Y_k$ be environment fragments read by observers. A standard idealization is conditional independence given X : Y_i are independent conditioned on X . In practice, the relevant quantity is an effective number of independent fragments $k_{\text{eff}} \leq k$, which degrades with correlation.

2.4 Residue and entropy

We distinguish records R from residue S . Records are structured, retrievable encodings of outcomes; residue is the distributed, effectively inaccessible remainder of pruning. The distinction has a physical anchor: Landauer (1961) showed that erasure of information carries an irreducible thermodynamic cost, linking information erasure—and thus record-clearing—to entropy production. Thermodynamic entropy is treated as a canonical proxy for S in many regimes, but the distinction matters: some records increase entropy, some decrease local entropy while exporting residue elsewhere.

2.5 Why nothing cumulative exists without records

Without records, collapse would still yield outcomes, but nothing about those outcomes would accumulate. Each resolution would vanish with the instant of its occurrence, leaving no durable basis for later selection, correction, inheritance, or consensus. This is not a hypothetical curiosity. It reveals something about the structure of collapse itself: records and update are not secondary products of an event that could, in principle, occur without them. They are what makes the event a resolution rather than a fluctuation. Collapse that leaves no trace and updates no constraint cannot enter cumulative history; operationally, it contributes nothing to the persistence layer. The record operation is therefore not one step among four—it is the hinge that converts outcome into history, and without it the kernel does not cycle.

In physics, without records, no measurement could become public objectivity. There would be outcomes, but no durable traces through which later observers could converge, no stable basis for consensus, and no mechanism by which one resolution could bind the next.

In biology, without records, no phenotype could become inherited bias. Evolution would not accumulate constraints across generations; it would repeatedly begin again, unable to convert successful collapses into reachability structure for future organisms.

In mind, without records, no learning, memory, or identity could persist. Each conscious resolution would begin from zero, unable to sediment into belief, self-model, or shared symbolic world.

At that point, record-time becomes intelligible in a thicker sense. Time is not only succession; it is retained succession: a ledger of resolved outcomes that continue to constrain what can happen next. Records are what make movement cumulative rather than punctual. They are how a system carries its past forward without collapsing into reset.

3. Records as a foundational layer across domains

If the record-first view is right, three portable signatures should appear wherever records operate: (S1) redundancy drives consensus—more independent record fragments, faster convergence; (S2) neutrality delays resolution—when constraints do not strongly favor one outcome, the system lingers; (S3) constraint sweeps produce hysteresis—accumulated records make the path back different from the path forward. The sections below instantiate these signatures across physics, biology, and mind, showing that records change their dominant carriers and timescales but preserve the same structural logic.

The table below summarizes how the carrier of records changes across domains while the structural role remains the same.

Domain	What counts as a record	What it constrains next	Typical signature
Physics	Detector traces, spectra, environment imprints	Later observation and consensus	S_1
Biology	Genomes, epigenetic marks, inherited structures	Phenotype reachability, adaptation	$S_1 / S_2 / S_3$
Mind	Memory traces, beliefs, symbols, institutions	Perception, judgment, coordination	S_2 / S_3

Table 1. Records change carriers and timescales across domains but preserve the same structural logic.

3.1 Physics: records, objectivity, and lawful stability

In physics, records are environment imprints: scattered radiation, detector marks, stable spectra, macroscopic traces. Decoherence theory treats these imprints as the mechanism by which quantum superpositions yield definite classical outcomes (Joos et al., 2003), and quantum Darwinism shows that objectivity arises when outcomes are redundantly recorded in many environment fragments such that independent observers can access different fragments and still converge (Zurek, 2009). The point is not to derive all objectivity from one toy model, but to show that record redundancy has a measurable consensus signature.

Proposition (redundancy implies exponential consensus).

Consider a binary outcome X in $\{0,1\}$ recorded in k conditionally independent fragments $Y_1, \dots, Y_k$. If each fragment has a minimum per-fragment discriminability (e.g., positive Chernoff information bounded below), then the Bayes-optimal error probability decays as:

$$P_e(k) \leq \exp(-k c_0) \quad \text{and} \quad P(\text{disagree}) \leq 2 \exp(-k c_0).$$

This provides an empirical agreement curve: disagreement should follow approximately $a * \exp(-b k_{\text{eff}})$ with $b > 0$, and saturate when fragments cease to be independent. This turns ‘objectivity from records’ into a measurable signature rather than an axiom.

3.2 Thermodynamics and cosmology: entropy and time as record-ledgers

In the record-first view, entropy is not disorder in the abstract; it is the record of pruning expressed as residue. This is a structural reading layered onto standard thermodynamics (Callen, 1985), not a substitute definition. Each resolution step produces both stabilized structure (records) and dispersed remainder (residue). The Second Law becomes a monotone statement about residue accumulation under ordinary regimes, while coherence and entropy can increase together.

Cosmologically, this suggests a shape-level prediction: from post-recombination to the present, $\log_{10} S_{\text{tot}}(t)$ should grow smoothly with time, increasingly dominated by black-hole entropy at late times (Egan & Lineweaver, 2010). Strong plateaus, sharp kinks, or highly irregular behavior would count against an entropy-as-record reading even if standard cosmology remains empirically intact.

The broader practice of observational cosmology underwrites this reading. The fact that science can estimate the age of the universe at all—from CMB temperature, redshift patterns, isotope ratios, stellar evolution, and primordial abundances—presupposes a persistence layer. Age is not a primitive quantity; it

is an inference from records. A universe that wrote no durable traces would not be dateable in principle, not merely in practice. What this paper calls the persistence layer is therefore not a theoretical addition to cosmology; it is a structural feature the discipline already relies on, here named and made explicit.

3.3 Biology: inherited records become constraints

In biology, records become explicit and heritable. Genomes are durable traces of past successful collapses and simultaneously part of the constraint architecture that biases what phenotypes are reachable. Beyond the genome, epigenetic marks, behavioral traditions, and symbolic inheritance provide additional record layers that carry constraint-bias across generations (Jablonka & Lamb, 2005). This is the mechanism by which life accumulates structure without teleology: records carry forward constraint-bias across biological record-time (generations).

Development and morphogenesis can be described as nested collapse sequences within an organism. Canalization and robustness correspond to deep coherence pockets: many micro-variations still converge to the same macro-outcome because constraint-bearing records shape the basin geometry (Waddington, 1957).

3.4 Mind: records as belief, identity, and externalized constraint

In the mind-phase, records include neural memory traces, explicit beliefs, narratives, and externalized artifacts. These records do not merely store past outcomes—they accumulate into the constraint structure under which perception resolves incoming signal (Clark, 2013; Jones, 2026a). Belief, in this framing, is record stabilized to the point where it functions as operative constraint: it shapes what future signal can become salient, not merely what is endorsed upon reflection.

Externalized records extend beyond the skull: speech, writing, diagrams, tools, institutions, and digital traces are durable records that become constraints on many minds. At this scale, consensus, controversy, and institutional hysteresis are record-level expressions of the same S-signatures (redundancy, neutrality, sweeps).

4. Probability, accessibility, and record history

A common category error treats probability as generative: if an event has nonzero probability within a formal model, it is treated as physically meaningful independent of the constraint-and-record stack that defines accessibility. This error is not merely philosophical; it follows from a misunderstanding of what collapse is. If collapse is inherently record-producing—if the trace and the update are constitutive of the event, not optional aftereffects—then every realized outcome sits at the end of a record chain that was itself built by prior collapses. Probability distributions describe the spread of outcomes within an accessible state space that the record stack defines. They do not generate that space, and they do not license outcomes for which no structural path exists. In this framework, the physical interpretation of probability is downstream of the structure of constraint and record, not prior to it. Treating the math as prior to the structure quietly reverses the dependency: it lets formal possibility stand in for structural reachability.

This resolves the intuition behind extreme combinatorial claims (e.g., complex macroscopic objects forming from vacuum). Such claims quietly ignore the nested record stack required to make the object a

reachable endpoint. If the record chain does not exist, the outcome is not merely improbable; for the system as presently constituted, it is structurally unreachable. Records define accessibility; probability summarizes variation within accessibility.

5. Portable tests and signatures

The three signatures previewed in Section 3 can be stated as portable empirical checks:

- S1 (redundancy $\rightarrow$ consensus): vary number of effectively independent records k_{eff} and fit disagreement to an exponential decay.
- S2 (neutrality $\rightarrow$ delayed resolution): tune conditions so multiple outcomes are comparably compatible with K ; measure slowed or labile resolution (reaction-time peaks, bistability, metastability).
- S3 (constraint sweeps $\rightarrow$ hysteresis): sweep a constraint parameter up and down and measure path dependence (loop area, branch separation, attractor switching).

Domain instantiations include quantum Darwinism mutual information curves, entropy-budget slope tests in cosmology, hysteresis in phase transitions and ecosystems, and rigidity/relapse patterns in belief and institutional dynamics.

5.1 What this paper is not

This paper is not a new physical law, not a replacement for domain-local models of thermodynamics, evolution, or cognition, and not a complete theory of objectivity, evolution, or mind. It isolates one structural claim—that records are the persistence layer that makes cumulative dynamics possible—and shows that this claim generates portable, testable signatures across domains.

6. Discussion and limitations

The record-first posture is not a denial of stochastic modeling, chaos, or uncertainty. It is a hygiene rule: treat randomness as residual under stated constraints, and treat objectivity and directionality as consequences of record structure rather than as primitives.

The strongest assumptions in formal consensus bounds are conditional independence and per-fragment discriminability. In practice, correlations reduce k_{eff} and can saturate agreement curves early. This is a feature, not a bug: it yields a measurable diagnostic that separates genuine redundancy from pseudo-redundancy.

Finally, all claims are scale-relative. What counts as a record, what counts as non-destructive readout, and what counts as a constraint must be stated at the level of analysis. The kernel notation (Section 2.2) is intended to enforce this discipline, not to erase domain differences. The methodological standards that govern this discipline—the structural conditions under which empirical claims stabilize and the integrity requirements for update operations—are formalized in companion documents (Jones, 2026b; Jones, 2026c).

7. Conclusion

Records are the persistence layer of collapse—and more precisely, they are constitutive of collapse as a cumulative, history-bearing cycle. Collapse that produces no trace and updates no constraint cannot enter cumulative history; it contributes nothing to the persistence layer. Records are therefore not one mechanism among others. They are the hinge on which the resolution cycle turns: the operation that converts isolated outcomes into cumulative history, and without which constraint, collapse, and update cannot form a cycle at all. Nested records generate time, memory, inheritance, objectivity, and apparent lawfulness—not as downstream effects, but as structural consequences of collapse being inherently record-producing.

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