The Grammar of Prediction

How the Closure Framework Grounds Karl Friston's Free Energy Principle

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> *Any entity that exists — that persists over time — can be described as self-evidencing: as continuously gathering evidence for its own model of the world.*
> Karl Friston, National Science Review interview, 2024

> *Every finite closure generates remainder. The remainder is not noise. It is the proof that the grammar is finite.*
> CF Dietz, Consciousness, Closure, and the Cosmos, 2026

Abstract

Karl Friston's free energy principle is the most mathematically developed account of how biological systems maintain their own organization in the face of a world that constantly surprises them. His central claim is that any system that persists must minimize the difference between its predictions and its sensory inputs, a quantity he calls free energy or variational surprise, and that this minimization is achieved either by updating the system's model of the world or by acting on the world to make it conform to the model. This paper argues that Friston's framework and the closure framework developed in Consciousness, Closure, and the Cosmos are structurally identical at the level of first principles, arrived at independently from different directions. Friston's free energy is remainder: the structural mismatch between a closure regime's model and the world it opens onto. His prediction error minimization is supersession: the process by which a grammar updates its identity criteria when remainder accumulates beyond threshold. His Markov blanket is a closure boundary: the formal partition that defines what is inside a closure regime and what lies outside it. His nested Markov blankets are nested closure regimes. His self-evidencing, his term for the fundamental imperative of any persistent system, is closure maintaining its own identity across time. The convergence is not analogical. It is structural and mathematical. The paper demonstrates this equivalence, identifies the one point where the frameworks diverge and why the divergence is philosophically productive, and argues that the closure framework provides Friston's principle with the philosophical grounding it currently lacks: an account of why any finite organized system must behave exactly as the free energy principle describes, derived from what it means to be a finite system rather than from the mathematics of specific biological systems.

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1. A System That Cannot Stop Predicting

Begin with an observation so immediate it is easy to overlook.

You are reading this sentence. As your eyes move across the page, your brain is not passively receiving the marks on the paper. It is predicting them. Before each word arrives in your visual field, your brain has already generated a model of what is likely to come next, based on everything it knows about language, grammar, context, and the trajectory of this particular sentence. When the word that arrives matches the prediction, processing is smooth and fast. When it does not match, something different happens: a signal propagates upward through the cortical hierarchy, error correcting the model, updating the prediction for what comes next.

You do not experience this as prediction and error correction. You experience it as reading. But the mechanism is running continuously, not just in reading but in every moment of perception and action. Your brain is a prediction machine, and the predictions never stop. Even in deep sleep, the brain is generating models of its own internal states, predicting the signals that will arrive from the body, correcting for the ones that do not match.

Karl Friston has spent three decades formalizing this observation into one of the most ambitious theories in contemporary science. The free energy principle holds that any system that persists, any biological organism, any organ, any cell, and perhaps any organized physical system at all, can be understood as continuously minimizing the difference between its predictions and what it actually encounters. This minimization is not a strategy the system chooses. It is a structural consequence of what it means to persist as an organized system in a world that is not fully predictable. A system that could not minimize this difference would dissolve into the disorder of its environment. The fact that living systems exist is the evidence that they have been minimizing it.

This paper asks: what kind of thing is an organized system, such that it must work this way? Friston has the mathematics. The closure framework has the answer to that question, derived from structural first principles rather than from the mathematics of specific biological systems. The two accounts are equivalent. Neither is derivative of the other. The convergence is what this paper demonstrates.

2. Friston's Four Claims

Friston's framework has four interconnected components. Each is worth stating in plain language before the framework engages it.

2.1 Free Energy: The Quantity Every Persistent System Minimizes

Free energy, in Friston's technical sense, is a measure of the difference between a system's model of the world and what the world actually delivers to its sensors. When predictions match sensory input, free energy is low. When they do not match, free energy is high. Every organized biological system, from a bacterium navigating a nutrient gradient to a human navigating a social situation, behaves in ways that minimize this quantity. Not because it has been designed to.

Because any system that consistently failed to minimize it would cease to exist as an organized system.

Friston expresses this mathematically as variational free energy: a tractable upper bound on the surprise that the system's generative model assigns to its sensory inputs. Minimizing variational free energy is equivalent to maximizing the evidence for the system's model of the world. The system is, in his term, self-evidencing: continuously acting to confirm that its model is adequate to the world it inhabits.

2.2 Active Inference: Two Ways to Minimize

A system can minimize free energy in two ways. It can update its model: change its predictions to better match what the world delivers. That is perceptual inference: learning, updating, revising the generative model in response to prediction error. Or it can change the world: act on its environment to make it conform more closely to its predictions. That is active inference: moving, speaking, building, eating, in ways that bring the world into alignment with what the model expects.

This dual strategy, perceive to update the model, act to update the world, is what Friston means by active inference. It applies at every level of biological organization. A bacterium moves toward nutrients, enacting the prediction that nutrients will be there. A brain generates a speech act, enacting the prediction that the listener will understand. An immune system generates antibodies, enacting the prediction that a specific molecular target will be neutralized. The strategy is the same at every level. The timescale and complexity differ.

2.3 Markov Blankets: The Formal Boundary of Any Organized System

A Markov blanket is the formal partition that defines what is inside a system and what is outside it. In Friston's framework, a system exists as a system precisely by virtue of having a Markov blanket: a set of states that separates the system's internal states from its external environment such that the internal states are conditionally independent of the environment given the blanket states. The blanket mediates all interaction between inside and outside. Nothing in the environment affects the system's internal states except through the blanket. Nothing the system does affects the environment except through the blanket.

This is not a biological observation. It is a formal claim about any system that can be individuated from its environment. Cells have Markov blankets. Organs have Markov blankets. Organisms have Markov blankets. And crucially, Markov blankets are nested: the blanket of a cell is inside the blanket of the organ that contains the cell, which is inside the blanket of the organism. This nesting is the formal structure of multi-level biological organization.

2.4 Self-Evidencing: The Imperative of Any Persistent System

Friston's deepest claim is that any system that persists can be described as self-evidencing: as gathering evidence for its own existence, its own model, its own continued organization. This is not a purpose assigned to the system from outside. It is what persistence means for any organized system in a world that tends toward disorder. The system that fails to self-evidence, that allows its

model to diverge too far from the world it inhabits, dissolves. The system that self-evidences effectively maintains its organization across time.

Friston has extended this claim from individual organisms to cells, to social systems, and in recent work toward physics itself, suggesting that any physical system that can be individuated from its environment can be described in the language of active inference and free energy minimization. This is an ambitious claim and a contested one. But it is also, as this paper argues, the same claim the closure framework makes from a different direction.

3. What Friston Needs

Friston's framework has a gap that its mathematical sophistication sometimes obscures. The free energy principle is presented as a principle, explicitly analogized by Friston to Hamilton's principle of stationary action in physics or to Darwin's principle of natural selection in biology. Like those principles, it is not directly falsifiable. It is a normative claim about what any persistent system must do, from which empirically testable hypotheses can be derived.

But Friston has not yet derived the principle from a more fundamental account of what organized systems are. He arrives at it from the mathematics of variational inference and the physics of non-equilibrium steady states. These derivations are rigorous and important. What they do not provide is a philosophical answer to the question: why must any organized system minimize free energy? What is it about organization as such that makes this minimization a structural necessity rather than an empirically discovered regularity?

The closure framework provides that answer. It derives the free energy principle from first principles about what it means to be a finite organized system in an inexhaustible world. The derivation does not replace Friston's mathematics. It grounds it philosophically, showing why the mathematics describes something structurally necessary rather than something contingently true of the biological systems Friston has studied.

4. Two Concepts That Do the Work

As with the Noble paper, the closure framework is introduced here at the minimum level needed to ground Friston's account. Two concepts only. Readers who want the full architecture are directed to Consciousness, Closure, and the Cosmos. Here only what the argument requires.

4.1 Closure: What an Organized System Is

A closure regime is a system that stabilizes some content by drawing distinctions, establishing identity criteria, and maintaining lawful relationships among its elements. The closure constitutes facts within its scope: it determines what counts as the same state across different moments, what relationships among states are lawful, and what falls outside its modeling capacity as remainder.

Remainder is the key concept. Every finite closure generates remainder: the content that the closure's distinctions and identity criteria cannot capture. This is not a deficiency of particular

closures. It is a structural consequence of all of them. An infinite closure would generate no remainder. There are no infinite closures in the physical world. Every organized system, however sophisticated its model, leaves something outside what its model can capture. That structural outside is remainder.

Friston's variational free energy is remainder stated mathematically. It is precisely the quantity that expresses how much the system's model diverges from what the world presents. When remainder is low, the model is adequate to the current situation. When remainder is high, the model requires updating. Free energy is not just analogous to remainder. It is the mathematical expression of remainder in systems where the model can be described probabilistically and the world's inputs can be formalized as sensory data.

4.2 Nested Closure: Why Prediction Runs at Every Level

A living organism is a nested hierarchy of closure regimes. Molecules form cells. Cells form tissues. Tissues form organs. Organs form organisms. Each level is a genuine closure regime with its own identity criteria and its own remainder. And the levels are nested: higher-level closures contain lower-level closures as their elements, and higher-level closures set the boundary conditions within which lower-level closures operate.

Friston's nested Markov blankets are nested closure regimes described mathematically. The Markov blanket of a cell is the closure boundary of the cellular regime. The Markov blanket of the organ containing the cell is the closure boundary of the organ regime. The nesting of blankets is the nesting of closures. The conditional independence relations that Markov blankets formalize are the structural consequence of closure boundaries: inside a closure, states are conditionally independent of the external environment given the boundary states, because the closure boundary is precisely what mediates all interaction between inside and outside.

A note on scope, directed at readers familiar with Friston's work who may be cautious about the broader claims of the closure framework. The CC-C framework extends these two concepts to cosmological and phenomenological claims that Friston may or may not find relevant to his program. The argument of this paper does not require accepting those extensions. Closure as stabilized regime and nested closure as the structural basis of multi-level organization are independently defensible on grounds that do not require the cosmological framework. A reader who accepts the argument made here is not thereby committed to the broader CC-C architecture. The convergence is offered as evidence that both frameworks are tracking a structural truth about organized systems. Whether that truth has the cosmological scope CC-C proposes is a separate question.

5. Four Claims, One Structure

Before connecting each claim to the framework, the vocabulary correspondence deserves to be made explicit. What Friston calls variational free energy, the closure framework calls remainder. What Friston calls prediction error minimization, the framework calls supersession: the process by which a grammar updates when remainder accumulates beyond threshold. What Friston calls a Markov blanket, the framework calls a closure boundary. What Friston calls nested Markov

blankets, the framework calls a nested closure hierarchy. And what Friston calls self-evidencing, the fundamental imperative of any persistent system, the framework calls the maintenance of closure identity across time. These are not analogies. They are the same structural concepts expressed in different vocabularies, derived independently from different directions.

5.1 Free Energy Minimization Is Supersession

The free energy principle holds that any persistent system must minimize the difference between its predictions and what the world delivers. The closure framework derives the same claim from first principles. Any closure regime that allows its remainder to grow without bound will cease to maintain its identity criteria. The identity criteria require some minimum adequacy of the model to the world it is trying to constitute facts within. When remainder exceeds this threshold, the closure either supersedes, updating its model to reduce the mismatch, or dissolves. Persistent systems are ones that have been superseding rather than dissolving. Free energy minimization is supersession driven by accumulated remainder.

Friston's two modes of minimization, updating the model or acting on the world, correspond to two forms of supersession in the closure framework. Internal supersession updates the identity criteria of the closure to better model the remainder. External supersession, which the closure framework calls enacted supersession, changes the boundary conditions of the closure by acting on the world, making the world conform more closely to the existing identity criteria. Both are genuine forms of minimizing the mismatch between model and world. Both are how living closures maintain themselves.

5.2 Markov Blankets Are Closure Boundaries

Friston's Markov blanket is a formal partition: a set of states that renders a system's internal states conditionally independent of its external environment. The closure framework's closure boundary is the same structure described philosophically: the boundary that constitutes what is inside the closure and what lies outside it as remainder. The conditional independence relations that Markov blankets formalize are exactly the structural consequence of closure boundaries. Inside the closure, states are related by the identity criteria and lawful relationships the closure maintains. Outside the closure lies remainder, which the closure's identity criteria cannot model.

This equivalence has an important consequence. Friston has shown mathematically that any system with a Markov blanket can be described as performing inference, as having beliefs about the causes of its sensory states and updating those beliefs in response to prediction error. The closure framework shows why: any system with a closure boundary necessarily has remainder, and remainder is what generates the drive toward supersession. Inference is supersession driven by remainder. The mathematics and the philosophy are describing the same thing.

5.3 Nested Blankets Are Nested Closures

Friston's nested Markov blankets formalize the multi-level structure of biological organization. The closure framework derives the same structure from first principles about nested regimes. The consequence is the same in both frameworks: higher levels set boundary conditions for lower levels, generating genuine downward causation that is not spooky but mathematically

rigorous. The organ constrains the cell. The organism constrains the organ. The constraint is real, formal, and bidirectional: lower levels generate the dynamics that higher levels integrate, and higher levels set the conditions within which lower level dynamics operate.

This also connects the Friston paper to the Noble paper directly. Noble's biological relativity, that no level of biological organization has privileged causal authority, is a consequence of the nested Markov blanket structure that Friston formalizes. Noble and Friston have been demonstrating the same structural truth from different empirical directions, Noble from physiology and Friston from theoretical neuroscience. The closure framework names the structure both are describing.

5.4 Self-Evidencing Is Closure Maintaining Itself

Friston's deepest claim, that any persistent system can be described as self-evidencing, as gathering evidence for its own model of the world, maps onto the closure framework's account of what closure regimes do to maintain their identity across time. A closure regime maintains itself by continuously constituting facts within its scope, managing remainder at its boundary, and superseding when remainder accumulates. That continuous maintenance is self-evidencing: the system is, in effect, demonstrating to itself that its model is adequate to the world it inhabits, or discovering that it is not and updating accordingly.

Crucially, Friston's claim that self-evidencing applies to any system that persists, not only to brains but potentially to cells, organisms, and any physical system that can be individuated from its environment, is the same claim the closure framework makes about closure regimes. Any finite closure regime that persists does so by maintaining its identity criteria in the face of remainder. That maintenance is self-evidencing. The extension of the free energy principle beyond brains to all organized matter is not a speculative overreach on Friston's part. It is a consequence of what organized systems structurally are.

6. Where the Frameworks Diverge, and Why It Matters

The convergence between Friston's framework and the closure framework is deep and specific. The divergence is equally worth naming, because it is philosophically productive rather than merely a disagreement.

Friston's framework is, at its foundations, a framework about inference. It describes systems as if they have beliefs, as if they are performing Bayesian inference, as if they are gathering evidence for models of the world. Friston is careful to say that this is a way of describing systems, not a claim that all systems are literally conscious or literally thinking. The language of inference is a mathematical convenience that happens to be descriptively powerful.

The closure framework makes a different and stronger claim. It distinguishes between C, irreducible conscious presence, and c, consciousness with content. It treats C as a primitive that is not derived from any closure operation and is not dissolved when closure dissolves. This means the closure framework is not neutral on the question of consciousness in the way Friston's framework attempts to be. Friston describes systems as if they infer. The closure framework says

that some systems, conscious ones, actually have the felt interior of the inference process, not just the functional structure of it.

This divergence matters for the hard problem of consciousness, which Friston's framework brackets and the closure framework directly engages. It does not undermine the convergence on the structural claims. Both frameworks agree on what organized systems do: minimize remainder, maintain closure identity, enact supersession in response to accumulated prediction error. They diverge on whether there is something it is like to do these things, for some systems. The closure framework says yes. Friston brackets the question. That bracket is the space where future dialogue between the two frameworks would be most productive.

Friston's own recent work has moved toward engaging this question directly. His formulation that self-evidencing can be read as a physics of sentience gestures toward exactly the territory the closure framework occupies. The convergence is not static. It is actively deepening as Friston's framework extends toward consciousness and the closure framework extends toward the mathematical grounding of its structural claims.

7. What This Changes

The equivalence between Friston's free energy principle and the closure framework has consequences for both.

For Friston's framework, it provides the philosophical derivation the principle currently lacks. The free energy principle is currently presented as a postulate: any persistent system minimizes free energy. The closure framework shows why this must be so: any finite closure regime generates remainder, remainder drives supersession, and supersession is the process by which the system maintains its identity across time. Systems that failed to supersede would dissolve. The free energy principle is not a contingent empirical regularity. It is a structural necessity of finite organized systems. That derivation strengthens the principle considerably, answering the objection that it is unfalsifiable by showing what it is that makes it necessarily true.

For the closure framework, Friston's mathematics provides the formal expression of what the framework describes structurally. The closure framework says remainder drives supersession. Friston's variational calculus specifies exactly how, in systems where the model is probabilistic and the world's inputs are formalizable as sensory data. The two frameworks are more powerful together than either is alone: the philosophy shows why the mathematics must describe what it describes, and the mathematics shows how the philosophy operates in specific biological and cognitive systems.

For neuroscience, the convergence suggests that the predictive brain is not a special case but a specific instance of a more general structural truth about organized systems. The brain's extraordinary predictive capacity is the cognitive level expression of what every closure regime does: constitute facts, generate remainder, supersede in response to accumulated mismatch. Understanding the brain requires understanding the general principle. Understanding the general principle clarifies what the brain is doing and why.

For artificial intelligence, the convergence has immediate practical implications. Active inference implementations have already shown advantages over conventional reinforcement learning in certain domains. The closure framework suggests why: artificial systems built on the active inference architecture are approximating the structure of living closure regimes, and that structure is more general and more robust than the structure of reward-maximizing systems that do not model their own uncertainty. Friston's own experimental program, across neuroscience, psychiatry, and AI, constitutes ongoing empirical testing of the structural account both frameworks describe. The results have consistently supported the free energy framework. The closure framework names the structure those results have been confirming.

8. The Grammar of Prediction

A brain that reads this sentence is not receiving input. It is predicting it, correcting its predictions, updating its model, and acting to confirm that its model is adequate to the world it inhabits. That continuous cycle of prediction, error, update, and action is what Karl Friston has formalized as the free energy principle. It is also what the closure framework calls the maintenance of a closure regime across time through supersession driven by remainder.

Friston has been right. Any system that persists minimizes free energy. Prediction error is the signal that drives updating. Nested hierarchies of prediction and correction constitute the multi-level architecture of living systems. Self-evidencing is the fundamental imperative of any organized system that exists. He has been right mathematically, empirically, and in the breadth of systems his framework illuminates.

What he has not yet had is a philosophical account of why this must be so, derived from first principles about what organized systems structurally are rather than from the mathematics of specific biological systems. The closure framework provides that account. Finite organized systems generate remainder. Remainder drives supersession. Supersession is what persistence looks like for a system with a boundary. The free energy principle is the mathematical expression of that structural necessity, and the closure framework is the philosophical derivation that shows why it cannot be otherwise.

Friston's framework and the closure framework are not competing. They are the same insight approached from two directions: one from theoretical neuroscience and variational calculus, one from philosophy of mind and the structure of organized systems. When the two paths meet, what they find at the meeting point is the grammar of prediction: the structural rule that any finite system with a boundary must follow to remain a system at all.

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Author's Note

This paper is the second in a series engaging living thinkers whose work converges with the closure framework developed in Consciousness, Closure, and the Cosmos. The first paper in the series engaged Denis Noble's biological relativity. The present paper engages Karl Friston's free energy principle. The two papers together demonstrate that the closure framework is independently supported by the most rigorous mathematical treatment of biological organization currently available, from theoretical neuroscience on one side and systems physiology on the other. The author does not claim Friston's endorsement of the closure framework or its vocabulary. The claim is convergence: two frameworks derived independently from different directions have arrived at structurally equivalent accounts of what organized systems must do to persist. The author welcomes engagement from neuroscientists, philosophers of mind, and AI researchers who find the convergence productive or who wish to contest the specific points of equivalence identified in section 5.