Life as Directed Causality

A Thermodynamic Isomorphism Between Being and Acting

Eli Adam Deutscher

Abstract

How does purposive agency emerge in a universe of blind physical laws? This paper answers by deriving and defending:

> **T6: The Life-Agency Isomorphism Theorem**: Life and minimal agency are isomorphic. A system is alive *if and only if* it possesses *Hormē* (the striving to persist), and it possesses *Hormē if and only if* it is an agent.

I argue that **Hormē** (Ὁρμή) is not a metaphor but a measurable thermodynamic state: the continuous work performed by a far-from-equilibrium system to maintain its boundaries. This constitutes the capacity to **"direct causal flow"**—altering the stream of cause and effect to secure persistence. By identifying this shared physical basis, the framework dissolves two persistent philosophical gaps: the **Life/Mind Gap**, by showing agency is the thermodynamic condition of life; and the **Mechanism/Teleology Gap**, by demonstrating that purposiveness is the immanent logic of dissipative structures. Finally, I sketch how this agency scales evolutionarily—from bacterial taxis to the human Nous (the meta-cognitive capacity for abstraction and self-modeling)—providing a naturalistic foundation for intrinsic normativity.

Keywords: agency, teleonomy, autopoiesis, thermodynamics, *Hormē*, philosophy of biology, enactivism, dissipative structures, Life-Mind Continuity, Life-Agency Isomorphism, Mechanism-Teleology Gap

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Introduction: The Problem of Two Gaps

How does mind emerge from matter? And how can purposive behavior exist in a world of blind physical causes? These two questions—the **Life/Mind Gap** and the **Mechanism/Teleology Gap**—have structured philosophical inquiry into living systems for centuries. They appear as dualisms: between mere life and conscious agency, and between mechanistic explanation and goal-directed description.

Proposed solutions tend to fall into one of three categories. **Eliminativists** deny the reality of one side, arguing either that agency is an illusion or that teleology is a pre-scientific relic.[1] **Dualists** accept both sides as real but metaphysically distinct, positing a non-physical principle (vital force, conscious will) to bridge the gap.[2] **Emergentists** claim that agency and purpose genuinely arise from complex material organization, but often leave the "how" opaque, risking a new mysterianism.[3]

A more promising path, pursued by **enactivist** and **autopoietic** traditions, seeks to naturalize agency and purpose by grounding them in the very organization of living systems.[4] Here, life is not passive matter but **operational closure** and **adaptive autonomy**. This view has made significant strides, yet it often remains at the level of formal or organizational description, leaving its physical and thermodynamic foundations underexplored.

I argue that both gaps stem from a failure to recognize the **thermodynamic core of life itself**. Living systems are not just complex chemical aggregates; they are **far-from-equilibrium dissipative structures** that must perform continuous work to maintain their organization against entropy. This work—what I term ***Hormē*** (Ὁρμή)—is not incidental to life; it *constitutes* being alive.[5]

Crucially, *Hormē* manifests as the capacity to *direct causal flow*: to expend energy to alter the stream of cause and effect in favor of the system's own persistence. A rock is carried by causal flow; a bacterium swims against it to reach nutrients. This distinction—between **being a conduit** of causality and **being a director** of causality—provides the precise physical criterion that separates living agents from non-living objects.

[1] Paul M. Churchland, "Eliminative Materialism and the Propositional Attitudes," *The Journal of Philosophy* 78, no. 2 (1981): 67–90.

[2] Thomas Nagel, *Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature Is Almost Certainly False* (Oxford University Press, 2012).

[3] David J. Chalmers, *The Conscious Mind: In Search of a Fundamental Theory* (Oxford University Press, 1996).

[4] Francisco J. Varela et al., *The Embodied Mind: Cognitive Science and Human Experience* (MIT Press, 1991); Evan Thompson, *Mind in Life: Biology, Phenomenology, and the Sciences of Mind* (Belknap Press, 2007).

[5] Hormē here refers to the "constitutive, non-negotiable impulse to strive and persist in one's own being," acting as the engine of agency (Eli Adam Deutscher, *Neo-Pre-Platonic Naturalism: A First-Principles Framework for Reality, Mind, and Knowledge* (Neo-Pre-Platonic Press, 2025), 52).

Once *Hormē* is identified as the shared constitutive property of life and agency, the two gaps dissolve:

- The **Life/Mind Gap** dissolves because agency is the behavioral expression of thermodynamic striving; mind is its information-sensitive refinement.
- The **Mechanism/Teleology Gap** dissolves because purpose is not an external final cause but the immanent logic of self-maintenance in a dissipative structure.

My argument proceeds as a formal derivation within a naturalistic ontology, culminating in **T6: The Life-Agency Isomorphism Theorem**.[6] Section 2 reviews the thermodynamics of living systems, steel-manning both reductionist and holistic accounts. Section 3 defines *Hormē* and distinguishes it from similar concepts. Section 4 presents and defends T6. Sections 5 and 6 apply the theorem to dissolve the two gaps. Section 7 addresses major objections. Section 8 concludes by reframing agency as a thermodynamic phenomenon.

The Thermodynamics of Living Systems

Any account of life must engage with its physical basis. The dominant reductionist view holds that living systems, however complex, are ultimately just elaborate molecular machines whose behavior is fully explained by the laws of physics and chemistry. From this perspective, teleology is an illusion, and agency is at best a useful shorthand for complex deterministic processes.[7]

Conversely, holistic or vitalist traditions have argued that life involves a principle not captured by mechanistic reduction—whether an *élan vital*, a soul, or a non-computable property of complex systems.[8] For them, the apparent purposiveness and autonomy of living beings point to a genuine ontological divide between the living and the non-living.

A third path, forged by the thermodynamics of non-equilibrium systems, offers a way through this impasse. The work of Ilya Prigogine and others showed that **dissipative structures**—open systems maintained far from thermodynamic equilibrium through continuous energy flow—exhibit self-organization, spontaneous pattern formation, and a kind of directional behavior.[9] A candle flame or a Bénard convection cell are simple examples: they are not alive, but they display organized, persistent forms that are not reducible to the properties of their individual molecules.

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[6] Deutscher, *Neo-Pre-Platonic Naturalism*, 199.

[7] Richard Dawkins, *The Selfish Gene* (Oxford University Press, 1976); Daniel C. Dennett, *The Intentional Stance* (MIT Press, 1987).

[8] NPN adopts Bergson's concept of "Duration" and the generative nature of existence but rejects the *élan vital* in favor of the thermodynamic *Hormē* (Deutscher, *Neo-Pre-Platonic Naturalism*, 49, n. 20). See also Henri Bergson, *Creative Evolution*, trans. Arthur Mitchell (Henry Holt; Company, 1911); Nagel, *Mind and Cosmos*.

[9] Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Bantam Books, 1984).

This insight was pivotal. Erwin Schrödinger, in his influential *What is Life?*, argued that living systems "feed on negative entropy," importing order to maintain internal organization while increasing environmental entropy.[10] Life, from this thermodynamic view, is a local and temporary reversal of the universal trend toward disorder. This thermodynamic perspective has been further developed by contemporary researchers who argue that life is not merely compatible with thermodynamic principles but may be a thermodynamic imperative. Eric Smith and Harold Morowitz demonstrate that life emerges as a predictable outcome when energy flows through chemical networks under far-from-equilibrium conditions.[11] Similarly, Stuart Kauffman's concept of "autonomous agents"—systems that perform thermodynamic work cycles to reproduce themselves—parallels our definition of *Hormē*, though Kauffman focuses on reproductive closure where we emphasize the more fundamental condition of persistent self-maintenance .[12] Terrence Deacon's "autogenic" systems, which generate their own constraints through self-maintaining processes, provide a complementary organizational perspective on what we identify as the thermodynamic imperative of *Hormē*.[13]

However, not all dissipative structures are alive. A hurricane, while organized and far-from-equilibrium, does not actively maintain its form against perturbation; its structure is an epiphenomenon of external gradients. The crucial advance came with the theory of **autopoiesis** (self-production) developed by Maturana and Varela. An autopoietic system is a dissipative structure that **continuously produces and regenerates the very components and processes that constitute it**, maintaining an operational closure that defines a distinct organizational boundary.[14] A living cell is the paradigm: its metabolic network produces the membranes and enzymes that sustain the network itself.

This provides a clear, organizational criterion for life. Yet, as even its proponents note, the autopoietic account can seem formal and abstract.[15] What is the *driver* of this self-production? What physical imperative sustains this closure against the relentless pull of entropy?

The answer lies in the **energetic cost of being**. Maintaining any bounded, low-entropy state within a high-entropy environment requires continuous work. This is not a metaphor but a

[10]Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell* (Cambridge University Press, 1944).

[11]Eric Smith and Harold J. Morowitz, *The Origin and Nature of Life on Earth: The Emergence of the Fourth Geosphere* (Cambridge University Press, 2016).

[12]Stuart A. Kauffman, *Investigations* (Oxford University Press, 2000). Kauffman's autonomous agents are defined by their capacity for self-reproduction and completion of work cycles. *Hormē* is the more primitive condition: the continuous work of maintaining far-from-equilibrium organization, which is logically prior to reproduction. A system must first persist before it can reproduce.

[13]Terrence W. Deacon, *Incomplete Nature: How Mind Emerged from Matter* (W. W. Norton & Company, 2012).

[14]Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living* (D. Reidel, 1980).

[15]Ezequiel A. Di Paolo, "Autopoiesis, Adaptivity, Teleology, Agency," *Phenomenology and the Cognitive Sciences* 4, no. 4 (2005): 429–52.

physical necessity captured by the Second Law.[16] Life, as a particularly complex and persistent form of bounded organization, thus exists on a knife-edge: it must perpetually harness energy to repair, rebuild, and regulate itself against dispersion.

This thermodynamic perspective does not contradict mechanism but enriches it. It shows that the "machine" of life is a very specific kind of machine: one whose raison d'être is its own persistence. It also undercuts vitalism by providing a physical, non-mysterious basis for the distinctive behavior of living systems.

The Entropic Asymmetry: The Cost of Being

Before defining the specific striving of life, we must establish a fundamental thermodynamic truth that applies to *any* bounded organization within the *Archē*–objective physical reality. This is not a special property of life, but the universal context in which life emerges.

T7: The Entropic Asymmetry Theorem (The Cost of Being)

> The maintenance of any bounded, low-entropy pattern (*Being*) requires continuous expenditure of energy (*Work*) against a standing gradient of entropic dissolution. Order is statistically unlikely and energetically expensive.

Derivation:

1. **From the Second Law:** In an isolated system, entropy tends to a maximum. Disordered states are statistically overwhelming.
2. **From Non-Equilibrium Thermodynamics:** A bounded, ordered state (low local entropy) can only be maintained by being an **open system** that continuously exports entropy to its environment.
3. **The Gradient:** This creates a standing, probabilistic gradient: the system's ordered state is constantly "pulled" toward the higher-entropy equilibrium of its surroundings.
4. **The Necessity of Work:** To resist this pull, the system must perform **continuous work**—it must import free energy and use it to repair, rebuild, and regulate its boundaries against dispersion.
5. **Conclusion:** Therefore, **being—the persistence of a bounded pattern—has an energetic cost.** This cost is not incidental; it is the thermodynamic price of defying statistical decay.[17]

[16] See also Jeremy L. England, "Dissipative Adaptation in Driven Self-Assembly" (Jeremy L. England, "Dissipative Adaptation in Driven Self-Assembly," *Nature Nanotechnology* 10, no. 11 (2015): 919–23). NPN identifies this thermodynamic necessity as the "work" required to maintain a far-from-equilibrium state, distinguishing agents from objects (Deutscher, *Neo-Pre-Platonic Naturalism*, 54).

[17] This mirrors the principle of "dissipative adaptation" described by England, "Dissipative Adaptation in Driven Self-Assembly", where systems must restructure themselves to efficiently absorb and dissipate energy to sustain their form.

This theorem provides the universal backdrop: **existence against entropy is work.** With this established, we can now ask: What happens when a system's very organization becomes dedicated to performing this work? That is the transition to life, and it brings us to the constitutive imperative of *Hormē*.

Defining *Hormē*: The Constitutive Striving

To naturalize agency, we must identify the specific physical operation that distinguishes a living agent from an inanimate object. I introduce the term ***Hormē*** (Ὁρμή) to designate this constitutive activity. While traditionally translated as "impulse," "onset," or "striving," I adopt it as a technical term defined on two levels:

1. NPN Definition (The Teleological Function): *Hormē* is the constitutive drive of a system to persist within the lawful structure of reality (*Logos*) by **directing causal flow** to aid survival. It is the engine of agency itself and is scale-invariant. In humans, it is expressed through the layered faculties of *Orexis*, *Thymos*, *Logistikon*, and the *Nous*.

2. Scientific Definition (The Physical Mechanism): *Hormē* is the continuous, internally regulated thermodynamic work required to maintain a far-from-equilibrium organizational state against entropic dispersion. It is the physical expression of persistence: the necessary activity that constitutes being alive, measurable as the energy flow that sustains bounded low-entropy organization.

Directing Causal Flow: The Logic of Agency

The concept of "directing causal flow" provides the rigorous mechanism that distinguishes an **Agent** from a mere **Object**. In a universe governed by cause and effect, an object (such as a rock rolling down a hill) is entirely subject to the causal flow of the *Archē*; its future state is determined solely by external forces and initial conditions. An agent, however, acts as a local cause that alters this trajectory.

This "directing" is not a violation of physics, but a specific mode of interaction where the system expends energy to bias outcomes toward its own persistence. This operation defines Agency across the entire biological spectrum:

1. **Minimal Agency (The Bacterium):** A bacterium swimming up a nutrient gradient is the paradigmatic case of directing causal flow. Without this action, the "causal flow" of the environment (diffusion, currents) would lead to nutrient scarcity and death. By engaging its flagella to move against or across this flow, the bacterium changes its predetermined future. It alters the probability landscape from **dissolution** (the default of *Neikos*) to **persistence**

(the achievement of *Philia*). This is not just a reaction; it is agency because the outcome is functionally linked to the system's survival.[18]

2. **Maximal Agency (The Navigator):** In complex organisms, this same operation scales up. A human dodging a threat or planting a harvest is directing causal flow over longer time horizons. The *Nous* models the inertial path ("if I do nothing, I starve next winter") and directs energy now to alter that outcome.

Therefore, *Hormē* is the thermodynamic engine that powers this intervention. Whether minimal or maximal, to be an agent is to possess the capacity to step into the stream of cause and effect and redirect it toward a shelter for one's own existence.

The Thermodynamic Basis

Having established the functional logic of *Hormē*, we can now define its necessary physical signature. A system possesses *Hormē* if and only if its continued existence as a distinct **far-from-equilibrium structure** requires **continuous, internally regulated work** against entropic dispersion.

This definition has several key components:

1. **Far-from-equilibrium structure:** The system maintains a state of low internal entropy relative to its environment.
2. **Continuous work:** This maintenance is not passive; it requires the ongoing transduction of energy.
3. **Internal regulation:** The work is directed by the system's own organization (e.g., metabolic networks, regulatory pathways), not merely external forces.
4. **Constitutive link:** This work is not an activity the system *does*; it is the activity that the system *is*. Cessation of this work means cessation of the system *as that living entity*.

Distinguishing *Hormē* from Related Concepts

Hormē is closely allied with, but refines, several existing concepts:

- **Autopoiesis:** *Hormē* is the **energetic driver** of autopoiesis. Autopoiesis describes the *organizational pattern* of self-production; *Hormē* names the *thermodynamic imperative* that sustains it. A system is autopoietic *by virtue of* its *Hormē*.
- **Conatus:** Spinoza's *conatus*—the endeavor of each thing to persist in its own being—is a profound philosophical precursor.[19] However, *conatus* is often treated as a metaphysical principles. *Hormē* grounds the same intuition in modern thermodynamics, making it empirically measurable.

[18] See Deutscher, *Neo-Pre-Platonic Naturalism*, p. 53: "Consider the simplest bacterium swimming up a chemical gradient… It is not merely reacting; it is expressing the primordial Hormē."

[19] Benedict de Spinoza, *Ethics*, trans. Edwin Curley (Princeton University Press, 1994), pt. III, prop. 6

- **Free Energy Principle:** In contemporary neuroscience, the Free Energy Principle states that self-organizing systems act to minimize variational free energy, which is mathematically related to surprising states.[20] *Hormē* is the **ontological precondition** for such a principle: only a far-from-equilibrium system that must maintain its boundaries has a "surprise" to minimize. The FEP describes the *computational strategy* that systems deploy; *Hormē* answers *why* systems are organized to deploy such strategies in the first place.[21]
- **Adaptivity and Agency:** Ezequiel Di Paolo defines adaptivity as a system's capacity to regulate its coupling with the environment in relation to a viability boundary.[22] *Hormē* is the **constitutive precariousness** that makes such regulation necessary. It is the "needful" aspect of the need-based autonomy that defines agency in enactivist thought.[23]

Operational Criteria and Test Cases

The definition yields clear, operational criteria for life and generates intuitive classifications:

System	Possesses *Hormē*?	Why?
Bacterium	Yes	Continuous metabolism actively maintains cellular integrity against diffusion and decay.
Mature Tree	Yes	Metabolic activity (photosynthesis, nutrient transport) maintains organismal structure.
Dormant Seed	No (in stasis)	Metabolic activity is suspended; persistence is passive. *Hormē* resumes upon hydration.
Virus (virion)	No	No metabolic activity. It is a stable configuration of molecules, not a far-from-equilibrium process.
Candle Flame	No	A dissipative structure, but its "boundary" is not self-maintained; it is a transient by-product of fuel combustion.
Self-balancing Robot	No	Performs work to maintain a state, but its organization is not self-produced and its "persistence" is not thermodynamically precarious, it is indifferent to balancing and flopping around on the ground indefinitely.

[20] Karl Friston, "The Free-Energy Principle: A Unified Brain Theory?" *Nature Reviews Neuroscience* 11, no. 2 (2010): 127–38.

[21] Friston's framework treats the free energy principle as a universal imperative for self-organizing systems but leaves the question of *what makes something a self-organizing system* underspecified. *Hormē* fills this gap: systems minimize free energy *because* they are constituted by the thermodynamic necessity of maintaining far-from-equilibrium organization.

[22] Di Paolo, "Autopoiesis, Adaptivity, Teleology, Agency."

[23] Xabier E. Barandiaran et al., "Defining Agency: Individuality, Normativity, Asymmetry, and Spatio-Temporal Origin of Action," *Adaptive Behavior* 17, no. 5 (2009): 367–86.

This framework draws a principled, physics-based line. Life is not a cluster of properties but a **specific mode of physical process**: the process of self-sustaining, anti-entropic work. With *Hormē* defined, we can now demonstrate its dual role as the foundation of both life and agency.

The Deduction of *Hormē*: Life as Local Causal Rebellion

The preceding sections have framed life thermodynamically and agency functionally. We now reveal the deductive core that makes them **not merely correlated but identical**. This deduction shows why life cannot be a "passenger" in the causal flow—why it must be, by its very physical constitution, a **source of novel causation**.

The Entropic Regime and Its Default Future

Our deduction begins from two physical certainties:

1. **The *Archē* is lawful** (FP1). Events follow the *Logos*—consistent, discoverable patterns.
2. **The cosmic tendency is entropic** (FP3, T7). *Neikos*—the drive toward dispersion and disorder—is statistically dominant. Left to impersonal physics, any bounded organization will dissolve.

This establishes the **default future**: for any localized pattern, the most probable path forward is entropic dissolution. This is the "billiard-ball" regime of passive, forward-only causation where futures are extrapolations of past states plus decay.

The Fork in the Causal Road

Within this regime, a system faces a fundamental fork:

Pathway	Mechanism	Example	Metaphor
Passive Conduction	The system's future is shaped **entirely by external forces**. Its structure may delay decay, but does not actively oppose it.	A rock weathering; a sandcastle eroding; a candle flame consuming wax until it gutters out.	**Passenger.** Carried by the current.
Active Intervention	The system **expends its own stored energy to perform work** that counters the entropic gradient. It alters local conditions to favor its continued existence.	A bacterium swimming toward nutrients; a plant growing leaves toward light; an animal seeking shelter.	**Navigator.** Steers against the current.

The difference is **categorical**, not gradual. The passenger's fate is sealed by initial conditions plus entropic decay. The navigator's fate is **open**—contingent on its own successful expenditure of energy against that decay.

The Thermodynamic Sine Qua Non: *Hormē*

Why can't a rock be a navigator? Because navigation has a **non-negotiable price**: continuous, self-directed work against the entropic gradient (T7: The Entropic Asymmetry).

This work is not an *activity* the system does; it is the **activity that the system *is***. To cease this work is to cease being that living organization. This constitutive, anti-entropic work **is** *Hormē*.

The Deduction of the Life-Agency Identity

From these premises, the identity follows with logical force:

P1 (The Boundary Condition): Any persistent entity maintains a distinction from its environment (GZP).

P2 (The Entropic Threat): The environment tends to erase that distinction (*Neikos*).

T7 (The Necessary Defense): Therefore, maintaining distinction requires continuous work against entropic erasure.

Definition 1 (Life): A system is **alive** if it maintains its distinction through continuous, internally regulated work.

Definition 2 (Agency): A system is an **agent** if it can, through its own operations, alter local causal outcomes to favor its persistence.

The Crucial Identity: The "continuous, internally regulated work" of Definition 1 **is physically identical to** the "altering of local causal outcomes" in Definition 2. The bacterium's metabolic work *is* its chemotactic steering. One is the thermodynamic process; the other is its causal consequence.

Theorem (T6): Therefore, a system is alive **if and only if** it is an agent. They are isomorphic because they describe the same physical phenomenon: a bounded system fighting to maintain its boundary against dissolution.

Life as Local Causal Indeterminacy

This reveals the radical implication: **Life breaks the entropic determinism** of its local domain. While this conclusion may seem startling against the backdrop of hard determinism—which demands we treat our experience of agency as an illusion—it is actually the more moderate and logically consistent position. It simply accepts the empirical reality of biological striving (Hormē)

and provides the physical mechanism that makes it possible, avoiding the incoherence of denying the very phenomenon we live every moment—including the **performative contradiction of the hard determinist**, who must exercise the very agency they deny in order to argue against it.

In the billiard-ball regime, the future is the past plus decay. But a living system **injects novel causation**—energy-expending work—that changes which possible future becomes actual. Without the bacterium's *Hormē*, the future is diffusion and death. With it, the future is nutrient acquisition and persistence.

This is not "co-determination" in a predetermined chain. It is **causal rebellion**: the living system becomes a **source of causation**, not merely a conduit. Its future is **dependent on its *Hormē***, not determined by its immediate past.

From Theorem to Taxonomy

The deduction yields a clean, physical taxonomy:

- **Non-Agents (Non-Living):** Systems whose persistence is passively determined by external forces and entropic decay. They are **passengers** on the causal chain. (Rocks, clouds, most dissipative structures).
- **Agents (Living):** Systems whose persistence **actively depends** on their own anti-entropic work. They are **navigators**, sources of causal novelty in their local domain. (All organisms, from bacteria to humans).

Hormē is therefore not a vital spark but the **physical mechanism of causal rebellion**. What Spinoza sensed as *conatus*—the endeavor to persist—we now see as a **deductive imperative**: in an entropic universe, any system that can pay the thermodynamic price to steer its future **must** do so, or cease to be.[24]

This deduction elevates T6 from proposition to **physical necessity**. Agency is not an emergent luxury; it is the fundamental signature of being alive in a universe that tends toward death.

T6: The Life-Agency Isomorphism Theorem

The preceding sections have framed life thermodynamically and agency functionally. We now reveal the deductive core that makes them **not merely correlated but identical**. This deduction shows why life cannot be a "passenger" in the causal flow—why it must be, by its very physical constitution, a source of novel causation.

[24]Spinoza, *Ethics*, Part III, Prop. 6

Formal Statement of the Theorem

> **T6: The Life-Agency Isomorphism Theorem**
>
> Life and minimal agency are isomorphic. A system is alive **if and only if** it possesses *Hormē* (the striving to persist), and it possesses *Hormē* **if and only if** it is an agent. The capacity to strive—to maintain far-from-equilibrium organization against entropy—is the constitutive property of both biological existence and navigational agency.

This theorem makes two bidirectional claims:

1. **Life → *Hormē* → Agency:** If a system is alive (as defined thermodynamically), it is engaged in *Hormē*, and that very engagement constitutes minimal agency.
2. **Agency → *Hormē* → Life:** If a system is a minimal agent (as defined functionally), its agency must be grounded in a constitutive striving (*Hormē*), which is the thermodynamic signature of life.

The theorem is **scale-invariant**. It applies equally to a bacterium performing chemotaxis and a human engaging in deliberate choice. The complexity of the mediating mechanisms (simple tropism vs. cortical deliberation) differs, but the constitutive grounding in *Hormē* does not.

The Conceptual Model: Life as Causal Rebellion

Our argument begins from the physical certainty that the cosmic tendency is entropic (*Neikos*). In this "billiard-ball" regime, the default future for any bounded system is dissolution. Within this regime, a system faces a fundamental fork:

Pathway	Mechanism	Metaphor
Passive Conduction	The system's future is shaped **entirely by external forces**.	**Passenger** (Carried by the current)
Active Intervention	The system **expends energy to perform work** that counters the entropic gradient.	**Navigator** (Steers against the current)

Why can't a rock be a navigator? Because navigation has a **non-negotiable price**: continuous, self-directed work against the entropic gradient (T7). This work is not an *activity* the system does; it is the **activity that the system *is***. To cease this work is to cease being that living organization. This constitutive, anti-entropic work **is** *Hormē*.

This reveals a radical implication: **Life breaks the entropic determinism of its local domain.** A living system injects novel causation—energy-expending work—that changes which possible future becomes actual. This is not "co-determination"; it is **causal rebellion**.

The Formal Derivations

Having established the conceptual necessity of this rebellion, we can now derive the isomorphism formally through two convergent pathways—one logical, one physical.

Derivation A: The Logical Necessity (From First Principles)

This derivation proceeds from the foundational axioms of Neo-Pre-Platonic Naturalism regarding the nature of existence and identity.

1. **From GZP (The Zero Principle):** Determination requires an indeterminate ground. For a specific system (Figure) to possess identity, it must emerge from a contrasting field (Ground). Therefore, any determinate entity must possess a **boundary** that distinguishes it from its environment.[25]
2. **From FP1 & FP2 (The Nature of Reality):** The *Archē* (reality) is a dynamic, lawful process (*Diachronic Primacy*). It is governed by the entropic force of *Neikos* (separation/dissolution), which naturally degrades boundaries over time.[26]
3. **From FP6 (The Primacy of the *Hormē*):** For a bounded entity to *persist* in such an environment (rather than dissolving back into the background), it cannot be passive. It must possess a constitutive drive to maintain its boundary against the flow of *Neikos*. This drive is *Hormē*.[27]
4. **Conclusion:** Therefore, any entity that persists as a distinct system in time (a living thing) *must* be an agent (a system defined by the striving to persist). Agency is the logical condition of persistence in a dynamic cosmos.

Derivation B: The Physical Necessity (From Thermodynamics)

This derivation proceeds from the established physics of non-equilibrium systems, providing the empirical validation of the logical claim.

1. **From Non-Equilibrium Thermodynamics:** Living systems are **far-from-equilibrium dissipative structures**. Unlike objects at equilibrium (e.g., a rock), they maintain a state of low internal entropy by continuously importing free energy and exporting entropy to their environment.[28]

[25] See Deutscher, *Neo-Pre-Platonic Naturalism*, p. 189 (ZP: The Necessity of Contrast).

[26] See Deutscher, *Neo-Pre-Platonic Naturalism*, p. 32 (FP2: Diachronic Primacy) and p. 45 (FP3: The Logos and Polarity).

[27] See Deutscher, *Neo-Pre-Platonic Naturalism*, p. 53 (FP6: Primacy of the Hormē).

[28] Prigogine and Stengers, *Order Out of Chaos*.

2. **From Schrödinger's Negentropy:** As Erwin Schrödinger established, life "feeds on negative entropy."[29] To maintain its organized state against the universal tendency toward disorder (the Second Law), a living system must perform **continuous work**. This work is not incidental; it is the fundamental thermodynamic condition for being alive.
3. Invoking the Entropic Asymmetry (T7): As established in Section 2.1, the maintenance of any bounded, low-entropy pattern requires continuous expenditure of energy (Work) against a standing gradient of dissolution. Order is energetically expensive; disorder is the statistical default.
    - **Therefore:** The maintenance of any bounded, low-entropy pattern (*Being*) requires continuous expenditure of energy (*Work*) against a standing gradient of entropic dissolution. Order is energetically expensive; disorder is the statistical default.
4. **The *Hormē* Identity:** This necessary, continuous, directed work against entropic dissolution **is** *Hormē*. *Hormē* is not a metaphor for life's activity—it *is* the thermodynamic work of persistence.
5. **The Agency Identity:** This same directed work—expending energy to maintain organizational boundaries against dissolution—is physically identical to **directing causal flow for self-maintenance**, which is the definition of minimal agency (Section 3.1).[30]
6. **The Isomorphism:** Therefore:
    - To be alive = to maintain far-from-equilibrium organization = to perform *Hormē* (directed work against entropy)
    - To be an agent = to direct causal flow for persistence = to perform *Hormē* (directed work against entropy)
7. **Conclusion:** Life and minimal agency are thermodynamically isomorphic. They share the same constitutive physical process: *Hormē*.

The Nature of the Identity

The theorem claims **identity**, not merely correlation. A helpful analogy is the relationship between *heat* and *molecular kinetic energy*. They are not merely correlated; they are identical descriptions of the same phenomenon at different levels of abstraction. One is the macroscopic phenomenon, the other its microscopic constitutive basis.

Similarly:

- ***Agency*** is the **macroscopic, behavioral phenomenon** (directing causal flow).
- ***Hormē*** is its **microscopic, thermodynamic constitutive basis** (the directed work of boundary maintenance).

[29] Schrödinger, *What Is Life? The Physical Aspect of the Living Cell*.

[30] This parallels Kauffman's definition of an "autonomous agent" as a system capable of completing at least one thermodynamic work cycle. See Kauffman, *Investigations*.

To have one is to have the other. The bacterium's chemotaxis (*agency*) *is* its metabolic work to maintain a glucose gradient across its membrane (*Hormē*).

This identity acts as the fulcrum for the rest of our inquiry. By anchoring agency in the basement of physics—in the thermodynamic cost of being—we preclude any need for "magic moments" later in evolution where mind must suddenly be injected into matter. The difficult work of formal deduction is complete; what remains is to trace how this fundamental isomorphism reshapes our map of the biological world.

Key Implications and Predictions

The theorem is not a sterile logical exercise. It generates testable predictions and reframes long-standing debates.

Prediction 1 (The Agency Threshold): Any system that meets the thermodynamic criteria for *Hormē* (e.g., active self-maintenance via metabolism) will exhibit observable, goal-directed behavior oriented toward maintaining its far-from-equilibrium state. This is empirically verifiable across the tree of life.

Prediction 2 (The Normative Ground): Any system lacking *Hormē* may exhibit complex, seemingly purposeful behavior, but it will lack an *intrinsic normative standard* by which its actions succeed or fail. Its "goals" are extrinsically assigned (e.g., by a programmer), not constitutively necessary. This provides a principled criterion for distinguishing genuine agency from sophisticated simulation.

Reframing the Life/Mind Problem: The theorem bridges the gap by showing that what we call "mind" or "agency" in its sophisticated forms is not a radical emergence from inert matter, but the **complexification of a property already present in the simplest living cell**. The problem is not "How does agency arise from non-agency?" but "How does complex, information-sensitive agency arise from minimal, thermodynamic agency?" This is a tractable question for evolutionary biology and cognitive science.[31]

Reframing the Is/Ought Problem (preview): For a system whose "is" is constituted by striving (*Hormē*), its "ought" is built in. Its factual state of being a persistent far-from-equilibrium pattern *implies* the normative imperative to sustain that pattern. This collapses Hume's guillotine for living systems, grounding normativity in physics rather than in sentiment or reason. This approach resonates with Christine Korsgaard's argument that agency itself grounds normativity—that to

[31] Peter Godfrey-Smith, *Metazoa: Animal Life and the Birth of the Mind* (Farrar, Straus; Giroux, 2020).

be an agent *just is* to be subject to normative requirements.[32] However, where Korsgaard locates normativity in rational self-constitution, we locate it in the thermodynamic necessity of boundary maintenance—a naturalistic foundation that applies to all living systems, not only rational agents. (This metaethical implication will be developed fully in a subsequent paper; here, it serves to illustrate the theorem's explanatory power.)

Contrast with Competing Accounts

The isomorphism thesis carves a distinctive path between existing theories:

- **Against Vitalism & Dualism:** T6 requires no *élan vital* or non-physical soul. The striving is fully physically constituted by non-equilibrium thermodynamics.
- **Against Mechanistic Reductionism:** While physical, T6 shows that the specific thermodynamic condition of being alive introduces a **non-eliminatable normative dimension**—success vs. failure relative to persistence—that is absent from descriptions of non-living mechanisms. A clock's failure to tell time is not a threat to its *existence*; a bacterium's failure to find nutrients is.
- **Against "Mind-First" Theories of Agency:** T6 decouples minimal agency from consciousness or sophisticated cognition. Agency is first and foremost a thermodynamic, organizational property. Consciousness, when it arises, *modulates* agency but does not create it *ex nihilo*.
- **Alongside Enactivism & Autopoiesis:** T6 is deeply consonant with these traditions but makes an explicit, formal identity claim and grounds it more directly in energetic necessity. It answers the 'why' of autopoiesis: systems are self-producing *because* they are constituted by *Hormē*—the imperative to perform the work of existence.

The Life-Agency Isomorphism Theorem thus provides a unified foundation. It explains why the search for a "mark of the cognitive" or the "origin of agency" inevitably leads us back to the very definition of life. In the following sections, we will apply this foundational insight to dissolve the two gaps identified at the outset.

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[32] Christine M. Korsgaard, *Self-Constitution: Agency, Identity, and Integrity* (Oxford University Press, 2009). Korsgaard argues for self-constitution: we create our agency through reflective endorsement of our practical identities. *Hormē* provides a more fundamental grounding: the normative requirement precedes reflection, located in the thermodynamic necessity of self-maintenance. Reflection (the *Nous*) operates *within* this prior normative field.

Dissolving the Life/Mind Gap

The Life/Mind Gap asks how subjective experience, intentionality, and "mind" can arise from mere biological matter. It is often framed as the "hard problem" of consciousness or the "explanatory gap" between third-person physical processes and first-person experience.[33] A less metaphysical but equally persistent version asks how **agency**—the capacity to act for reasons, to have goals, to be a source of action—emerges from systems that seem, at base, to be blindly mechanistic.

The isomorphism established in T6 provides a direct path through this impasse. It does so by rejecting the premise that mind or agency must be *added to* life. Instead, it demonstrates that a core property of mind—minimal agency—is **already present in the thermodynamic condition of being alive**. The gap dissolves when we see that what we recognize as "mind" in its sophisticated forms is a *scaled and mediated version* of a constitutive property of all living systems.

From Thermodynamic Striving to Information-Sensitive Agency

T6 establishes that minimal agency is *Hormē*: the thermodynamic striving to persist. At this baseline, in a bacterium, agency is direct and unmediated. The system's organization couples it to its environment such that its activity (e.g., metabolism, taxis) is intrinsically oriented toward boundary maintenance.

The evolutionary transition from minimal to complex agency is not the sudden appearance of a new ontological category, but the **augmentation of *Hormē* with information-sensitive regulation**. As organisms become more complex, face more variable environments, and develop multiple, potentially conflicting sub-systems (e.g., for nutrient intake, predator avoidance, social interaction), simple coupling is insufficient. The constitutive striving must be *managed*.

This management requires:

1. **Sensing and Modeling:** The capacity to detect and internally represent environmental and internal states.
2. **Conflict Resolution:** A regulatory mechanism to arbitrate between competing demands (e.g., hunger vs. safety).
3. **Prediction and Planning:** The capacity to anticipate future states and adjust behavior proactively.

These are not "mental" additions to a physical body; they are **functional elaborations of *Hormē***, evolved to serve the same constitutive end: persistence in a complex world.

[33] Chalmers, *The Conscious Mind.*

The Layered *Psyche*: An Evolutionary Model of Scaled Agency

We can model this scaling of agency as the evolution of a layered regulatory architecture—the *Psyche*. This model shows how complexity builds upon, rather than replaces, the thermodynamic core.[34].

- ***Orexis* (Ὄρεξις):** The foundational layer of biological drive, directly servicing *Hormē* through homeostatic regulation (hunger, thirst, pain avoidance). It is present in all life.[35].
- ***Thymos* (Θυμός):** The strategic-social layer, emerging with group living. It manages in-group/out-group dynamics, status, and alliances. Its drives (e.g., for belonging, dominance) are extensions of *Hormē* into the social domain.
- ***Logistikon* (Λογιστικόν):** The **co-primal regulatory layer**. Critically, the *Logistikon* does not evolve *after Orexis* and *Thymos*; it evolves *concurrently* with them. The moment a system has multiple, potentially conflicting striving vectors (e.g., flee a predator vs. defend offspring), a regulatory mechanism to resolve those conflicts becomes a **necessity for effective action**. Without it, the system would suffer paralysis or maladaptive oscillation. The *Logistikon* is the evolved solution to this problem, a "manager" of striving whose function is to optimize for the net *Hormē* of the whole system.[36].
- ***Nous* (Νοῦς):** The modeling and meta-cognitive layer. The *Nous* provides the capacity for abstraction, long-term scenario planning, and—crucially—self-modeling. It is a high-energy-cost adaptation deployed when the *Logistikon's* heuristics and instincts fail, or when novel, long-range strategic problems arise.[37].

This layered model finds empirical support in affective neuroscience. Jaak Panksepp's identification of "primary process emotions" (SEEKING, RAGE, FEAR, CARE, PANIC/GRIEF, PLAY, LUST) maps directly onto the *Orexis* and *Thymos* layers—these are the ancient, subcortical circuits that directly service *Hormē* through appetitive drives and social-strategic responses.[38] The *Nous* as a meta-cognitive, self-modeling system finds support in Michael Graziano's Attention Schema Theory, which argues that consciousness arises from the brain's model of its own attention processes—a clear instance of the self-referential monitoring required for sophisticated navigation.[39]

[34]For the complete evolutionary derivation of this stratified architecture, see Deutscher, *Neo-Pre-Platonic Naturalism*, ch. 6

[35]See Lawrence W. Barsalou, "Perceptual Symbol Systems," for support on cognition grounded in sensorimotor systems Lawrence W. Barsalou, "Perceptual Symbol Systems," *Behavioral and Brain Sciences* 22, no. 4 (1999): 577–660.

[36]This aligns with Kahneman's dual-system theory: the *Logistikon* corresponds to the effortful, calculating System 2, while *Orexis* and *Thymos* map to the automated System 1 Daniel Kahneman, *Thinking, Fast and Slow* (Farrar, Straus; Giroux, 2011).

[37]See Bernard Baars' Global Workspace Theory for the neuroscientific correlate of the Nous as an emergent integrator Bernard J. Baars, *A Cognitive Theory of Consciousness* (Cambridge University Press, 1988).

[38]Jaak Panksepp, *Affective Neuroscience: The Foundations of Human and Animal Emotions* (Oxford University Press, 1998). Panksepp's SEEKING system, in particular, is the neurobiological implementation of *Hormē*-driven exploration and resource acquisition, present in all mammals and homologous structures in simpler vertebrates.

[39]Michael S. A. Graziano, *Consciousness and the Social Brain* (Oxford University Press, 2013).

This model reveals that the "mind" (in the sense of the *Nous* and its executive arm, the *Logistikon*) is not the *origin* of agency but its **most sophisticated instrument**. The *Nous* does not generate striving; it is tasked with *figuring out how best to fulfill* the striving that constitutes the system's very existence. The so-called "gap" between life and mind is, in fact, the distance between a simple regulatory loop (bacterial chemotaxis) and a complex, multi-layered one (mammalian cognition). It is a difference of degree, not kind.

Continuity, Not Mystery

This framework reframes the central questions. The challenge is no longer the magical emergence of agency from non-agency. The challenge is to understand the **evolutionary pathways and computational principles** by which information processing becomes integrated with thermodynamic striving.

- **The "Hard Problem" of Agency** is dissolved. Agency is not a problem to be explained *ab initio*; it is the starting condition of life. The explanatory task shifts to detailing the mechanisms of scaling.
- **The "Mark of the Cognitive"** is clarified. The search for a bright line between cognitive and non-cognitive systems is often misguided.[40] T6 suggests the relevant continuum is one of **informational mediation of *Hormē***. All living systems are on this continuum; some are farther along it.
- **Bridging Biology and Cognitive Science:** This view is deeply consonant with embodied, enactive, and ecological approaches in cognitive science, which stress the continuity of life and mind and see cognition as a tool for the guidance of action in a precarious world.[41]

By grounding agency in the thermodynamic reality of life, T6 does not explain away the richness of human experience. Instead, it provides that richness with a solid foundation. Our capacity for love, morality, art, and science is not a ghost in the machine; it is the machine's own fantastically complex solution to the primordial problem of keeping its flame lit against the cosmic wind.

Dissolving the Mechanism/Teleology Gap

The second persistent divide is between mechanistic explanation—which describes *how* a system operates through efficient causes—and teleological description—which explains *why* a system behaves as it does in terms of goals, purposes, or final causes. Since the Scientific Revolution, mechanistic explanation has been ascendant, while teleology has been exiled to the realms of theology, vitalism, or dismissed as a heuristic fiction.[42] The living world, however, stubbornly

[40] Daniel D. Hutto and Erik Myin, *Radicalizing Enactivism: Basic Minds Without Content* (MIT Press, 2013).
[41] Thompson, *Mind in Life*; James J. Gibson, *The Ecological Approach to Visual Perception* (Houghton Mifflin, 1979).
[42] Ernst Mayr, "Cause and Effect in Biology," *Science* 134, no. 3489 (1961): 1501–6.

presents itself as purposive: hearts beat *to* pump blood, roots grow *toward* water, animals hunt *for* food.

The standard move is to explain this apparent purpose away. The neo-Darwinian synthesis reduces teleology to *teleonomy*: goal-directed behavior is the product of blind variation and natural selection, which engineer systems that *behave as if* they had goals.[43] On this view, purpose is an illusion; only mechanism is real.

T6, and the concept of *Hormē*, suggests a more radical and satisfying solution: **Teleology is not an illusion to be explained away, but a real, physically-grounded phenomenon inherent to a specific class of mechanisms—far-from-equilibrium dissipative structures engaged in self-maintenance.** This position aligns with James Barham's "teleological realism," which argues that functional norms are objective features of biotic systems, not subjective projections.[44] The gap dissolves not by eliminating one side, but by showing that the two sides describe the same system at different levels of analysis.

From External *Telos* to Immanent *Hormē*: Inverting the Direction of Purpose

The historical tension stems from a specific conception of teleology: the Aristotelian *telos* (final cause). In this model, purpose is often interpreted as a **pull from a future ideal**. The acorn's development is *for the sake of* the mature oak, its perfect form. This "pull" model is incompatible with modern physics, which knows only efficient causes propagating forward in time.

The *Hormē*-based model reframes this. Purpose is not a pull from a future ideal, but a **push from a present, constitutive condition**. However, unlike standard efficient causation, this "push" is circular and self-referential. A system does not act *for the sake of* a future state of flourishing; it acts *because* its current state of far-from-equilibrium organization **necessitates action to avoid immediate dissolution**.

- **Bacterial Chemotaxis:** The bacterium does not move toward glucose *for the sake of* future metabolic prosperity. It moves because its current constitutive state—a precarious, low-entropy pattern—will collapse if it does not. The "goal" is immanent in its present need.
- **Heartbeat:** The heart does not beat *for the sake of* the organism's future survival. It beats because the organism's *current* far-from-equilibrium state requires continuous circulation to distribute energy and remove waste. Cessation means immediate systemic failure.

This is **immanent teleology**, or more precisely, **teleonomy grounded in constitutive thermodynamics**. The "end" is not a represented future state, but the **continuous maintenance of**

[43]Colin S. Pittendrigh, "Adaptation, Natural Selection, and Behavior," *Behavior and Evolution*, 1958, 390–416; Jacques Monod, *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology* (Knopf, 1971).

[44]James Barham, "Teleological Realism in Biology," *Synthese* 185, no. 1 (2012): 31–54.

the conditions that allow the process itself to persist. Purpose is built into the causal topology of the system. In this sense, for a self-maintaining system, efficient causation *is* teleonomic; the *telos* is immanent in the efficient cause.

Aristotle's Four Causes and the Location of *Telos*

To clarify precisely where this framework diverges from and aligns with Aristotelian teleology, a brief examination of the four causes is necessary. Aristotle distinguished material cause (what something is made of), formal cause (its structure), efficient cause (what brings it about), and final cause (*telos*, what it is *for*).[45] In the Aristotelian schema, these are distinct explanatory principles.

For a self-maintaining dissipative structure, however, these causes collapse into a unified causal topology. The material cause (the molecular components), formal cause (the organizational pattern), and efficient cause (the metabolic processes) are all constituted *by* and oriented *toward* the final cause—which is not an external ideal but the continuation of the very process that instantiates them. The efficient causes (metabolic reactions) generate the formal cause (the bounded organization), which requires specific material causes (nutrients, energy), all of which exist *because* the system is engaged in the work of self-maintenance.

The *telos* is thus **immanent in the efficient causation itself**. It is not that the heart beats (efficient cause) *in order to* achieve circulation (final cause) as two separate things. Rather, circulation *is* what the heart's beating *is*, when that beating is understood within the context of a self-maintaining organism. The "for the sake of" is not a temporal arrow pointing forward, but a logical relationship of functional necessity within a present, ongoing process.

This is why *Hormē*-based teleology is fully compatible with mechanistic explanation while retaining genuine purposiveness. We do not reject Aristotle's insight that living systems exhibit final causation; we relocate the *telos* from a transcendent pull to an immanent imperative.[46]

Mechanism and Teleology as Complementary Descriptions

Having clarified this relationship to Aristotelian teleology, we can now see how mechanism and teleology become complementary descriptions. With this reconception, the conflict between them evaporates.

- **The Mechanistic Description** answers: "*How* does this system work?" It traces the efficient-causal pathways: the ion channels in bacterial membranes, the chemical gradient sensors, the flagellar motor. This description is complete, causal, and essential.

[45] Aristotle, *Physics*, vol. 1, ed. Jonathan Barnes (Princeton University Press, 1984), *Physics* II.3.

[46] For a complete reconstruction of Aristotelian *entelechy* and *energeia* in light of modern thermodynamics, and a demonstration that Aristotle's own biology contains the seeds of this immanent teleology, see Eli Adam Deutscher, "Aristotle's Telos and the NPN Correction: From Synchronic Pull to Diachronic Push," 2026, https://neopreplatonic.com/papers/Aristotle/.

- **The Teleological (Teleonomic) Description** answers: "*Why* is this system organized this way?" It identifies the constitutive constraint that shapes and explains the organization of the mechanism: the imperative of *Hormē*, the need to maintain far-from-equilibrium integrity. This description is functional, explanatory, and equally essential.

The two are related as **structure to function**, or **process to constraint**. The mechanism is the set of processes; the teleonomy is the functional constraint (*Hormē*) that those processes collectively serve. To ask, "Why does the bacterium have a chemotaxis mechanism?" is not to invoke a mystical final cause. The answer is physical and immediate: **Because without a mechanism to find nutrients, the far-from-equilibrium structure that is the bacterium cannot persist.** The teleonomy is the raison d'être of the mechanism. This relationship is best understood as "weak emergence," where the macro-state (agency) is derivable from the micro-dynamics but possesses distinct causal powers via constraint.[47]

Naturalizing Normativity and Function

This framework provides a robust naturalization for two concepts often seen as teleological holdouts: **biological function** and **normativity**.

- **Function:** The function of a component is its specific contribution to the system's *Hormē*—its role in maintaining the far-from-equilibrium whole. The heart's function is to circulate blood *because* circulation is necessary for the organism's continuous self-maintenance. This is a **constitutive function** account, as opposed to an etiological (history-based) one.[48] It grounds function in the current organization of the system, not solely in its evolutionary past. This differs from Ruth Millikan's influential etiological account, which grounds proper function in the historical selection processes that produced the trait.[49] While Millikan's account successfully explains why hearts pump blood (because ancestors with blood-pumping hearts were selected), it locates function in the past. The *Hormē*-based account locates function in the present thermodynamic necessity: the heart pumps blood because *right now*, the organism's far-from-equilibrium state requires circulation. Both accounts are valid but address different explanatory targets—evolutionary history vs. constitutive necessity.[50]

- **Normativity:** Within the system, states and actions can be "good" or "bad," successful or failing. This normativity is not subjective. It is the objective, physical relationship between

[47] Mark A. Bedau, "Weak Emergence," *Philosophical Perspectives* 11 (1997): 375–99.

[48] Ruth Garrett Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism* (MIT Press, 1984); Alvaro Moreno and Matteo Mossio, *Biological Autonomy: A Philosophical and Theoretical Enquiry* (Springer, 2015).

[49] Millikan, *Language, Thought, and Other Biological Categories.*

[50] A complete function is both: historically selected *and* presently necessary. The evolutionary account explains *why this mechanism exists*; the thermodynamic account explains *why it must operate.* For living systems, these converge: mechanisms that fail to serve present *Hormē* are eliminated by selection.

an action/state and its consequence for the system's *Hormē*. Drinking water is "good for" a dehydrated animal because it directly serves the constitutive work of maintaining fluid balance and cellular integrity. This naturalizes normativity without recourse to values, sentiments, or divine commands; it is the normativity of a physical equation—solve it correctly, and you persist; solve it incorrectly, and you dissolve.

The Status of Purposive Language

Does this mean we can safely use purposive language in science? Yes, but with precise meaning. To say "The plant grows leaves *to* photosynthesize" is not a sloppy shorthand. It is a valid teleonomic statement. It means: "The growth of leaves is part of a self-maintaining organization (*Hormē*) for which the capture of solar energy is a constitutive requirement." The "in order to" is physically real; it refers to the role of a process within a self-sustaining causal topology.

This resolves the tension in Ernst Mayr's distinction between teleology and teleonomy. Mayr argued teleonomy is acceptable as "program-directed behavior" while teleology implies conscious purpose.[51] We show that teleonomy is constitutively grounded in thermodynamic necessity, not merely as a metaphor for genetic programs, but as the causal logic of any *Hormē*-driven system. The program itself (metabolic network, genetic regulatory system) is the physical implementation of the thermodynamic imperative.

Objections and Replies

A thesis as broad and foundational as the Life-Agency Isomorphism will inevitably attract scrutiny. Engaging with the strongest possible objections is not merely defensive; it is a vital step in clarifying the theory's scope, limits, and empirical commitments. Here, I address the most significant challenges.

The Scope Problem: "Too Broad" and "Too Narrow"

Objection (Too Broad): "Under your definition, a hurricane, a candle flame, or a self-sustaining nuclear reaction would qualify as alive and agential. They are far-from-equilibrium dissipative structures that 'direct causal flow' to maintain their form against entropy."

Reply: This objection confuses *dissipation* with *self-maintenance*. While all living systems are dissipative structures, not all dissipative structures are living. The critical distinction is **organizational closure** or **autopoiesis**.[52] A hurricane has no internal, self-produced boundary that

[51] Mayr, "Cause and Effect in Biology."
[52] Maturana and Varela, *Autopoiesis and Cognition.*

it actively regulates; its "form" is an epiphenomenon of external atmospheric gradients. A candle flame does not metabolically repair its structure; it is a transient dissipative process with no organizational memory or regulatory loop. These systems lack *Hormē* because they do not perform work *to maintain a self-demarcated organizational identity*. They are processes, but not *self-processes*. The definition is precisely broad enough to capture all autopoietic systems and no broader.

Objection (Too Narrow): "You exclude viruses, dormant seeds, and frozen tardigrades. Yet these are paradigm cases of biological entities. Your definition also seems to exclude future sophisticated AI, which may exhibit clear agency."

Reply: This objection conflates *potential* for life with *actual* living process. A virus (virion) is a stable configuration of molecules, a *possible* trigger for a living process (infection) in a host cell. A dormant seed is a metabolically arrested *stage in a life cycle*, not a living process itself. These are **cryptobiotic states**—temporary suspensions of *Hormē*. Their "aliveness" is dispositional, not occurrent. This is a feature, not a bug: it accurately reflects that life is a continuous activity, not a static property. Regarding AI, this objection previews a separate, complex debate. Briefly, T6 provides a criterion: an AI would be an agent *if and only if* its organization constituted a far-from-equilibrium process whose continued existence required work, and for which its actions were constitutive of that work. Most current AI architectures are clearly not this; they are tools whose "goals" are extrinsically assigned. The objection, therefore, does not show the definition is too narrow, but that it provides a clear test for genuine agency in non-biological systems.

The Circularity Charge

Objection: "Your argument is circular. You define life by *Hormē* (striving), define minimal agency by *Hormē*, and then 'discover' they are isomorphic. This is a tautology masquerading as a discovery."

Reply: The isomorphism is an **empirical identity claim**, not a definitional tautology. The logic is:

1. Independent, thermodynamic analysis reveals that living systems are characterized by continuous self-maintenance work (a factual claim from non-equilibrium physics).
2. Independent, philosophical/behavioral analysis reveals that minimal agents are characterized by goal-directed activity with intrinsic norms (a conceptual claim from action theory and enactivism).
3. *Hormē* is the concept I introduce to name the property identified in step 1.
4. I then demonstrate that the property named in step 1 **is functionally identical to** the property described in step 2. The circularity is apparent, not real. It is analogous to discovering that "temperature" (a macroscopic concept) is "mean molecular kinetic energy" (a

microscopic concept). The identity is substantive, linking two independently characterized domains.

The Consciousness Requirement

Objection: "Agency requires consciousness, or at least some form of subjective experience. A bacterium is a blind automaton. It may react to gradients, but it does not *act*; it has no perspective, no interests. Therefore, it is not an agent, and T6 fails."

Reply: This objection **conflates agency with conscious agency**. It imposes a high-level, human-centric criterion onto a broader phenomenon. Minimal agency, as defined in enactivist and organizational biology, requires **autonomy** (self-governed activity) and **normativity** (success/failure relative to a system-intrinsic standard).[53]

This objection conflates phenomenal consciousness with functional perspective. Following Thompson's life-mind continuity thesis and Hans Jonas's existential interpretation of biological facts, we argue a bacterium has a functional point of view—its boundary defines a locus of normativity—without requiring phenomenal experience.[54] The question is not whether the bacterium "feels" anything, but whether its organization constitutes a normative standard (viability) by which its actions succeed or fail. *Hormē* establishes this standard as thermodynamically objective. To deny this is to hold a vitalist or dualist position, insisting that only systems "like us" (conscious) can be genuine sources of action.

The Teleology Charge (Aristotelian)

Objection: "You are smuggling Aristotelian final causes back into science. *Hormē* sounds like a dressed-up version of *telos*—an inherent striving toward an end. This is pre-modern, unscientific metaphysics."

Reply: This is perhaps the most important objection to resolve. The Aristotelian *telos* is a **pull from a future ideal** (the acorn is *for* the oak). *Hormē*, in contrast, is a **push from a present, constitutive condition**. The bacterium does not strive *toward* a future state of "being well-fed"; it acts *from* its current state of being a precarious, far-from-equilibrium pattern that will dissolve without continuous work. This is not a forward-looking final cause but an **immanent, mechanical imperative**. The "end" is not a represented goal but the **persistence of the process itself**. This is fully consistent with mechanistic explanation; it simply acknowledges that certain mechanisms (self-maintaining ones) have an intrinsic, physically-grounded orientation. I reject

[53] Barandiaran et al., "Defining Agency."

[54] Thompson, *Mind in Life*; Hans Jonas, *The Phenomenon of Life: Toward a Philosophical Biology* (Harper & Row, 1966).

Aristotelian transcendent teleology; I am advocating for a naturalized **teleonomy** grounded in non-equilibrium thermodynamics.[55]

The Evolutionary Priority Objection

Objection: "Life is defined by evolution by natural selection, not thermodynamics. A system is alive if it is capable of reproduction, variation, and heredity. Your focus on individual self-maintenance is secondary."

Reply: This objection reverses the order of dependence. Evolution by natural selection **presupposes** self-maintenance. For a system to be subject to selection, it must first *persist long enough to reproduce*. *Hormē*—the work of individual persistence—is the **enabling condition** upon which the historical process of evolution operates. The thermodynamic definition captures this foundational stratum of individuality. Furthermore, the evolutionary definition struggles with borderline cases (sterile workers, mules) and says nothing about the moment-to-moment reality of being alive. The two definitions are complementary, describing different temporal scales: thermodynamics describes the **constitutive process** of an individual, evolution describes the **historical population process**. T6 addresses the former, which is logically and ontologically prior.

The Measurement Problem

Objection: "Your core concept, 'directed causal flow,' is metaphorical and not scientifically measurable. How do you operationalize *Hormē* for a novel system (e.g., a putative alien life form or advanced robot)?"

Reply: *Hormē* is operationalizable through a series of empirical tests:

1. **Boundary Detection:** Identify a spatial or functional demarcation that is actively maintained (e.g., a membrane with sustained potential, a coherent behavioral domain).
2. **Energy Dissipation Correlation:** Measure if energy inflow is correlated with the maintenance of that boundary's low-entropy state, not merely with generic work output.
3. **Compensatory Response:** Perturb the system. Does it engage in specific, internally regulated activity to restore its boundary conditions (homeostasis, allostasis)?
4. **Cessation Test:** If internal work ceases, does the bounded, low-entropy organization rapidly degrade toward equilibrium?

These are standard procedures in systems biology and the study of autonomous systems.[56] They move the concept from metaphor to measurable phenomenon.

[55] Mayr, "Cause and Effect in Biology"; Matteo Mossio and Leonardo Bich, "What Makes Biological Organisation Teleological?" *Synthese* 194, no. 4 (2017): 1087–114.

[56] Di Paolo, "Autopoiesis, Adaptivity, Teleology, Agency."

By meeting these objections, the Life-Agency Isomorphism Theorem demonstrates not only its coherence but its explanatory power and empirical grounding. It withstands charges of vagueness, circularity, and unscientific teleology, positioning itself as a robust framework for understanding the nature of life and agency.

Conclusion: Agency as a Thermodynamic Phenomenon

This paper began with two gaps that have long fragmented our understanding of living systems: the divide between life and mind, and the conflict between mechanism and teleology. I have argued that these gaps are artifacts of a deeper conceptual failure: the failure to recognize that life and agency share a single, constitutive thermodynamic foundation.

The core of the argument is **T6: The Life-Agency Isomorphism Theorem**. By defining life thermodynamically as the activity of *Hormē*—the continuous, self-directed work of maintaining far-from-equilibrium organization against entropy—and by defining minimal agency as goal-directed activity grounded in an intrinsic normative standard, the theorem demonstrates their identity. To be alive *just is* to be a minimal agent. The striving that constitutes existence is the same striving that constitutes action.

From this foundation, the two target gaps dissolve:

1. **The Life/Mind Gap** dissolves because agency is not a mysterious addition to life; it is life's fundamental mode of being. What we call "mind" in complex organisms is not a separate substance but the **scaled and informationally-mediated expression of *Hormē***. The layered architecture of the *Psyche*—from *Orexis* and *Thymos* to the co-primal *Logistikon* and the modeling *Nous*—shows how thermodynamic striving becomes sophisticated cognition through evolutionary elaboration, not mystical emergence.

2. **The Mechanism/Teleology Gap** dissolves because purpose is not a mystical final cause pulling from the future, but the **immanent logic of a self-maintaining mechanism**. Teleology is reconceived as *teleonomy*: the "push" of *Hormē* from a present constitutive condition, rather than the "pull" of a *telos* toward a future ideal. The mechanistic description (*how* it works) and the teleonomic description (*why* it is organized to work that way) become complementary accounts of the same physical system.

This framework achieves a rigorous naturalization without eliminative reduction. It does not explain away agency or purpose; it **grounds them in physics**. Agency is what dissipative structures do when their dissipation is channelled through self-produced organizational closure. Purpose is the functional signature of a system whose operation is its own precondition for continued existence.

Implications and Future Directions

The implications of this isomorphism are profound and extend across multiple disciplines:

- **For Philosophy of Biology:** It provides a precise, physicalist criterion for life that complements genetic and evolutionary definitions, centering the individual organism's continuous struggle for persistence. It offers a constitutive account of biological function and naturalizes normativity within living processes.
- **For Cognitive Science and Action Theory:** It bridges the gap between enactivist theories of autonomy and the physical sciences, providing a clear thermodynamic basis for concepts like *viability*, *adaptivity*, and *intrinsic norm*. It suggests that the search for the "mark of the cognitive" should begin with the simpler question: "Is this system engaged in *Hormē*?"
- **For Ethics:** As previewed, T6 collapses the is/ought gap for living systems. If to *be* is to *strive to persist*, then for any such system, facts about what fulfills or frustrates that striving carry normative force. This lays the groundwork for a naturalistic, objective, yet relational foundation for ethics.[57]
- **For Artificial Intelligence and the Study of Alien Life:** The theorem provides a clear, non-anthropocentric criterion for assessing claims of genuine agency or life. It shifts the question from "Can it think?" or "Is it made of cells?" to "Is its organization such that its continued existence constitutively depends on its own activity?"

Concluding Reflection

We are accustomed to seeing the universe as divided between passive stuff and active agents, between meaningless mechanism and purposeful mind. The Life-Agency Isomorphism challenges this partition at its root. It suggests that **agency is not a rare exception in a clockwork cosmos, but a fundamental pattern within it**—the pattern that arises when matter organizes itself into a flame that fuels its own shape, a whirlpool that maintains its own vortex, a living system that fights, moment by moment, to keep its story from ending.

To understand ourselves as agents, then, is not to find a ghost in the machine. It is to recognize the machine we are: a fantastically complex, self-modeling dissipative structure, born from and forever engaged in the ancient, thermodynamic work of keeping the world at bay, of being a cause and not merely an effect. In this light, the pursuit of knowledge, ethics, and meaning is not a flight from our physical nature, but its most exquisite expression.

*This paper is part of the larger systematic inquiry developed in *Neo-Pre-Platonic Naturalism (2025)*, which derives these definitions of agency and value from the fundamental logic of distinction.

[57]For the detailed derivation of this ethical framework, see *Neo-Pre-Platonic Naturalism* Deutscher, *Neo-Pre-Platonic Naturalism*, ch. 5.

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