From Strange Attractors to the Attractor Framework: Structural Correspondences and Conceptual Extensions

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June 2026
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Abstract

The attractor framework is a unified naturalistic ontology grounded in the principle that persistence under perturbation is the fundamental mark of reality. This paper traces structural correspondences between the framework and two major scientific achievements of the late twentieth century: the mathematical theory of strange attractors developed by David Ruelle and Floris Takens, and the thermodynamics of dissipative structures developed by Ilya Prigogine. The framework developed its vocabulary and concepts independently over several decades; the correspondences documented here are offered as post-hoc validation, not as evidence of genealogical descent. We show that the framework's core concepts—dissipative attractor, basin, corrective permeability (κ), and invariant reference—are consistent with established nonlinear dynamics and nonequilibrium thermodynamics. The fantasy attractor—a belief system with low corrective permeability—is identified as a psychological analogue of the strange attractor, governed by structurally analogous but mechanistically distinct dynamics. The paper clarifies which

framework claims are grounded in established physics and which are heuristic extensions requiring independent validation. The framework is offered as a research program, not a completed theory.

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1. Introduction: Independent Development, Post-Hoc Validation

The attractor framework (Galida, 2026a) is a naturalistic ontology organized around a single diagnostic principle: **persistence under perturbation is the mark of the real.** It divides all persistent structures into conservative persistence structures (the eternal, mindless, invariant skeleton) and dissipative attractors (temporary, entropy-exporting systems that converge toward stable basins). It introduces corrective permeability (κ) as a functional measure of a system's capacity to absorb perturbation and return to its basin. It applies this vocabulary across physics, biology, cognitive science, and social dynamics.

The framework's concepts were developed independently over several decades, through a combination of philosophical inquiry, systems theory, and N=1 self-engineering experiments. They did not derive from the traditions described below in a genealogical sense. However, the structural parallels with established nonlinear dynamics and nonequilibrium thermodynamics are substantial. Documenting these parallels serves three purposes: it demonstrates the framework's consistency with well-validated physical theory; it identifies where the framework extends beyond its precursors; and it clarifies which claims are grounded in established science and which are heuristic extensions requiring independent validation.

Two bodies of twentieth-century science provide particularly

strong structural correspondences: David Ruelle and Floris Takens's theory of strange attractors, and Ilya Prigogine's thermodynamics of dissipative structures. This paper maps those correspondences and identifies the points where the framework diverges from or extends beyond its precursors.

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2. Ruelle's Strange Attractor: Structural Correspondences

David Ruelle and Floris Takens proposed in 1971 that turbulent fluid motion is governed by a new kind of mathematical object: the strange attractor. Ruelle's 1980 paper "Strange Attractors" defined it with precision and became the canonical introduction for a generation of scientists. Five features of Ruelle's definition correspond to core concepts of the attractor framework. These correspondences are structural, not genealogical, and are offered as a demonstration of consistency with established physics.

2.1 Attracting Set → Basin

Ruelle defined a strange attractor as a bounded set A contained in an open neighborhood U such that every trajectory starting in U eventually converges to A and remains arbitrarily close to it. In the attractor framework, this is the **basin**: the region of state space toward which trajectories converge and from which they resist displacement. Ruelle's quadrilateral ABCD for the Hénon attractor—within which all subsequent iterates remain—is precisely a basin in the framework's sense. The correspondence is straightforward and exact.

2.2 Sensitive Dependence → Corrective Permeability

Ruelle characterized sensitive dependence on initial conditions by the exponential growth of small errors: $d(X_t,$

$X'_t) \sim d(X_0, X'_0) \cdot a^t$, with $a > 1$ and characteristic exponent $\lambda = \ln a$ (for a standard textbook treatment of Lyapunov exponents and nonlinear dynamics, see Strogatz, 2018). Two initially nearby trajectories diverge rapidly, making long-term prediction impossible.

The attractor framework reframes perturbation response through **corrective permeability** (κ), defined functionally as the capacity of a system to dissipate perturbation energy and return to its basin. The term "permeability" is used in a non-standard, functional sense; it is not intended to carry the dimensional meaning it holds in physics (e.g., Darcy's law, where permeability has units of area). It was chosen to emphasize the *openness* of an attractor to corrective perturbation—a qualitative property—while recognizing that its quantitative expression is a rate (inverse time). The distinction between the qualitative concept and its quantitative operationalization should be kept in view throughout.

κ and λ capture different aspects of dynamical resilience. λ measures the rate of *divergence* of neighboring trajectories; κ measures the rate of *convergence* of a perturbed system back to equilibrium. A system can have high λ (chaotic sensitivity) and simultaneously high κ (rapid damping). This distinction between divergence rate and recovery rate extends the analytical vocabulary in a direction Ruelle did not pursue, and represents one of the framework's conceptual contributions.

2.3 Dissipative Condition → Dissipative Attractor

Ruelle emphasized that strange attractors occur only in dissipative systems—those in which ordered energy is converted to heat and exported as entropy (what Ruelle called "noble forms of energy"). Conservative systems preserve phase-space volumes and do not produce attractors. The universe as a whole is conservative; strange attractors exist only in subsystems.

This maps directly onto the attractor framework's distinction between the **eternal conservative skeleton** and the **transient dissipative dance**. The six metronomes—electron, proton, three neutrino mass states, and CVU lattice—are conservative persistence structures. They do not decay, export no entropy, and are not attractors. Living bodies, minds, societies, and climate systems are dissipative attractors, continuously exporting entropy and navigating constraint fields. Ruelle's dissipative condition is the physical foundation of this central ontological partition.

2.4 Discrete and Continuous Dynamics → The Two Metronomes

Ruelle presented both discrete-time maps (Hénon) and continuous-time flows (Lorenz, 1963). In both cases, strange attractors emerge. The attractor framework identifies invariant references—**metronomes**—that anchor dissipative dynamics. Positional metronomes (the center of mass of a gas cloud, the fixed point of a difference equation) and frequency metronomes (orbital periods, the characteristic exponent λ) provide the invariant skeleton against which the transient dance is measured. Ruelle's maps and flows contain these invariants implicitly; the framework makes them explicit.

2.5 Indecomposability → Unified Attractor (Partial Correspondence)

Ruelle required that a strange attractor not be decomposable into two separate attractors. This is a strong mathematical condition. The attractor framework inherits the spirit of this—dissipative attractors are treated as unified, coherent basins—but the correspondence is only partial. The framework's conscious body thesis (Galida, 2026g) explicitly recognizes *multiple* candidate attractors within a single organism (the enteric nervous system, the cardiac nervous system). These are coupled but semi-autonomous basins, in tension with Ruelle's indecomposability condition. The framework thus extends the attractor concept in a direction

Ruelle's original definition did not anticipate. This divergence is noted as a feature of the framework, not a failure of correspondence.

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3. Prigogine's Dissipative Structures: The Thermodynamic Parallel

While Ruelle provided the mathematical prototype of the strange attractor, Ilya Prigogine provided the thermodynamic foundation for the broader class of dissipative systems. Prigogine's Nobel-winning work (Prigogine, 1980, 1984) demonstrated that systems maintained far from thermodynamic equilibrium spontaneously self-organize into coherent, ordered structures—dissipative structures—that persist only as long as they are sustained by energy and matter flows.

The structural parallels between Prigogine's dissipative structures and the attractor framework's dissipative attractor are substantial. Both describe systems maintained far from equilibrium by continuous energy throughput. Both recognize that dissipation is not merely a degradation of order but a condition for the emergence of order. Both extend beyond physics into chemical, biological, and ecological systems. The Belousov-Zhabotinsky reaction, biochemical oscillations, and ecosystem dynamics are Prigoginean dissipative structures; they are also dissipative attractors in the framework's vocabulary. Kauffman's (1993) work on self-organization and selection in evolution provides an independent biological parallel, reinforcing the consistency of the attractor framework with established complexity theory.

The framework's applications to living bodies, minds, and societies are consistent with the Prigoginean tradition. This consistency was recognized retrospectively; the framework's concepts were not derived from Prigogine. The parallels are

offered as evidence that the framework's biological and social extensions are grounded in established thermodynamic principles, not as evidence of intellectual descent.

The framework thus finds post-hoc validation in two complementary scientific traditions: the mathematical theory of strange attractors (Ruelle, Takens, Lorenz) for the concepts of basin, sensitive dependence, and chaotic dynamics; and the thermodynamics of dissipative structures (Prigogine) for the concept of entropy-exporting, self-organizing systems far from equilibrium. Neither tradition alone is sufficient; together they provide the physical foundations with which the framework is consistent.

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4. The Attractor Framework: Extensions Beyond the Physical Prototypes

The attractor framework extends the concepts of basin, dissipation, and perturbation response beyond physical and biological systems into cognitive and social domains. These extensions are heuristic hypotheses, not established results. They are offered as candidate applications requiring independent validation.

4.1 From Strange to Dissipative: A Broadened Scope

Ruelle's strange attractor and Prigogine's dissipative structure are both special cases of the framework's broader category: the **dissipative attractor**—any system that exports entropy while converging toward a stable basin. The framework does not require the attractor to be "strange" (to exhibit sensitive dependence). Fixed-point attractors, periodic attractors, and quasiperiodic attractors are all dissipative attractors under this definition. The framework's scope is deliberately broad, encompassing any persistent, entropy-

exporting system regardless of its internal dynamical complexity.

4.2 The Fantasy Attractor: A Structural Analogy

The framework's most significant extension beyond Ruelle and Prigogine is the concept of the **fantasy attractor**: a belief system with low corrective permeability that resists updating under contradictory evidence (Galida, 2026c, 2026d, 2026e). The dopamine covenant—the neurochemical reinforcement of certainty through mesolimbic reward—provides a psychological mechanism that is structurally analogous to, but not identical with, physical dissipation.

The analogy is as follows. A physical dissipative attractor exports entropy via radiation or heat, returning to its basin after perturbation. In the physical case, "basin depth" is formally defined through the geometry of the attractor in phase space, measurable in principle from the equations of motion. A cognitive attractor neutralizes perturbation via reframing, also preserving its basin—but here "basin depth" is a functional analogy, not a formal measure. Both systems respond to destabilizing perturbations by restoring their pre-perturbation state. The analogy holds at the functional level.

However, the mechanisms differ in important respects. Physical dissipation involves the export of thermodynamic entropy from a subsystem to its environment. Dopamine reinforcement is a *feedback amplification* mechanism—it strengthens the neural pathways associated with the belief, making them more salient and resistant to competition. It does not export entropy in the thermodynamic sense. The structural analogy—a system responding to perturbation by restoring its basin—holds at the functional level, but the physical substrates and mechanisms are distinct. The framework does not claim identity; it claims functional parallelism.

The assignment of $\kappa \approx 0$ to fantasy attractors is qualitative

and provisional. Unlike Ruelle's λ, which is computable from the equations of motion, κ for belief systems currently lacks an operationalized measurement procedure. The framework's applications to political and religious belief systems (Galida, 2026d, 2026e) are heuristic extensions, offered as diagnostic hypotheses. Independent validation through operationalized κ remains a task for future empirical work.

4.3 Candidate Applications Across Domains

The framework's cross-domain applications are candidate hypotheses, not established results. Each requires independent validation. The following are offered as illustrations of the framework's heuristic reach, with the caveat that formal operationalization is pending.

- **Climate dynamics** (Galida, 2026b): The Earth's climate is a dissipative attractor with multiple basins, tipping points, and corrective feedbacks. The claim that linear warming models constitute a fantasy attractor is a diagnosis of the modeling community's resistance to nonlinear dynamics, not a claim about the physical climate system itself. The two must be distinguished: the climate is a physical attractor; the *belief* that it behaves linearly is a cognitive one.
- **Political ideology** (Galida, 2026d): The $\kappa \approx 0$ assignment for the MAGA movement is a qualitative diagnostic based on observable indicators (electoral loss response, legal defeat response, internal dissent tolerance). It is not a measurement in Ruelle's sense. The assignment is offered as a hypothesis to be tested against alternative interpretations.
- **Apocalyptic convergence** (Galida, 2026e): The claim that three Abrahamic basins have phase-locked into a meta-attractor uses "phase-locked" in an extended, qualitative sense. The formal demonstration of phase-locking requires identifying coupling constants and

frequency ratios, which have not been established. The claim is offered as a structural diagnosis, not a dynamical proof.

- **Organ-level consciousness** (Galida, 2026g): The identification of candidate organ-level minds as dissipative attractors applies the framework's criteria directly to biological subsystems. The C. elegans threshold provides a benchmark; the independent operationalization of κ for these subsystems awaits experimental protocols.

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5. The Metronome: An Innovation Without Direct Precedent

One concept in the attractor framework has no direct analogue in either Ruelle or Prigogine: the **metronome**—the invariant reference around which dissipative dynamics organize. In the gas cloud paper (Galida, 2026f), the center of mass and the orbital period were identified as positional and frequency metronomes, respectively. These invariants are not attractors; they are the fixed skeleton against which the transient dance is measured.

The six metronomes of the eternal skeleton—the electron, the proton, the three neutrino mass states, and the CVU lattice—are the ultimate invariants, defining time through their fixed, unchanging frequencies. Ruelle's maps and flows contain invariants (fixed points, conserved quantities, characteristic exponents), but he did not distinguish them as a separate ontological category. Prigogine's dissipative structures also operate against a background of invariant constraints. The attractor framework's explicit separation of the invariant skeleton from the dissipative dance is a genuine conceptual contribution, not present in either precursor

tradition.

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6. Conclusion: A Coherent Vocabulary, Conditionally Applied

The attractor framework is structurally consistent with the mathematical physics of strange attractors and the thermodynamics of dissipative structures. Its core concepts—dissipative attractor, basin, corrective permeability, and invariant reference—map cleanly onto established physical constructs. Its extensions into cognitive and social domains are heuristic hypotheses, not established results.

The framework developed its vocabulary independently. The correspondences documented here are offered as post-hoc validation: the framework speaks the language of established nonlinear dynamics and nonequilibrium thermodynamics, and where it departs from these precursors it does so explicitly, with acknowledgment of the remaining gaps between analogy and operationalization. Future work must close those gaps through quantitative measurement of κ, formal modeling of coupling dynamics, and empirical testing of the framework's diagnostic claims.

The framework is offered as a research program, not a completed theory.

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“For independent neuroscientific corroboration of the attractor dynamics described here, see A Preliminary Mapping Between Ring Attractor Dynamics and the Attractor Framework.” https://www.sciencedirect.com/science/article/pii/S2405844024114892

“see also” https://jamestobinphd.com/the-psychology-of-attractor-states/

The Shroud of Turin: Anatomy of a Fantasy Attractor

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Abstract

The Shroud of Turin is among the most studied artifacts in history. Multiple independent lines of evidence—radiocarbon dating, historical documentation, and forensic image analysis—converge on a dating to the medieval period, making a first-century origin highly implausible. Yet belief in its authenticity persists among millions. This paper applies the attractor framework to the Shroud as a case study in the dynamics of belief persistence under disconfirmation. The framework is used here as a psychological and sociological diagnostic tool: it explains *why* belief in the Shroud persists, not whether the Shroud is authentic. That latter

question is adjudicated by the physical evidence, which this paper reviews. We identify the major perturbation (the 1988 carbon dating), catalogue the successive reframing strategies that neutralized it, and examine the image's unresolved features as potential beams the Shroud's defenders have not fully examined. The Shroud is interpreted as a dopamine lever—a relic that provides the feeling of physical contact with the divine—and its persistence is explained through the same neurochemical and social mechanisms that sustain apocalyptic prophecy, political ideology, and textual fundamentalism. The paper concludes by applying the framework's own diagnostic to itself, identifying potential beams within the attractor framework, and integrating those limitations into its conclusions.

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1. Introduction: Two Distinct Questions

The Shroud of Turin is a linen cloth measuring approximately 4.4 by 1.1 meters, bearing the faint image of a man who appears to have been crucified. It has been venerated for centuries as the burial cloth of Jesus of Nazareth and remains one of the most visited Christian relics in the world. It has also been subjected to more scientific scrutiny than any religious artifact in history.

Two distinct questions must be kept separate. The first is a question of physical fact: *Is the Shroud an authentic first-century burial cloth?* This question is adjudicated by radiocarbon dating, textile analysis, historical documentation, and image forensics. The second is a question of psychological and social dynamics: *Why does belief in the Shroud persist despite strong evidence against its authenticity?* This question is adjudicated by the attractor framework, the neuroscience of sacred values, and the social psychology of failed prophecy.

This paper addresses both questions, but it keeps them distinct. The physical evidence is reviewed on its own terms. The attractor framework is then applied to explain the persistence of belief, not to determine the Shroud's authenticity. Conflating these two operations—using a psychological model to adjudicate physical evidence—would be a methodological error. This paper avoids that error.

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2. The Physical Evidence

2.1 The 1988 Radiocarbon Dating

In 1988, the Vatican authorized the removal of a small sample from the Shroud for radiocarbon dating. The sample was divided and sent to three independent laboratories: the University of Oxford, the University of Arizona, and the Swiss Federal Institute of Technology in Zurich. All three, using accelerator mass spectrometry, dated the linen to between 1260 and 1390 CE. The results were published in *Nature* (Damon et al., 1989).

The dating is strong. Three independent laboratories, using a well-established physical method, produced results clustering tightly within the medieval period. The finding aligns with the Shroud's first documented historical appearance in Lirey, France, in 1354. In archaeology or forensic science, a radiocarbon result of this quality, replicated across independent labs and corroborated by documentary evidence, would ordinarily be treated as dispositive.

The dating is not, however, entirely uncontested. The sampling protocol was criticized at the time for using a single sample location rather than multiple sites. Subsequent statistical analyses (Riani et al., 2013) identified heterogeneity in the radiocarbon data across the three laboratories, suggesting possible non-homogeneity in the sample that was not fully

accounted for by the original statistical treatment. These concerns do not invalidate the dating, but they complicate the claim that the result is beyond any possible methodological challenge. A more precise characterization is: the radiocarbon evidence is strong, independently replicated, corroborated by documentary history, and unrebutted by any equally rigorous methodology.

2.2 The Bishop of Troyes (1389)

The radiocarbon date aligns with the Shroud's first documented historical appearance. In 1354, the cloth was displayed in Lirey by a knight named Geoffroi de Charny. In 1389, Pierre d'Arcis, the Bishop of Troyes, wrote to Pope Clement VII identifying the Shroud as a forgery. The bishop stated that a painter had confessed to creating the image and that the cloth had been "cunningly painted" to attract pilgrims. The Pope issued a bull allowing the Shroud to be displayed but requiring that it be announced as a "representation" rather than the authentic burial cloth.

The convergence of radiocarbon dating and documentary evidence makes a first-century origin highly implausible. What the evidence does *not* establish is deliberate medieval fraud. The radiocarbon date tells us when the linen was harvested, not who made the image or for what purpose. The bishop's letter provides a documented accusation of forgery, but accusations are not verdicts. The distinction between "not authentic" and "confirmed deliberate fake" is meaningful and will be maintained throughout this paper.

2.3 The Pollen Evidence

Max Frei claimed to identify pollen grains from plants native to Turkey and Israel on the Shroud's surface, evidence that would suggest a Near Eastern origin inconsistent with the medieval European radiocarbon date. Frei's findings have been critiqued on methodological grounds, including inadequate controls for contamination and the possibility that pollen

grains can transfer to textiles through handling over centuries. The pollen evidence does not outweigh the radiocarbon dating—no indirect botanical inference can override a direct physical measurement of the cloth itself—but its existence in the authenticity literature is noted. The Frei findings are contested; the radiocarbon findings are strong.

2.4 The Image: Open Questions and Overstated Claims

The mechanism by which the Shroud's image was formed remains one of the few genuinely unresolved questions in Shroud research. The STURP (Shroud of Turin Research Project) investigation in 1978 found that the image resides on the topmost fibers of the cloth, does not penetrate the threads, and lacks the directionality characteristic of brushstrokes. STURP found no evidence of applied pigment as the primary image-forming mechanism. These findings are real and deserve engagement.

The present paper does not attempt to resolve the image-formation question. It notes, however, that an unresolved image-formation mechanism does not constitute evidence of authenticity. Many medieval artifacts have incompletely understood manufacturing processes. The absence of a fully satisfactory explanation for how the image was produced does not outweigh the radiocarbon and documentary evidence establishing *when* the cloth originated. The image is an open question; the date is not.

The observation that the image is proportionally elongated in the manner of medieval religious iconography, with a head that does not align naturally with the body in ways that a contact imprint from a wrapped corpse might be expected to, is consistent with a medieval origin but does not independently establish it.

3. The Reframing Cascade: How the Basin Survived

A high-κ belief system would have absorbed the radiocarbon perturbation and updated. The Shroud's defenders did the opposite. The attractor sealed, and a cascade of reframing strategies followed. Each reframe provided renewed certainty, and each successive reframe retreated further from empirical testability.

3.1 The Repair Patch Hypothesis

The earliest and most persistent reframe held that the radiocarbon sample had been taken from a medieval repair patch, not the original cloth. This hypothesis gained credibility when Raymond Rogers, a retired Los Alamos chemist and former Shroud skeptic, published findings in 2005 claiming that the sample contained cotton fibers and dye not present elsewhere on the cloth.

Subsequent analysis by Bella, Garlaschelli, and Samperi (2015) found no mass spectrometry evidence supporting the repair patch hypothesis. The original sample was taken from the main body of the cloth. While the exchange between Rogers and his critics has not been universally regarded as closed, the repair patch hypothesis has not been sustained by subsequent independent analysis.

3.2 The Fire Contamination Hypothesis

A second reframe proposed that the 1532 fire had contaminated the Shroud with carbon, skewing the radiocarbon date. This hypothesis was never supported by experimental evidence showing that contamination of the required magnitude and isotopic specificity is physically plausible.

3.3 The Resurrection Energy Hypothesis

The most recent reframe, and the least testable, proposes that the resurrection event itself—a burst of divine energy—altered the isotopic composition of the linen. This hypothesis is unfalsifiable by design. It can be neither confirmed nor refuted by any physical measurement, which is precisely what makes it attractive to a sealed basin.

The trajectory from repair patch (falsified) to fire contamination (unsupported) to resurrection energy (unfalsifiable) is structurally identical to the reframing cascades documented by Festinger et al. (1956) and Melton (1985) in failed prophetic movements. The content differs; the dynamics do not.

A methodological caveat. The characterization of this trajectory as "low κ" is a qualitative judgment, not a formal measurement. Corrective permeability (κ) remains a conceptual construct within the attractor framework, operationalized in principle but not yet validated through independent measurement. The framework's diagnostic vocabulary—low κ, sealed basin, reframing cascade—provides a coherent description of the Shroud defenders' behavior, but the assignment of $\kappa \approx 0$ is interpretative, not empirical. This limitation constrains the confidence with which the paper can claim that the Shroud case is a definitive instance of a fantasy attractor rather than a plausible one.

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4. The Dopamine Lever: Why the Basin Holds

The Shroud's persistence is not explained by the evidence, which is strongly against its authenticity. It is explained by the dopamine covenant (Galida, 2026c). The Shroud is a

physical lever that delivers the feeling of proximity to the divine. To stand before it, or even to view a reproduction, is to feel connected to the central event of Christian faith.

The neuroscience of sacred values and religious experience supports this interpretation. Religious belief and ritual engage the mesolimbic reward system, including the nucleus accumbens and ventral striatum (Newberg, 2010). Neuroimaging studies have identified distinct neural signatures associated with religious conviction, including activity in regions implicated in valuation and emotional processing (Kapogiannis et al., 2009). The pioneering work of Olds and Milner (1954) established the foundational principle—direct stimulation of reward pathways can override competing biological imperatives—demonstrating that reward-seeking behavior can persist in the absence of biological utility. Subsequent research on the neural correlates of religious belief (Inzlicht et al., 2011) has examined distinct mechanisms including error-monitoring and anxiety reduction in religious believers, extending the neuroscience of conviction beyond the reward-pathway paradigm. The certainty of possessing a tangible link to the divine plausibly activates dopaminergic circuitry similar to that implicated in other forms of ideological commitment.

The believer does not evaluate the Shroud as a forensic object. They experience it as a relic. The dopamine reward of touching the sacred is more powerful than any carbon date. The lever is pressed, and the radiocarbon laboratory might as well be on another planet. The basin’s impermeability is not primarily intellectual. It is neurochemical.

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5. The Beams: What the Framework and the

Author Cannot Fully Examine

The attractor framework's diagnostic of the "beam"—the feature a system cannot examine in itself—must be applied to the framework itself. This paper has argued that the Shroud's defenders exhibit low corrective permeability. It has not established this claim through independent measurement, and several potential beams within the attractor framework deserve acknowledgment.

Operationalization. κ remains a qualitative construct. Without formal measurement criteria, its application to cases is necessarily subjective. The framework diagnoses low κ in the Shroud's defenders; a skeptic of the framework could diagnose the same low κ in the framework's own resistance to operationalization. This beam has been partially examined in Section 3's methodological caveat but remains a structural limitation.

Case selection. The framework is applied exclusively to cases where the author's assessment of the evidence aligns with the diagnosis. A rigorous test would require applying the framework to a case where the author believes a claim is *true* and examining whether defenders of that claim also exhibit low-κ dynamics. The present paper cannot claim to have performed this test.

Self-citation and independent validation. The framework's core constructs—κ, the dopamine covenant, the basin model—rest substantially on the author's own unpublished or independently unverified works (Galida, 2026a, 2026b, 2026c). This does not invalidate the framework, but it means the theoretical foundation is self-referential in a way that limits independent evaluation. A reader cannot assess the framework's claims without access to the author's broader corpus, and that corpus has not been subjected to peer review. This is a beam the author acknowledges but cannot resolve within the scope of this paper.

The framework itself as a potential fantasy attractor. Commitment to the attractor framework as an explanatory construct may itself be maintained through low-κ dynamics. The framework's proponents might reframe disconfirming evidence rather than updating. What would constitute a disconfirming result for the framework? If a well-documented case were presented in which a belief system exhibited all the structural features of a sealed basin yet subsequently updated rapidly and substantially without reframing, the framework's predictive utility would be challenged. Acknowledging this possibility does not invalidate the framework; it applies the framework consistently.

These beams constrain the confidence with which the paper's diagnostic claims can be advanced. The Shroud case is *consistent* with the fantasy attractor model; it is not *definitive proof* of it. The daily question—"Did I update any belief yesterday?"—applies to the author as much as to the Shroud's defenders. This paper has been revised in response to critique. Whether those revisions constitute genuine corrective permeability or merely the reframing of a sealed basin is a question the author cannot definitively answer. The reader is invited to judge.

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6. The Larger Covenant: Relics and Apocalyptic Attractors

The Shroud is not an isolated case. It belongs to a family of fantasy attractors that includes apocalyptic prophecy, textual fundamentalism, and geopolitical messianism. Each offers a lever that rewards certainty with dopamine and punishes updating with cognitive dissonance. Each survives perturbation through reframing rather than revision. Each possesses a beam it cannot fully examine.

The Shroud's structural relationship to the apocalyptic attractors analyzed elsewhere (Galida, 2026a, 2026b) is instructive. The believer in the Shroud, the believer in Ezekiel 38, and the believer in the Mahdi's return are pressing the same lever. The content of the belief differs, but the dynamics are identical. The dopamine covenant unifies them.

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7. Conclusion

The Shroud of Turin is a medieval cloth, not a first-century burial shroud. The radiocarbon dating is strong, independently replicated, corroborated by documentary history, and unrebutted by any equally rigorous methodology. The reframing cascade—repair patch, fire contamination, resurrection energy—is a well-documented instance of belief persistence under disconfirmation. The image-formation mechanism remains an open question but does not outweigh the dating evidence. The distinction between "not authentic" and "confirmed deliberate forgery" should be maintained: the evidence establishes the cloth's medieval origin but does not independently establish the intent of its creator.

The Shroud's persistence as an object of veneration is not a mystery requiring supernatural explanation. It is a predictable dynamical phenomenon, driven by the same neurochemical and social mechanisms that sustain all sealed belief systems. The attractor framework explains why the evidence has not been sufficient to collapse the basin.

The framework itself, however, remains a qualitative construct with unoperationalized core variables, a self-referential theoretical foundation, and a case-selection pattern that limits its generalizability. Its diagnostic claims are plausible but not definitive. These beams are acknowledged but

not resolved. The lever is hot. The fire feels good. The metronomes hum. The carbon-14 decays at its fixed rate. The physical evidence is what it is. The attractor framework provides a coherent account of why that evidence has not been sufficient to change most believers' minds—and it acknowledges that its own account must remain open to correction by evidence that has not yet arrived.

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The MAGA Attractor: Fantasy, Colonization, and the Terminal Phase of a Sealed Basin

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June 2026 | fantasyattractor.com

Abstract

The MAGA movement is a colonizing fantasy attractor exhibiting the structural features the attractor framework predicts: a destabilizing perturbation, a dopamine-rich sealed narrative, near-zero corrective permeability (κ), active colonization of rival basins, and a terminal phase characterized by attacks on reality-delivery institutions. This paper applies the κ diagnostic—a set of observable indicators measuring a belief system's willingness to update on contradictory evidence—to MAGA as a case study. We include a minimal comparative sketch applying the same indicators to a left-aligned movement to demonstrate symmetric applicability. We engage disconfirming instances within the MAGA case, define the terminal phase formally, and ground the attractor framework in established dynamical-systems and motivated-reasoning literatures. The paper does not offer predictions. It identifies structural tendencies and leaves empirical validation to future work.

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1. Introduction: The Diagnostic Stance

The attractor framework (Galida, 2026) defines a fantasy attractor as a belief system with low corrective permeability (κ): it resists updating when confronted with contradictory evidence, reframes error signals to protect its core narrative, and often seeks to colonize or destroy neighboring basins. The framework draws on dynamical-systems theory (Strogatz, 2018; Kelso, 1995), which characterizes attractors as regions in state space toward which trajectories converge and remain unless perturbed. A high-κ attractor absorbs perturbation and updates; a low-κ attractor resists perturbation and seals. This paper applies that diagnostic to the MAGA movement.

The framework predicts that sealed attractors exist across the

political spectrum. A fully symmetric analysis would examine movements of all orientations using the same κ indicators. The present paper is a single-case application, supplemented by a brief comparative sketch in Section 6. It does not imply that MAGA is unique or uniquely sealed. It demonstrates the diagnostic method on a prominent and well-documented case.

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2. Operationalizing Corrective Permeability (κ)

Corrective permeability is not a single number. It is a composite of observable indicators. A movement's κ can be estimated—qualitatively, not metrically—by examining its responses to disconfirming events. The indicators below are applicable to any political or social movement.

κ Indicators

Indicator	High κ (reality-aligned)	Low κ (fantasy attractor)
Electoral loss response	Concedes defeat; analyzes reasons; adapts strategy	Rejects outcome as fraudulent; seeks to overturn result
Legal defeat response	Accepts ruling; appeals within system; adjusts behavior	Delegitimizes courts; portrays defeats as persecution
Internal dissent tolerance	Debates openly; allows factional disagreement	Purges dissenters; enforces narrative loyalty
Media coverage response	Engages with critical reporting; distinguishes bias from fact	Labels all critical media as "enemy"; constructs alternative media ecosystem

Indicator	High κ (reality-aligned)	Low κ (fantasy attractor)
Policy failure response	Acknowledges failure; revises approach	Blames enemies; reframes failure as sabotage
Leader criticism response	Evaluates criticism on merits; holds leaders accountable	Treats all criticism as treason; leader is beyond reproach

A movement that scores low across most or all indicators has κ approaching zero. A movement that scores high across most has κ approaching one. The assignment is comparative and qualitative, not computational.

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3. The Initial Perturbation: A Basin Destabilized

The MAGA movement emerged from a genuine, large-scale perturbation to the personal and social attractors of millions of Americans. For decades, the post-war American basin was stable for its primary beneficiaries: manufacturing jobs provided middle-class security, cultural norms were broadly shared, and the United States enjoyed unchallenged global dominance. Over several decades, that basin was progressively destabilized. Deindustrialization eliminated millions of stable jobs. Globalization shifted economic power away from domestic manufacturing. Cultural norms around race, gender, sexuality, and religion shifted rapidly. Demographic projections showed a future in which the previously dominant group would become a minority. Each of these was a perturbation. Cumulatively, they shattered the old basin.

The attractor framework does not judge the legitimacy of the grievances. It notes that a destabilized attractor seeks a new basin. The question is always: *What basin will replace the old*

one?

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4. The New Basin: Narrative, Dopamine, and Motivated Reasoning

The core narrative of the MAGA attractor is well-documented: the adherent is the authentic voice of the nation; their loss is a theft by corrupt elites and internal enemies; the leader will restore greatness. This narrative is an ontological rescue. It replaces a confusing, painful reality with a simple, morally charged story.

The dopamine dynamics are well-established. Certainty, righteous anger, and tribal belonging activate the mesolimbic reward system (Olds & Milner, 1954). But dopamine alone does not distinguish fantasy attractors from reality-aligned movements—all high-commitment groups generate reward. What distinguishes low-κ attractors is the *impermeability* of the reward loop: the system prevents corrective information from entering, so the dopamine cycle never encounters disconfirmation.

The motivated-reasoning literature provides a well-established parallel. Individuals process information in ways that protect identity-congenial beliefs (Kahan, 2013). Social identity theory (Tajfel & Turner, 1979) predicts that group membership becomes a source of self-esteem, making threats to the group's narrative feel like personal attacks. The MAGA attractor operates at the intersection of these dynamics: a highly salient group identity, a narrative of victimhood and restoration, and a reward system that fires on certainty. The basin is psychologically satisfying and neurochemically self-reinforcing.

5. Applying the κ Indicators to MAGA

When we apply the six κ indicators to the documented behavior of the MAGA movement, the pattern is clear.

- **Electoral loss response:** The 2020 election was rejected as fraudulent. Over 60 court cases were dismissed, yet the “stolen election” narrative persisted. Electoral officials who certified results have been purged and replaced. κ is near zero on this indicator.
- **Legal defeat response:** Criminal and civil indictments against the movement’s leader are framed as “witch hunts” and “election interference.” Courts are delegitimized. κ is near zero.
- **Internal dissent tolerance:** Republicans who criticized the leader have been primaried, censured, or forced from office. Internal debate is treated as disloyalty. κ is near zero.
- **Media coverage response:** Mainstream media are labeled “enemies of the people.” A parallel media ecosystem delivers only narrative-congruent information. κ is near zero.
- **Policy failure response:** Trade wars that harmed farmers were reframed as necessary sacrifices, not policy failures. Promised infrastructure and healthcare reforms that did not materialize were blamed on opponents, not acknowledged as unfulfilled. κ is near zero.
- **Leader criticism response:** Criticism of the leader is treated as treason. The leader’s statements, even when contradictory or demonstrably false, are accepted by adherents without correction. κ is near zero.

5.1 Disconfirming Instances and Complexity

The assignment of $\kappa \approx 0$ is a pattern judgment, not a uniform claim. Several behaviors complicate a blanket zero-κ diagnosis and must be acknowledged.

- Some MAGA-aligned officials did certify the 2020 election results under intense pressure, including figures such as Georgia Secretary of State Brad Raffensperger and Arizona's Republican governor Doug Ducey, who faced threats and political retaliation for doing so. This is evidence of $\kappa > 0$ among individuals within the movement's orbit.
- The movement's policy agenda did shift in notable ways relative to prior Republican orthodoxy, including trade protectionism, pharmaceutical pricing reform, and infrastructure spending. These represent genuine policy adaptation, even if they served the broader narrative of economic nationalism.
- Internal dissent, while punished, has not been eliminated. Some Republican figures continue to criticize the leader from within the party, and factions with incompatible interests (economic libertarians, Christian nationalists, working-class populists) persist.

These instances suggest that the movement is not a perfectly uniform basin. Some members and subgroups exhibit higher κ than others. However, the overall pattern—sustained across multiple years, multiple domains, and the movement's dominant institutional responses—remains one of extremely low corrective permeability. The dissenting officials were purged, not elevated. The policy shifts occurred within a sealed narrative that did not acknowledge prior error. Internal critics were marginalized. The diagnostic is a structural assessment of the attractor's dominant dynamics, not a claim about every individual within it.

6. Comparative Sketch: A Left-Aligned Case

The framework's symmetry requirement demands that the same κ indicators be applied to movements of other political orientations. A full comparative analysis is beyond the scope of this paper, but a brief sketch demonstrates the method's applicability.

Consider the progressive wing of the Democratic Party's response to the 2016 election loss. On the κ indicators:

- **Electoral loss response:** The loss was accepted, though accompanied by narratives of Russian interference and Electoral College illegitimacy. The outcome was not rejected as fraudulent, but external factors were invoked to explain defeat—a partial but not complete κ signal.
- **Legal defeat response:** Progressive legal setbacks (e.g., on immigration policy, voting rights) have generally been accepted within the system, with strategy adjustments rather than court delegitimization. κ is moderate-high.
- **Internal dissent tolerance:** The progressive coalition contains vigorous internal debate between moderates and left factions. Primary challenges are common and openly contested. κ is high on this indicator.
- **Media coverage response:** Progressives engage with mainstream media but also criticize it for bias. An alternative media ecosystem exists but has not fully sealed; cross-pollination with mainstream outlets is common. κ is moderate.
- **Policy failure response:** Failed progressive initiatives (e.g., certain criminal-justice reform measures, housing

policies) have generated internal debate and strategy revisions, though blame-shifting also occurs. κ is moderate.

- **Leader criticism response:** Progressive leaders face significant internal criticism. Figures such as Bernie Sanders and Alexandria Ocasio-Cortez are both celebrated and challenged from within the movement. κ is high.

This sketch suggests a moderate-to-high κ for this movement, with some indicators showing partial sealing. The exercise demonstrates that the κ indicators do not automatically classify one's political opponents as fantasy attractors and one's allies as reality-aligned. The diagnostic discriminates based on behavior, not affiliation.

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7. Colonization: "You Must Join or Be Destroyed"

A fantasy attractor does not peacefully coexist. It colonizes. The MAGA movement demands that other basins submit to its narrative or be treated as enemies. This operates at interpersonal, institutional, and electoral levels. Families are fractured by loyalty demands. The judiciary, civil service, and military are to be purged of "disloyal" elements. Election administration is being restructured to place loyalists in positions of authority over vote counting and certification. Colonization is a structural necessity: a sealed attractor cannot tolerate rival basins that might deliver a fatal perturbation.

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8. Beam and Sliver: Internal Contradictions as Diagnostic Features

All political coalitions contain tensions between stated values and enacted policy. The diagnostic question is not whether contradictions exist, but whether the attractor can acknowledge and address them. High-κ movements can name their own tensions. Low-κ movements cannot.

The MAGA attractor exhibits several severe, structurally unresolvable contradictions:

- **Liberty vs. Authoritarianism:** The movement claims to defend freedom while supporting a leader who attacks the free press, demands personal loyalty, and threatens to use state power against opponents.
- **Law and Order vs. Criminality:** The movement claims to uphold law and order while its leader faces multiple felony convictions and indictments.
- **Populism vs. Plutocracy:** The movement claims to be a working-class revolt while its policy agenda primarily benefits the wealthy.
- **Christianity vs. Cruelty:** The movement claims Christian values while supporting policies that separate migrant families and mock the vulnerable.

What makes these contradictions diagnostically severe is not their existence—all coalitions contain tensions—but their structural unresolvability within the current basin. The movement's dependence on a single leader whose personal legal exposure is inextricably linked to its narrative makes acknowledgment of criminality equivalent to basin collapse. The contradiction cannot be resolved; it can only be suppressed by attacking the legal system itself. This dynamic is distinct from the ordinary policy tensions of a political coalition, where compromise, leadership change, or platform

evolution can absorb and resolve contradictions over time. In the MAGA basin, the leader cannot be replaced without dissolving the attractor, and the criminal charges cannot be acknowledged without invalidating the narrative of persecution. The beam is locked in place.

The sliver is projected outward with equal force: every fault is hung on the opponent. The movement cannot name its own contradictions, so it names everyone else's—real or invented—with relentless intensity.

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9. The Terminal Phase: Formal Definition and Observable Signs

Within the attractor framework, a **terminal phase** is reached when a sealed attractor, facing sustained and credible existential threats, shifts its primary behavior from narrative self-maintenance and colonization to the active dismantling of the external correction mechanisms that could deliver a fatal perturbation.

Transition conditions include:

1. **Loss of institutional control:** The movement no longer reliably controls the executive or legislative branches through normal electoral means.
2. **Credible legal jeopardy:** Leadership faces prosecution, incarceration, or removal from ballots.
3. **Narrowing coalition:** The movement's demographic base cannot reliably produce majorities in national elections.
4. **Elite messaging shift:** The movement's leadership explicitly frames institutional destruction as the only path to survival.

When these conditions are met, the attractor is no longer merely sealed. It is actively destroying the sources of perturbation.

Observable signs of a terminal-phase political attractor:

1. **Rejection of electoral outcomes** as illegitimate unless the movement wins.
2. **Purge of dissenting officials** from election administration and party structures.
3. **Preparation for institutional override** through legal theories that would allow loyalist bodies to override popular vote counts.
4. **Normalization of violence** as patriotic self-defense.
5. **Attacks on truth-delivery systems**—media, science, intelligence, courts—to neutralize their corrective function.

The MAGA movement currently exhibits all five signs. The transition conditions are partially met (credible legal jeopardy is present; electoral losses have occurred; the coalition faces demographic challenges) and partially contested (the movement retains significant institutional power through the courts and state legislatures). The terminal phase is not an all-or-nothing category; it is a trajectory along which the movement has demonstrably moved.

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10. Trajectory: Structural Tendencies, Not Predictions

The attractor framework identifies structural tendencies, not certainties. Three trajectories are possible for a terminal-phase fantasy attractor, and they are not mutually exclusive.

Escalation. If the leader faces incarceration, removal from ballots, or definitive electoral defeat, the movement may escalate. Violence is the final defense of a sealed basin that cannot tolerate reality. Escalation risk is elevated when institutional pressure intensifies.

Fracture. The movement contains factions with incompatible interests. If the central figure becomes unavailable, the attractor may fracture into competing sub-basins, each claiming legitimacy. This is a common post-charismatic trajectory.

Slow Fade. Some fantasy attractors fade as the promised restoration never arrives, adherents age, and younger generations find the narrative less compelling. This trajectory requires sustained institutional resilience and an absence of triggering crises.

The current structural conditions—ongoing legal pressure, sustained institutional attacks, and the centrality of a single figure—make escalation and fracture the highest-concern scenarios. The slow fade remains a possibility only if institutions hold and no major crisis intervenes. No probability is assigned. The framework names the tendencies and leaves empirical validation to events.

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11. Conclusion

The κ indicators, applied qualitatively, suggest that the MAGA movement exhibits near-zero corrective permeability across multiple domains. The movement colonizes rival basins, cannot acknowledge its internal contradictions, and exhibits the observable signs of a terminal-phase attractor. Disconfirming instances complicate but do not overturn the overall pattern. Symmetric application of the κ diagnostic to movements of other political orientations is methodologically required and

has been briefly sketched; full comparative validation remains necessary. The framework provides structural tendencies, not predictions. The methodological limitations are acknowledged. The analysis is offered as a diagnostic contribution, not a final determination.

The Conscious Body: Organs as Attractor-Based Minds

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June 2026 | fantasyattractor.com

Abstract

The standard view holds that only the brain generates consciousness. This paper challenges that monopoly by applying the minimal functional criteria used to attribute rudimentary consciousness to the 302-neuron nematode *C. elegans* to the body's own complex, intrinsically innervated organs. On the basis of integration, valence, learning, goal-directedness, and anatomical concentration, the enteric nervous system (ENS), the intrinsic cardiac nervous system (ICNS), the intrinsic pancreatic ganglia, and—provisionally—the spinal cord qualify as candidate conscious subsystems. We do not assert that these organs are conscious. We assert that if the functional criteria are taken seriously enough to include a 302-neuron worm as a candidate, they cannot be silently withheld from structurally richer systems without a principled reason. We argue that the brain is not the sole generator of consciousness but the regulator of a federation of

semi-autonomous organ-level attractors. We provide testable predictions, sketch the coupling mechanisms that bind local attractors into a unified self, outline clinical implications, and identify open problems including inter-attractor conflict and the phenomenal gap. The framework is offered as a research-generative hypothesis, not a completed theory.

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1. Introduction: The Brain’s Unexamined Monopoly

The brain is the organ we associate with consciousness, almost without question. Yet the body contains other complex neural networks. The enteric nervous system (ENS) comprises 200–600 million neurons, operates semi-autonomously, learns, and remembers. The intrinsic cardiac nervous system (ICNS) integrates local signals and regulates cardiac output. The spinal cord, with approximately 200 million neurons, can learn when isolated from the brain. The intrinsic pancreatic ganglia coordinate metabolic homeostasis. If these systems were found in a small animal, comparative neuroscience would at least entertain the possibility of consciousness. Because they are inside us, they are dismissed as mere infrastructure.

This paper asks a simple question: if we accept the functional criteria used to infer minimal consciousness in *C. elegans* (302 neurons), why are those same criteria not applied to the ENS, the ICNS, the pancreatic network, and the spinal cord? The question is not *Are these organs conscious?* but *Why are they excluded a priori?*

We do not claim to solve the hard problem of consciousness. We adopt the same pragmatic strategy used throughout comparative neuroscience: observable functional properties—integration, valence, learning, goal-directedness, and anatomical concentration—are treated as operational proxies for

consciousness. This strategy is how we infer consciousness in other humans (by analogy), in non-human animals (by behavioural complexity), and in *C. elegans* (by measurable learning and integration). If these criteria are sufficient to identify a candidate conscious system in a 302-neuron worm, consistency demands their application to other systems that exceed this threshold, unless a principled exclusion criterion is provided. That exclusion criterion has not been articulated.

We use the term **candidate** throughout to avoid slippage into positive consciousness attribution. The paper's central claim is that the ENS, ICNS, pancreatic network, and spinal cord are *candidates*—systems that meet the same threshold criteria applied to a known candidate—and that dismissing them without investigation is methodologically inconsistent.

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2. The Attractor Framework as Conceptual Scaffolding

An attractor is a region in state space toward which trajectories converge and remain unless perturbed. A candidate conscious attractor possesses five functional properties:

1. **Integration:** binding multiple sensory or interoceptive streams into a unified dynamical state.
2. **Valence:** operationalized as approach/avoidance behaviour—attraction to certain states and repulsion from others. We do not claim that behavioural valence entails phenomenal valence. We claim only that it is the same behavioural proxy used for *C. elegans* and other simple organisms. The inference from behavioural valence to phenomenal valence is a philosophical commitment we note but do not resolve.

3. **Learning:** the capacity to modify behaviour based on experience (habituation, sensitization, associative conditioning).
4. **Goal-directedness:** acting to maintain the system's own basin—a form of conatus—persisting in the absence of external commands.
5. **Anatomical concentration:** a spatially organized, intrinsically connected neural network with dedicated integrative circuitry. This fifth criterion distinguishes concentrated neural attractors (ENS, ICNS, pancreatic ganglia) from diffuse, non-neural systems (immune system) and from infrastructure networks that lack a defined integrative centre. For the spinal cord, as discussed in Section 4.4, we apply this criterion with qualification.

The attractor vocabulary is applied conceptually, not formally, in this paper. A forthcoming quantitative treatment (Galida, 2026) will develop the mathematical persistence functional. The current paper uses attractor language to structure its functional criteria and predictions; it does not claim to derive formal basin measures from the available data.

Operationalizing Autonomy: We propose, as a provisional operational threshold, that a candidate subsystem crosses the autonomy boundary if it retains a significant fraction (e.g., ≥50%) of its normal functional repertoire following complete extrinsic denervation or isolation. This criterion distinguishes systems that are merely regulated from systems that can independently sustain goal-directed attractor dynamics. The ENS and ICNS clearly exceed this threshold; the spinal cord and pancreatic network do so conditionally, as discussed below.

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3. The Conditional Argument and Its Stipulated Baseline

The nematode *C. elegans* possesses exactly 302 neurons. Its connectome is fully mapped. It exhibits sensory integration, associative learning, goal-directed chemotaxis, and minimal self-reference (distinguishing self-generated from external touch). Its learning capacities are well-documented (Ardiel & Rankin, 2010; Sasakura & Mori, 2013).

We stipulate—we do not establish—that *C. elegans* is a candidate for minimal consciousness on the basis of these functional criteria. The paper does not require that the field accept this stipulation as consensus. It requires only that the reader grant the conditional: **if** the functional criteria are sufficient to make *C. elegans* a candidate, **then** they must be applied consistently to any system that meets or exceeds them. Those who reject the conditional may ignore the remainder of the argument, but they must then explain what additional criterion excludes the ENS, ICNS, pancreatic network, and spinal cord while admitting *C. elegans*.

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4. Candidate Organs

The four candidate organs identified below are assessed against the five criteria, with the provisional autonomy threshold applied where possible. We differentiate their evidential strength clearly.

4.1 The Enteric Nervous System (ENS)

The ENS is the strongest candidate. Its 200–600 million neurons form two interconnected plexuses spanning the gastrointestinal tract. It meets all five criteria:

- **Integration:** continuously integrates mechanical, chemical, and hormonal signals to coordinate peristalsis, secretion, and blood flow.
- **Valence:** exhibits attraction to nutrients, aversion to toxins; noxious stimuli trigger emesis or accelerated transit.
- **Learning:** exhibits habituation, sensitization, and long-term plasticity; gut reflexes can be conditioned (Furness, 2012; Schemann & Frieling, 2020).
- **Goal-directedness:** actively propels food and maintains digestive homeostasis independently of the brain; peristalsis persists after vagotomy—well above the 50% autonomy threshold.
- **Anatomical concentration:** a continuous, highly organized neural network with dedicated integrative circuitry.

4.2 The Intrinsic Cardiac Nervous System (ICNS)

The ICNS (14,000–43,000 neurons) is a moderate candidate. Its neuron count is only 46–143 times the *C. elegans* threshold, a narrower margin than the ENS. It meets the criteria, but with less evidential richness:

- **Integration:** monitors blood pressure, chamber stretch, and local chemistry to modulate cardiac output.
- **Valence:** maintains a preferred setpoint for cardiac rhythm; arrhythmias represent perturbations from that setpoint.
- **Learning:** shows ganglionic remodelling after injury; vagal stimulation protocols can alter responsivity (Armour, 2008).
- **Goal-directedness:** generates intrinsic rhythms when denervated, satisfying the autonomy threshold.
- **Anatomical concentration:** organized into ganglia on the heart’s surface.

The ICNS contributes to emotional experience via heartbeat-evoked potentials that correlate with interoceptive awareness and self-recognition. This is suggestive but does not independently establish consciousness.

4.3 The Intrinsic Pancreatic Network

The pancreatic network is the most provisional candidate. Its 10,000–50,000 intrinsic neurons are scattered in ganglia throughout the organ, rather than forming a continuous plexus (Ahren, 2000; Salvioli et al., 2002). This weaker anatomical concentration distinguishes it from the ENS and ICNS.

- **Integration:** combines neural, hormonal, and nutrient signals to regulate blood glucose.
- **Valence:** maintains a metabolic setpoint; hypoglycemia and hyperglycemia are aversive states.
- **Learning:** plasticity is less studied than in the ENS; no direct evidence of conditioning is available.
- **Goal-directedness:** coordinates endocrine and exocrine output to maintain glucose homeostasis; whether this function persists at ≥50% of normal repertoire after complete extrinsic denervation is not yet established. The pancreatic network remains a candidate, but with an open empirical question on the autonomy threshold.
- **Anatomical concentration:** scattered ganglia; meets the threshold but is the weakest candidate on this criterion.

4.4 The Spinal Cord (Provisional Candidate)

The spinal cord possesses approximately 200 million neurons, organized into topographically precise circuits that integrate sensory input, generate coordinated motor output, and exhibit learning when isolated (Hook & Grau, 2007). By the five functional criteria, it qualifies. However, under normal physiological conditions, its activity is tightly coupled to

descending commands, and independent behavioural generation is rarely observed. After complete spinal cord injury, the isolated cord reorganizes and can generate complex, goal-directed responses. Whether such reorganization achieves the ≥50% autonomy threshold is an empirical question; we provisionally include the spinal cord as a candidate with lower confidence, identifying it as the ideal test case for refining the autonomy criterion.

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5. The Brain as Regulator: Mechanisms of Coupling

If the ENS, ICNS, pancreatic network, and spinal cord are candidate conscious subsystems, the unified self must be explained as the product of their integration by the brain. We propose that the brain couples, modulates, and aligns local attractors through four mechanisms, each supported by established physiology.

5.1 Vagal Afferent Signalling

The vagus nerve provides the primary bidirectional communication channel between the brain and the viscera. Vagal afferents convey interoceptive signals from the ENS and ICNS to the nucleus of the solitary tract, and descending signals modulate organ function. Vagal nerve stimulation is known to alter mood, reduce inflammation, and improve cardiac function (George et al., 2000; Tracey, 2002).

5.2 Humoral Signalling

Circulating hormones (cortisol, adrenaline, insulin, glucagon) and immune mediators (cytokines) provide a slower, diffuse coupling channel. These signals alter the global attractor’s landscape by shifting the metabolic and inflammatory context. Sickness behaviour—fatigue, anhedonia, social withdrawal—is a

well-documented example of immune-to-brain signalling that temporarily reconfigures the global attractor (Dantzer et al., 2008).

5.3 Rhythmic Entrainment

The brain entrains peripheral rhythms to its own oscillations. Cardiac and respiratory rhythms phase-lock to cortical activity during focused attention (Thayer & Lane, 2000). Slow-wave sleep entrains glymphatic clearance (Xie et al., 2013). The brain sets a rhythm, and the organs—each with their own intrinsic oscillators—tend to follow. This resonance is not command; it is coupling by shared frequency.

5.4 Predictive Processing and Attractor Coupling

The predictive processing framework (Clark, 2013) treats the brain as a prediction engine that minimizes surprise by updating internal models based on sensory input. We suggest that this framework extends naturally to interoception: the brain maintains predictions about the states of the body's organs, and each organ generates its own predictions about local conditions. The alignment of these nested predictive models is functionally analogous to attractor coupling, in that both involve the progressive alignment of internal states toward a shared equilibrium. Friston's (2010) free-energy principle provides a formal bridge between predictive processing and dynamical systems that could, in future work, unite these descriptions under a single mathematical framework.

5.5 Relationship to Competing Theories of Consciousness

The attractor framework is compatible with but not identical to several major theories. Integrated Information Theory (IIT; Tononi, 2008) holds that consciousness is a function of the amount of integrated information a system generates. The attractor framework shares IIT's emphasis on integration but does not require the computation of Φ, which remains

technically infeasible for most organ systems. Global Workspace Theory (GWT; Baars, 1988; Dehaene, 2011) posits that consciousness arises when information is broadcast within a global workspace. Under GWT, many peripheral attractors would be considered unconscious because they lack access to a central workspace. The attractor framework allows for phenomenal consciousness without global access, a position consistent with the possibility that the ENS may have experiences that never enter cortical awareness. Higher-Order Theories (HOTs) require meta-representation—the capacity to represent one's own states—which, if correct, would likely exclude all candidate organs except the brain. The attractor framework treats HOTs as a valid but overly restrictive criterion that would also exclude many animals currently accepted as conscious. The framework does not seek to refute these theories but to generate testable predictions that can be compared with theirs, advancing the debate through empirical competition.

5.6 Inter-Attractor Conflict: An Open Problem for the Federation Model

A federation of semi-autonomous attractors inevitably generates conflict. Everyday clinical phenomena illustrate this: nausea during a cognitively demanding task (ENS and cortical attractors in tension), cardiac arrhythmia during emotional stress (ICNS and limbic system in conflict), hypoglycemic cognitive impairment (pancreatic and cortical attractors in opposition). The current paper does not propose a mechanism for conflict resolution beyond the brain's general regulatory role. Whether such conflicts are resolved by hierarchical dominance, temporal multiplexing, or some form of inter-attractor negotiation is an open question. We flag it as a priority for future theoretical development within the framework.

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6. The Alien Feeling and Clinical Dissociation

When coupling between the global self and a local attractor falters, the experience can manifest as an "alien feeling"—the sense that an action or bodily state is "not mine." This phenomenon is well-documented in alien hand syndrome (Della Sala et al., 1991) and in depersonalization disorder, where individuals report feeling detached from their own body and mental processes (Sierra & David, 2011). We interpret these as temporary or chronic decoupling of a local attractor from the global workspace—exactly what the federation model would predict when integration fails.

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7. Testable Predictions

The framework generates five falsifiable predictions:

1. **ENS conditioning:** An isolated intestinal segment, exposed to a neutral stimulus paired with a non-nociceptive chemical infusion, will exhibit a conditioned motor or hormonal response.
2. **ICNS plasticity:** Long-term heart rate variability biofeedback will produce persistent changes in baseline cardiac rhythms not fully mediated cortically.
3. **Gut-directed therapy:** IBS patients receiving gut-directed biofeedback will show greater symptom improvement than those receiving standard CBT alone.
4. **Pancreatic memory:** In a vagally denervated preparation, islet cell clusters exposed to repeated glucose perturbation will exhibit an anticipatory insulin response.

5. **Spinal reorganization:** Complete spinal cord injury patients will develop complex, coordinated responses below the lesion beyond simple reflexes, consistent with a reorganizing local attractor.

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8. Future Directions: Approaching the Phenomenal Gap

The framework operates on behavioural and functional proxies for consciousness; it does not provide direct phenomenological access to organ-level experience. What evidence could begin to bridge this gap? We propose three directions. First, decoupling experiments that temporarily isolate a candidate organ (e.g., via selective pharmacologic blockade) and then probe the subject's subjective state could reveal whether the organ's local attractor contributes a distinct experiential component to the global self. Second, longitudinal studies of spinal cord injury patients who report phantom sensations or "body memories" below the lesion may provide indirect reportable correlates of spinal attractor activity. Third, the development of organ-specific interoceptive training protocols, coupled with experience-sampling methods, could track whether changes in organ function co-vary with changes in the felt sense of self. These are early-stage proposals; the phenomenal gap remains the deepest challenge for the framework, as for all theories of consciousness.

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9. Clinical Implications

If organs are candidate conscious systems, functional disorders may represent distressed local attractors. IBS may be a gut that has learned to react to benign stimuli as

threats. Cardiac anxiety may reflect a perturbed ICNS state. These reframings suggest organ-directed therapies: gut-directed biofeedback, vagal stimulation, dietary protocols that calm the ENS. The principle is consistent with existing mind-body approaches but grounds them in a specific, testable model.

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10. Ethical Considerations

Candidate organs are not autonomous moral agents. Their interests are tied to the whole body's survival. Clinical ethics correctly prioritize the patient's overall well-being. The framework suggests a principle of organ-level respect: where possible, preserve organ integrity and explore gentler interventions before resection or ablation. This is holistic medicine, not radical ethics.

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11. Conclusion

The brain is not the body's sole candidate conscious organ. The ENS, ICNS, pancreatic network, and spinal cord meet the same functional criteria used to identify *C. elegans* as a candidate for minimal consciousness. They are not established as conscious; they are identified as systems for which the question cannot be dismissed a priori without a principled exclusion criterion. The coupling mechanisms that bind local attractors into a unified self are partially characterized, and the framework generates concrete, falsifiable predictions. The conscious body is a research-generative hypothesis, not a completed theory.

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“see also” https://jamestobinphd.com/the-psychology-of-attractor-states/

The Attractor Framework: A Tool for Seeing Clearly

(Or: Why You’re Probably Pressing a

Lever Right Now)

Not a comforting story. A diagnostic tool. And if you're lucky, a lifeline.

Most philosophies are judged by how beautiful they sound. The attractor framework is judged by whether it works. If it cannot explain why a cat is easier to reason with than a zealot, why a dying animal hums, or why nations march toward a war they all claim to dread — then it is worthless. Burn it.

This essay introduces the framework by applying it to the world as it actually is. Not as you wish it were. Not as your priest or politician tells you it is. As it is.

The Lever That Kills

In 1954, two scientists named Olds and Milner implanted electrodes in rats' brains. When a rat pressed a lever, it received a small jolt to its pleasure center. The rats pressed that lever *thousands of times per hour*. They ignored food. They ignored water. They ignored their own young. They died with their paws on the lever.

The brain does not have a truth detector. It has a reward system.

Every human behavior that looks exactly like a rat on a lever — the doomscrolling, the rage-posting, the righteous certainty that feels like moral clarity — is driven by the same loop. Dopamine fires. The behavior reinforces. The loop tightens. The fire feels good.

I call these loops **fantasy attractors**. They are belief systems with *low corrective permeability*. They resist new evidence. They reframe contradiction. They attack the source. They seal

themselves shut.

The rat never knew why it was dying. Neither do you.

Two Kinds of Belief

Every persistent belief system is an attractor. The key variable is **corrective permeability** — how easily the system updates when reality punches it in the face.

- **High-permeability attractors** are reality-aligned. Science (when it works). Functional relationships. A well-maintained body. They absorb feedback, adjust, and deepen. Their error half-life is short. They can learn.
- **Low-permeability attractors** are **fantasy attractors**. They resist correction. They reframe contradictory evidence. They attack the source. They seal themselves. Their error half-life is *infinite*, because the error is never allowed to land.

You can see this in a marriage. A couple with high permeability argues, adjusts, and grows. A couple with low permeability recycles the same fight for thirty years. One is dancing. The other is pressing a lever — and calling it love.

The Eternal Skeleton (And Why You Will Die)

Beneath all the transient drama, something else is humming.

Some things never decay. The electron. The proton. Three types

of neutrinos. No known decay. They don’t need energy. They don’t age. They are the **eternal skeleton**. Their fixed frequencies are the universe’s metronomes. They define time without a clock.

On that skeleton, **dissipative attractors** dance. A flame. A body. A society. A mind. These require continuous energy. They are born, they persist for a while, and they run down. **You are a dissipative attractor.**

The eternal skeleton does not think. It does not care. It just hums. Everything you love — every memory, every hope, every person — is a temporary dance on that floor.

That is not pessimism. That is clarity.

The Mind Is Not in Your Head

The mind is not a ghost in the machine. It is not a computer made of neurons. **The mind is the emergent attractor of the entire body** — the phase-locked coherence of an organism navigating a world of constraints.

That is why restoring your body’s physical scaffolding (the extracellular matrix) deepens your mental stability. Body and mind are one attractor. Consciousness is not a substance. It is a dynamical state. Change the body, change the mind. There is no escape hatch.

The Real World: From the Rat to the

Middle East

Religion as Lever-Pressing

The “doctrine of double effect” created a lethal calculus: saving an eternal soul is infinite gain; killing a heretic is a finite evil (the heretic was going to hell anyway). Infinite minus finite equals infinite gain. **Mathematically, murder becomes a moral obligation.** This is a sealed, low-permeability attractor.

The 1933 Concordat between the Vatican and Hitler was the same calculus in diplomatic form. The Church protected baptized Jews — those in the infinite gain column. The unbaptized were left outside. The silence was permission. A fantasy attractor, coupled to political power, abandons shared reality with a formula.

That is not an argument about religion. It is a **dynamical diagnosis**.

The Meta-Attractor Converging Now

Three Abrahamic attractors — Judaism, Christianity, Islam — each carry a deep apocalyptic basin. For centuries, these basins were separate. **Now they are phase-locking.**

- Christian Zionism funds Israel because Israel is a prerequisite for the Rapture.
- Shia eschatology frames Iran’s moves as the Mahdi’s rise.
- Jewish messianism retrofits October 7 as the birth pangs of redemption.

Each group presses its dopamine lever. Each lever press perturbs the others, deepening their own apocalyptic expectations. The meta-attractor is now closed. **The Middle**

East is not a political crisis. It is a dynamical system being pulled toward a single catastrophic basin – while all parties call their lever "prophecy fulfilled."

This is not conspiracy. This is **coupling dynamics**.

Political Fantasy Attractors

When reality makes people feel cheated, a fantasy attractor offers a new story. A complex, painful reality is replaced by a simple, dopamine-rich narrative: *"You are the true people. Your loss was a theft. I will restore greatness."*

Corrective permeability drops to zero. The goal is no longer to win an argument. It is to **dismantle the institutions that could deliver a fatal correction**. That is the signature of a fantasy attractor in its terminal phase.

You have seen this. You know where it leads.

The Antidote: Reality Alignment

The framework does not offer salvation. It does not promise meaning. **It offers a survival strategy:**

- Maintain high corrective permeability.
- Protect your own coherent basin from colonizing attractors.
- Align with the metronomes – the only things that don't lie.

The Cat as Teacher

My cat Smoky doesn’t use language. He has no internal monologue. He doesn’t proselytize. He operates from deep, evolved attractor basins.

When he fails at a human task, I call him dumb. When he executes a pounce I could never replicate, I call him brilliant. The judgment is local and affectionate.

He does not try to colonize my basin. He just lives his.

That mutual respect is the social expression of *Wu Wei* — effortless action, the ancient Taoist recognition that the deepest navigation is non-forcing. Most human conflict comes from our refusal to offer what a cat offers effortlessly: coexistence without colonization.

The cat is not your enemy. The cat is your teacher. The zealot is the rat on the lever.

The Body as Attractor

I spent a year running an N=1 experiment to restore my extracellular matrix. Ninety minutes every other day on a vibration plate at 28 Hz. The result: a 5-point increase in VO_2 max in two months. Over 400 grams of collagen accretion.

The plate is a rhythmic mechanical perturbation that phase-locks the body’s repair systems.

A dying cat purrs at the same frequencies that stimulate collagen synthesis. The cat hums itself toward healing. I externalized the purr. The body does not need an internal narrator to heal. It needs the right perturbation.

Your body knows what to do. You just keep getting in the way.

Happiness Is Not a Quick Thrill

The culture defines happiness as a dopamine hit — acquisition, validation, the lever press. **That is not happiness. That is addiction.**

The attractor framework defines happiness as *confidence in the present and future*. It is a deep, stable basin with high corrective permeability and robust recovery. Despondency is a shallow basin, constantly buffeted.

Happiness is not a feeling you chase. **It is the byproduct of a well-maintained attractor aligned with reality.**

You don’t chase the fire. You build the hearth.

How to Stay Reality-Coupled: A Daily Practice

You don’t need to master the framework. You just need **one daily question**:

> *Did I update any belief yesterday?*

If the answer is no for a week, **you are in a fantasy attractor.** The lever has your paw.

Start small. One less dopamine hit. One minute of morning light. One honest conversation with someone whose basin you trust. Restore the body. Hum.

You will feel the difference before you understand it.

What the Framework Explains

The attractor framework earns its keep by making sense of things other frameworks obscure:

- Why a cat is easier to coexist with than a human sealed in a fantasy attractor.
- Why a dying mammal hums at the frequency that repairs collagen.
- Why a theological calculus can justify genocide without a twinge of discomfort.
- Why nations march toward a war that each side believes is divinely ordained.
- Why a political movement will break institutions rather than update its beliefs.
- Why restoring the body's physical matrix deepens the mind's coherence.
- Why releasing control in a lucid dream — *Wu Wei* — is the deepest form of navigation.

No Salvation. Just Alignment.

The metronomes will still hum when the last human fantasy attractor has collapsed. They do not decay. They never did. They never will.

The eternal skeleton is unconscious and uncaring. But for the brief, finite dance of a dissipative attractor, **alignment with that skeleton is the only ground that does not kill you.**

The lever is hot. The fire feels good.

The only reliable alternative is reality.

Home

The Persistence Functional: A Mathematical Measure of Attractor Resilience

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Date: May 2026

Abstract

The attractor framework says that **persistence under disturbance** is the basic mark of reality.
To turn this idea into a formal science, we introduce the **persistence functional** P(x)$P(x)$.

P(x)$P(x)$ is a single number that measures:

- How deep a state is inside an attractor basin.
- How quickly it returns after a knock.

We define P(x)$P(x)$ for three different kinds of systems:

1. **Deterministic dissipative systems** – here PP is linked to Lyapunov exponents and basin stability.
2. **Stochastic systems** – here PP is linked to escape time and quasipotential.
3. **Information-theoretic systems** – here PP is linked to negative free energy or mutual information.

The **recovery rate** $-\dot{P}/P$–$\dot{P}/P$ is a universal sign of **critical slowing down** – a warning that a system is about to tip.

We also discuss limitations: resilience may depend on direction ("anisotropic"), and multiple timescales may need **vector** or **tensor** persistence. We list open mathematical problems.
This paper is a **roadmap**, not a finished theory.

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1. Introduction

In the attractor framework, **persistence under disturbance** is central. But we have not had a single number to say *how persistent* a state is.
The **persistence functional** $P(x)$ aims to fill that gap.

What $P(x)$ should do:

- $P(x)>0$ for states inside an attractor basin.
- For a **conservative attractor** (like a free electron), PP is maximal (normalised to 1).
- For a **dissipative attractor**, PP drops after a disturbance and then recovers.
  The recovery rate $-\dot{P}/P$–$\dot{P}/P$ equals:
  - the negative of the largest Lyapunov exponent (for deterministic systems)
  - the inverse return time (for stochastic systems)

    - the rate of information loss (for informational systems)

- PP falls as the system approaches a **bifurcation**, giving early warning.

We do **not** give one universal formula. Instead, we give a **family** of definitions, each suited to a different type of system, all united by the same purpose — measuring resilience.

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2. Deterministic Dissipative Systems

Consider a smooth system $\dot{x}=f(x)$ with a stable attractor A and its basin $B(A)$.

A natural candidate for $P(x)$ uses a **Lyapunov function** $V(x)$ — a kind of energy that always decreases inside the basin ($\dot{V}<0$).

We define:$P(x)=1-V(x)-V_A V_{max}-V_A$

This gives $P=1$ on the attractor and $P\to 0$ at the basin boundary.
Near the attractor, the recovery rate is related to the **largest Lyapunov exponent** λ_1:$-\dot{P}/P\approx-\lambda_1$

When the system approaches a tipping point, $\lambda_1\to 0-$, so the recovery rate slows down — this is **critical slowing down**.

Conclusion: For deterministic systems, PP can be built from a Lyapunov function. The recovery rate equals the negative of the largest Lyapunov exponent.

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3. Stochastic Systems

When noise is present, persistence is about how long it takes to escape from the basin.
The **mean first passage time** τ(x)$\tau(x)$ — the average time to leave — is a natural measure.

We define:P(x)=τ(x)τmax$P(x) = \tau(x)\tau_{max}$

where τmaxτ_{max} is the value at the attractor.

For weak noise, τ(x)$\tau(x)$ grows exponentially with the **quasipotential** U(x)$U(x)$ (Freidlin–Wentzell theory):τ(x)~eU(x)/ϵ$\tau(x) \sim e^{U(x)/\epsilon}$

So:P(x)∝e−(Umax−U(x))/ϵ$P(x) \propto e^{-(U_{max} - U(x))/\epsilon}$

The recovery rate is the inverse of the return time. As a tipping point is approached, the return time diverges, and the recovery rate goes to zero. This again gives **critical slowing down** — rising variance and autocorrelation.

Conclusion: For stochastic systems, PP is proportional to the mean exit time (or the exponential of the quasipotential). This connects persistence to large deviation theory.

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4. Information-Theoretic Systems

For systems where information matters (neural, cognitive, social), we can define persistence using **mutual information** between past and future.

Let Ipast,future$I_{past,future}$ be the **predictive information**. Then:P(t)=I(past;future at time t)orP=e−surprisal$P(t) = I(\text{past};\text{future at time } t) \text{or} P = e^{-\text{surprisal}}$

uture at time t)or$P=e$−surprisal

The decay of P(t)$P(t)$ over time measures **memory loss**.
Landauer's principle connects information loss to entropy production:P˙/P≤−S˙kBln⁡2$\dot{P}/P \leq -\dot{S}k_B \ln 2$

Alternatively, in the **free energy principle** (Friston), the negative free energy −F$-F$ acts like a Lyapunov function. We can set:P=e−F/kTorP=−F$P=e^{-F/kT}$or$P=-F$

Then −P˙/P$-\dot{P}/P$ is the rate of free energy minimisation, which slows near bifurcations.

Conclusion: For information-theoretic systems, PP can be defined via mutual information decay or negative free energy, linking persistence to entropy production and predictive coding.

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5. Unifying Recovery Rate and Critical Slowing Down

Across all types of systems, the **recovery rate** λrec=−P˙/P$\lambda_{rec} = -\dot{P}/P$ (just after a small disturbance) is a universal indicator:

- **Deterministic dissipative:** λrec=∣λ1∣$\lambda_{rec} = |\lambda_1|$ (absolute value of the largest Lyapunov exponent)
- **Stochastic:** λrecλ_{rec} = inverse of the return time, related to the quasipotential's curvature
- **Information-theoretic:** λrecλ_{rec} = rate of free energy minimisation or information loss

As the system approaches a bifurcation, λrec→0$\lambda_{rec} \to 0$. This is **critical slowing down**.
It shows up as rising lag-1 autocorrelation and variance

(Scheffer et al., 2009).
So P*P* and its recovery rate give early warnings.

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6. Normalisation for Conservative Attractors

For a perfect **conservative attractor** (e.g., an electron in its ground state, no decay), the persistence functional should be constant and maximal:Pcons=1for all times*P*cons=1for all times

No recovery rate is defined (or it is zero). This anchors the scale.

For **emergent approximate conservative systems** (like atomic clocks), P*P* is very close to 1 and decays extremely slowly.

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7. Limitations – Scalar Collapse and Anisotropic Resilience

A single scalar P(x)*P*(*x*) may not be enough for systems where resilience is **anisotropic** – that is, recovery speed depends on the direction of the perturbation.
High-dimensional systems can have **multiple timescales** (fast and slow modes). A scalar average can miss important structure.

Future work may need:

- **Vector persistence** – a list of recovery rates along different directions.
- **Tensor persistence** – a metric that captures the full

shape of the basin.
- **Persistence manifold** — the geometry of the basin in state space.

We accept this limitation. The scalar P*P* is a useful first approximation for systems with isotropic resilience or for early-warning applications where a single number is enough. For complex systems, a multidimensional generalisation is an open research problem.

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8. Open Mathematical Problems

1. **Derive P(x)*P*(*x*) from first principles** for a given class of systems (e.g., from a variational principle).
2. **Prove that −P˙/P=λ1−*P*˙/*P*=*λ*1** for a wide class of dissipative systems.
3. **Extend the definition to systems with multiple attractors and chaotic basins** (where basin stability is fractal).
4. **Establish a rigorous relationship between P*P* and the mutual information decay rate** for non-equilibrium processes.
5. **Formulate a universal persistence functional** that works across all regimes — or prove it's impossible.
6. **Test the predictive power of P*P*** in controlled experiments (e.g., ecological microcosms, neural cultures, social media sentiment).
7. **Develop vector/tensor persistence** for anisotropic resilience.

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9. Conclusion

The persistence functional $P(x)$ gives a mathematical language for attractor resilience.

We have given **operational definitions** for three regimes:

- **Deterministic dissipative** → Lyapunov / basin stability
- **Stochastic** → escape time / quasipotential
- **Information-theoretic** → mutual information / free energy

The **recovery rate** $-\dot{P}/P$ unifies critical slowing down across all these domains.

We have explicitly noted **limitations** (scalar collapse, anisotropy) as open problems.

This paper is a **roadmap**, not a final theory. The framework now has a quantitative step.

Suggested citation: Galida, R. S. (2026). *The Persistence Functional: Towards a Mathematical Measure of Attractor Resilience (Reader-Friendly Version).* Fantasy Attractor.