The First Cut

How Boundary Logic Derives Physics

Eli Adam Deutscher

Abstract

We begin with a single primitive act: cutting from a background to make a distinction. This "first cut" establishes a bounded entity against an indeterminate ground (*Apeiron*). We show that persistence is not a state but a **cybernetic process**: identity is maintained through the integral of corrective work against decay over time. From the symbolic form $A(t) = \neg_t|\neg_{t_0} A|$, we immediately derive the integral form $A(t) = A_0 + \int(\Phi - N)d\tau$ —the historical ledger of all maintenance acts. This integral is the foundation: its optimization yields the differential balance law $dA/dt = \Phi - N$, recovers classical logic as its zero-maintenance limit, and necessitates the Second Law of Thermodynamics. Calculus emerges as the native mathematics of this maintenance process, and physics as its domain-specific expression. The framework unifies geometry, dynamics, and cybernetics into a single first philosophy. Finally, we apply this calculus to classical metaphysics, demonstrating that the maintenance integral resolves long-standing paradoxes of material identity—such as the Ship of Theseus—by defining existence not as static substance, but as a continuous history of entropic resistance.

Keywords: Boundary Logic, Metaphysics of Physics, Cybernetics, Entropic Asymmetry, Apeiron, Second Law of Thermodynamics, Neo-Pre-Platonic Naturalism, Logic, Law of Identity, Calculus, physics

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1 Introduction: Starting with the Cut, Not Substance

Metaphysics has traditionally begun with *substance*—with an account of *what is*. It asks: Is reality made of matter? Mind? God? Forms? Atoms? This approach assumes, from the outset, that there is already a "what" to talk about. It begins in the middle of the story.

We begin earlier.

Before there can be a "what," there must be a "this" as opposed to a "that." Before there can be an entity, there must be a way for one thing to be distinct from another. We therefore start not with a substance, but with an *operation*: the act of cutting a distinction. This is the **first cut**.[1] It is the minimal, primordial act that makes any metaphysics possible.

To cut away from the background is to create a boundary. The boundary separates an inside from an outside. With this single move, the most fundamental dyad is born: figure and ground, bounded and unbounded, determinate and indeterminate.

This starting point carries an immediate, inescapable consequence: for there to be an inside, there must be an outside. The boundary cannot bound nothing; it must bound *something* against *something else*. If the "outside" were itself another bounded entity, we would require yet another outside to separate them, leading to an infinite regress. The only coherent stopping point is an outside that is *not itself bounded*—an indeterminate background. This is the **General Zero Principle (GZP)**, and it forces us to acknowledge the *Apeiron* (Ἄπειρον)—the boundless, undifferentiated ground—as a necessary precondition for any determinate existence.[2]

To demystify this concept, consider a simple thought experiment: imagine a universe consisting of nothing but a single dog.

Almost inevitably, one visualizes the dog floating in a void or silhouetted against a black backdrop. This mental act smuggles in the indeterminate background. We instinctively provide the "space" or "blackness" because we cannot conceive of a boundary without a contrast. If we rigorously remove this background—if the "outside" is truly nothing—then the dog has no limit. It becomes co-extensive with reality. The universe is no longer a distinct dog; it is a totality of Dog-Everywhere.

The background, therefore, is neither a specific "thing" (which would require its own background, leading to infinite regress) nor absolute "nothing" (which would collapse the boundary). It is the context for identity. The necessity becomes undeniable if we picture a second dog. For two dogs

[1] George Spencer-Brown, *Laws of Form* (Allen & Unwin, 1969) pioneered a similar approach in *Laws of Form*, though our derivation differs fundamentally in treating distinction as temporal rather than timeless

[2] The term originates with Anaximander; see G. S. Kirk et al., *The Presocratic Philosophers*, 2nd ed. (Cambridge University Press, 1983), pp. 100-142; See Eli Adam Deutscher, *Anaximander and the Zero Principle: The Relational Ontology of the Apeiron*, 2026, https://neopreplatonic.com/papers/Anaximander/ for the full argument that he was not doing substance metaphysics but relational ontology

to exist as distinct entities, there must be an indeterminate "non-dog" interval between them. Without the Apeiron—the indeterminate ground—distinction itself is geometrically impossible.

Thus, our first move—the cut—does not presume the existence of objects. It establishes the *geometric condition* for any object to exist at all: to be is to be bounded, and to be bounded is to stand in contrast to an indeterminate ground. We have not yet said what things *are*; we have only described the shape that anything must take to be a "thing" in the first place.

This inversion—from substance to distinction, from "what" to "how"—is the foundation of everything that follows. From the logic of the boundary, we will derive the dynamics of persistence, the necessity of work, the inevitability of decay, and the mathematical structure of physical law.

We begin with the cut because the cut is where existence begins.

1.1 The Cybernetic Stance

If reality is composed of boundaries, and boundaries must be maintained, then existence is fundamentally a **cybernetic process**—a process of feedback-driven maintenance. A boundary that persists does so not by magic, but by *work*: the continuous expenditure of energy to keep the inside distinct from the outside.[3]

This perspective shifts metaphysics from a static catalog of "what is" to a dynamic study of **how things stay what they are**. It is a navigational, rather than a taxonomic, approach. The central question becomes: *How does a bounded entity maintain its boundedness across time?*

The answer will take us from symbolic logic to integral calculus to thermodynamics, revealing that:

1. Identity is historical—it is the sum of all past maintenance acts.
2. Maintenance requires a balance of opposing forces: cohesion (*Philia*) and dissolution (*Neikos*).
3. The laws of physics are the universal patterns of this maintenance balance.
4. The Second Law of Thermodynamics is not contingent but necessary—a theorem of boundary logic.

We call this framework **boundary metaphysics**, and it serves as the geometric-dynamical core of the larger *Neo-Pre-Platonic Naturalism (NPN)* system.[4]

[3]We employ "cybernetic" in the sense of Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (MIT Press, 1948) and W. Ross Ashby, *An Introduction to Cybernetics* (Chapman & Hall, 1956): systems that maintain goal-states through feedback correction

[4]See Eli Adam Deutscher, *Neo-Pre-Platonic Naturalism: A First-Principles Framework for Reality, Mind, and Knowledge*, Pre-Release First Edition (Neo-Pre-Platonic Press, 2025) for full context of First Principles, Theorems, and the Navigator Protocol.

2 From Static Boundary to Historical Maintenance

Having established the geometric necessity of the boundary, we must now confront its temporal reality. A cut in the abstract is timeless, but a cut enacted in the physical *Archē* is immediately subject to the flow of Becoming. To understand existence not merely as a logic but as a physics, we must transition from the static geometry of the cut to the dynamic labor of keeping it distinct. We begin by analyzing the fundamental problem that time poses to identity.

2.1 The Problem of Persistence

A circle drawn in sand at time t_0 may be washed away by the tide by time t. A living cell, once formed, must constantly repair its membrane and metabolism or it will dissolve. A star, ignited, must burn fuel to resist gravitational collapse.

Existence at one moment does not guarantee existence at the next. **Persistence is not given; it is achieved.**

Thus, the question shifts from *what is* to *how does it stay*. The boundary, once cut, must be *maintained*. This maintenance is not a one-time act but a continuous process—a defense of the original cut across time.

The central question of this inquiry is: *What does it mean to be the same thing over time?*

Classical metaphysics, relying on "Substance Ontology," struggles with this question. Consider the ancient paradox of the **Ship of Theseus**: if a ship has every wooden plank replaced one by one during a voyage, is it the same ship when it returns? If identity is made of matter, the answer is no—the ship is a fraud. Yet intuition insists the ship persists.[5]

We propose that the difficulty lies not in the ship, but in the assumption that identity requires material permanence. Under Boundary Logic, the ship persists as a distinct bounded object where the work to maintain that boundary (Φ)—the replacement of planks—outpaces the decay of the wood (N) and the dissolution of the structure back into the background. The material substrate is not the bound entity; the **distinction maintained through time** is. This applies to people just as it does to boats. No material in our body persists indefinitely, but we remain a continuous entity through the ongoing work of repairing our boundary against the decaying pressures of reality.

To be is not to be a static object, but to be a **continuous bound entity**. In the following sections, we formalize this intuition into a rigorous physical calculus.

[5] Plutarch, *Life of Theseus*, 23.1.

2.2 The Symbolic Maintenance Equation

We represent this process symbolically. Let A denote a bounded entity. At the initial moment t_0, the act of distinction—the first cut—is performed. We symbolize this act as $\neg_{t_0}$, so that:

$$|\neg_{t_0} A|$$

represents the **indeterminate background as excluded at** t_0 . It is the "outside" fixed by the first cut.

Now, at a later time t, to still *be* A, the entity must re-perform the act of exclusion. It must again exclude that same background. We write this as:

$$A(t) = \neg_t |\neg_{t_0} A|$$

Here, $\neg_t$ is the act of exclusion performed at time t. The equation says:

> *To be A at time t is to have continuously maintained the exclusion of the background from* t_0 *to* t.

This is not a logical identity. It is a **temporal re-enactment**. The two negations are separated in time. Because they are temporal acts, the double negation does **not** cancel in the timeless way of logic ($\neg\neg A \equiv A$). Instead, it represents a process: the ongoing labor of keeping the boundary sharp.

2.3 Work as the Currency of Maintenance

Maintenance is not free. It requires **work**. Inside any bounded entity, there are processes that tend to hold it together, to reinforce its boundary, to export disorder. We call this collective, boundary-sustaining work *Philia* (Φιλία), the force of cohesion and attraction.

Simultaneously, there are processes that tend to dissolve the boundary, to disperse its components, to increase internal disorder. We call this the dispersive tendency *Neikos* (Νεῖκος), the force of separation and decay.[6]

These are not moral categories. *Philia* is not "good" and *Neikos* is not "evil." They are the exhaustive polarities of cosmic dynamics, the two fundamental modes of relation within the *Archē* (Ἀρχή), the totality of determinate reality.[7] A boundary exists only in the tension between them.

[6] Empedocles' *Philia* and *Neikos*; M. R. Wright, *Empedocles: The Extant Fragments* (Yale University Press, 1981).
[7] See Deutscher, *Neo-Pre-Platonic Naturalism*, 44-46

2.4 The Integral Form: Identity as Accumulated History

Now we translate the symbolic equation into a mathematical form that captures the **historical accumulation of maintenance work**.

Suppose at each moment τ, the net work done to maintain the boundary is the difference between cohesive work and dispersive tendency: $\Phi(\tau) - N(\tau)$. Over a small time interval $d\tau$, this net work contributes a small change to the boundary's integrity.

Let $A(t)$ represent the **boundary integrity** of the entity at time t —its degree of distinction from the background. This corresponds to what thermodynamics calls **negentropy**: a measure of order, structure, or information.[8]

If the boundary starts with initial integrity $A(t_0)$ at time t_0, then at a later time t, its integrity is the initial value plus the accumulated net work over the interval:

$$A(t) = A(t_0) + \int_{t_0}^{t} \big[\Phi(\tau) - N(\tau)\big]\, d\tau$$

This is the **integral form** of the maintenance equation. It is the core mathematical object of our theory.

2.4.1 Interpretation of the Integral Form

1. **Identity is Historical:** You are not your current state. You are **the entire history of work done to maintain you**. The integral sums every moment of repair, every expenditure of energy, every resistance against decay, from the moment of your formation until now.
2. **The Ledger of Existence:** The integral is a ledger. The Φ terms are deposits—cohesive work that adds to integrity. The N terms are withdrawals—decay that subtracts from integrity. Your current balance $A(t)$ is the net result.
3. **Cybernetics Embodied:** This integral is what a cybernetic system optimizes. A living organism, for example, regulates its metabolism (Φ) to counteract entropic decay (N) so as to maximize (or at least sustain) the integral over time. The integral is the **cumulative payoff** of all past regulatory actions.
4. **From Symbolic to Integral:** The symbolic form $A(t) = \neg_t|\neg_{t_0} A|$ represents identity as a series of discrete re-enactments. The integral form emerges as the limit where the interval between these acts goes to zero ($\Delta t \to 0$). Thus, identity becomes the continuous sum

[8] Schrödinger introduced "negative entropy" to explain how an organism "sucks orderliness from its environment" to maintain its organization against the Second Law, Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell* (Cambridge University Press, 1944).

of all re-enactments, uniting the discrete logic of the cut with the smooth continuity of physical time.

2.5 The Necessity of Both Forces

Note that both Φ and N are always positive. If $\Phi = 0$, there is no cohesive work, and the integral runs negative—the boundary dissolves. If $N = 0$, there is no dispersive tendency, and the integral grows without bound—but such a world would have no resistance, no friction, no cost. In reality, both are present. Indeed, a stable boundary requires a dynamic balance: $\Phi \approx N$ over time, so that $A(t)$ remains relatively constant.

This balance is not static. It is an ongoing achievement—a continual optimization of the maintenance relationship. How that optimization occurs is the subject of the next section.

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3 The Cybernetic Loop: Optimizing the Integral

The maintenance integral provides the scorecard of existence, but it does not explain the strategy. How does a system ensure that the net work remains positive in a fluctuating environment? The answer lies in the operational logic of the system itself—a continuous process of sensing and correcting that transforms the mathematical requirement of integration into the biological reality of navigation. Here, we define the mechanism by which the integral is actually maximized.

3.1 The Goal of Maintenance

From the integral form:

$$A(t) = A(t_0) + \int_{t_0}^{t} \big[\Phi(\tau) - N(\tau)\big]\, d\tau$$

we see that the **boundary integrity** $A(t)$ at any moment is the accumulated result of past net maintenance work. For an entity to persist—or better yet, to flourish—it must **optimize this integral over time**.

The goal is not merely to keep $A(t)$ positive, but to maximize (or at least sustain) the cumulative net work $\int(\Phi - N)d\tau$ across the entity's lifespan. This is the fundamental objective of any bounded system that strives to persist—what NPN calls the *Hormē* (Ὁρμή), the constitutive drive to maintain one's being [9].

[9] See Deutscher, *Neo-Pre-Platonic Naturalism*, Chap. 5.

3.2 The Structure of the Loop

This optimization does not happen by chance. It occurs through a **cybernetic loop**—a feedback-driven process of sensing, comparing, acting, and integrating. The loop can be described in four stages:

3.2.1 1. Sense Current Integrity

The system must have some means of assessing its current boundary integrity $A(t)$. In a living cell, this might be chemical gradients or membrane potentials. In an organism, it might be homeostatic signals like hunger, pain, or fatigue. In a conscious agent (*Navigator*), it is the perception of self-integrity—the feeling of coherence, health, or purpose.[10]

3.2.2 2. Predict Future Trajectory

Given the current state and environment, the system projects the future value of the integral:

$$A(t + \Delta t) = A(t) + \int_{t}^{t+\Delta t} \big[\Phi(\tau) - N(\tau)\big]\, d\tau$$

This prediction is based on an **internal model** of how Φ and N will behave under current conditions. A bacterium moving up a glucose gradient is, in effect, predicting that future Φ (energy intake) will outweigh future N (energy expenditure).

3.2.3 3. Act to Optimize

If the predicted trajectory is suboptimal ($A(t + \Delta t)$ too low), the system acts to adjust Φ or N. It might:

- Increase Φ: seek resources, repair damage, build structure.
- Decrease N: avoid threats, reduce waste, conserve energy.
- Change strategy altogether: if the current model is failing, the system may need to abandon it and try a new approach.

This is where **agency** manifests: the capacity to redirect causal flows to favor the maintenance of self-boundaries.[11]

[10] See Eli Adam Deutscher, *The Scalar Stack: Free Will as the Capacity to Direct Causal Flow*, Neo-Pre-Platonic Press, 2026, https://www.neopreplatonic.com/papers/Free_Will/ for the full argument that free will is a scalar stack that separates life from objects.

[11] See Eli Adam Deutscher, *Life as Directed Causality: A Thermodynamic Isomorphism Between Being and Acting*, 2026, https://www.neopreplatonic.com/papers/Life_Agency_T6/ for the life-agency isomorphism and the derivation of agency as the ability of life to direct the causal flow of the *Archē*.

3.2.4 4. Integrate and Repeat

The action changes $\Phi(t)$ or $N(t)$, which updates the integral. The system then senses the new $A(t)$, predicts again, acts again, in a continuous loop.

3.3 From Discrete to Continuous

In real systems, this loop is not a series of discrete steps but a continuous, embedded process. The "prediction" is often implicit in evolved reflexes or learned habits. The "action" is often a physiological or behavioral adjustment happening in real time.

The cybernetic loop is, in essence, the **operational definition of the Popper Protocol** within NPN.[12] It is the mechanism by which a finite Navigator—or any bounded system—refines its models and actions to better align with the Logos—the objective, intelligible structure of the Archē.

3.4 Optimization as Survival

Note that "optimization" here is not necessarily conscious or perfect. It is **functional**: whatever behavior tends to increase $\int(\Phi - N)d\tau$ over time will be selected for, whether by natural selection, learning, or reasoning.

Thus, the cybernetic loop explains:

- **Evolution:** Organisms with better internal loops (better sensors, predictors, actuators) out-compete others.
- **Learning:** Animals update predictive models to avoid pain (high N) and seek reward (high Φ).
- **Reasoning:** Humans consciously simulate scenarios to choose actions that maximize long-term integrity.[13]

3.5 The Loop Embodied in the Integral

The integral form *already contains* the history of all past loop iterations. Each moment τ in the integral corresponds to a cycle of the loop: sense $A(\tau)$, predict, act to adjust $\Phi(\tau)$ or $N(\tau)$, integrate.

Thus, the integral is not just a mathematical expression—it is the **physical record of the cybernetic process**. It is the "memory" of what worked and what didn't.

[12] See Deutscher, *Neo-Pre-Platonic Naturalism*, 242.

[13] See **Deutscher2026_First_Lesson?** for the full learning stack.

3.6 From Loop to Law

When the cybernetic loop operates continuously and successfully, it drives the system toward a **dynamic equilibrium** where $\Phi(t) \approx N(t)$ most of the time, with occasional adjustments. In the limit of perfect, instantaneous adjustment, the system would always maintain:

$$\Phi(t) = N(t)$$

so that:

$$\frac{dA}{dt} = 0$$

and $A(t)$ stays constant.

But perfect adjustment is impossible in a changing world with finite information. There is always lag, error, and noise. Therefore, the system is always *chasing* equilibrium, never quite reaching it. This chasing is the differential form of the maintenance law—the subject of the next section.

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4 The Differential Law: The Instantaneous Shadow of the Integral

While the integral captures the total history of an entity, the physical universe operates in the immediate present. The forces of *Philia* and *Neikos* do not act on the past; they act on the current state. To understand the mechanics of interaction, we must therefore derive the instantaneous expression of the maintenance equation—the rate of change that defines the boundary's survival at any given moment . This differential form bridges the gap between our metaphysical history and standard physical dynamics.

4.1 From Cumulative History to Momentary Rate

The integral form:

$$A(t) = A(t_0) + \int_{t_0}^{t} \left[\Phi(\tau) - N(\tau)\right] d\tau$$

contains the entire history of maintenance. But to act in the present, a system must know not just where it has been, but **where it is going right now**. It needs the *rate of change* of its boundary integrity.

This is given by the **fundamental theorem of calculus**. Taking the derivative with respect to time on both sides yields:

$$\frac{dA}{dt} = \Phi(t) - N(t)$$

This is the **differential form** of the maintenance equation.[14] It is the instantaneous, momentary expression of the global, historical integral.

4.2 Interpretation of the Differential Form

1. **The Current Balance:** At each instant t, dA/dt tells you whether you are currently winning ($\Phi > N$) or losing ($\Phi < N$) the maintenance battle. It is the **live feed** of the cybernetic loop.
2. **The Gradient of Survival:** For a living system, $dA/dt > 0$ means growth, repair, flourishing. $dA/dt < 0$ means decay, injury, decline. $dA/dt = 0$ means stasis—a precarious balance.
3. **The Engine of the Cybernetic Loop:** The cybernetic loop described earlier uses dA/dt (or its proxy signals) as the **error signal**. A negative dA/dt triggers corrective action: increase Φ, decrease N, or both.

4.3 The Differential as the "Shadow" of the Integral

The relationship between the integral and differential forms is exact:

$$A(t) = \text{History} \quad \longleftrightarrow \quad \frac{dA}{dt} = \text{Current Rate}$$

The differential is the **shadow** cast by the integral at each moment. It does not contain the past, but it determines the future—because the future integral will be built from the present rate.

This is why physics—the science of change—is written in differential equations. They capture the *instantaneous laws* that govern how histories accumulate.

4.4 Universality of the Form $dA/dt = \Phi - N$

This differential equation is not limited to any particular scale or domain. It appears throughout physics and biology in various guises:

- **Thermodynamics:** $dS/dt = \dot{Q}/T + \dot{S}_{\text{gen}}$ (entropy balance)
- **Population Dynamics:** $dP/dt = \text{births} - \text{deaths}$

[14] Cf. dissipative structures; Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos* (Bantam Books, 1984).

- **Economics:** $dK/dt =$ investment $-$ depreciation
- **Ecology:** $dE/dt =$ energy inflow $-$ energy outflow
- **Chemical Engineering:** $dM/dt = (\dot{M}_{\text{in}} + \dot{R}_{\text{gen}}) - (\dot{M}_{\text{out}} + \dot{R}_{\text{cons}})$ (general mass balance)

In each case, there is a conserved or quasi-conserved quantity (A) whose rate of change equals inflow (Φ) minus outflow (N). This universal form emerges because **all persistent systems are engaged in boundary maintenance**, and maintenance is a balancing act. These fields did not arbitrarily choose this differential form; they discovered the only mathematical structure capable of describing persistence.

4.5 The Necessity of Polarity, Revisited

The differential form makes clear why both Φ and N must be positive and non-zero for a bounded world to exist.

If $N = 0$ everywhere, then $dA/dt = \Phi \geq 0$. All boundaries would grow without limit, eventually merging into a single, undifferentiated mass—Parmenides' frozen "One." There would be no distinct entities, only boundless cohesion.

If $\Phi = 0$ everywhere, then $dA/dt = -N \leq 0$. All boundaries would decay instantly, leaving only dispersion—a cosmic dust with no structure.

Thus, **a world of distinct, persistent things requires both cohesive and dispersive tendencies in tension.** This is NPN's FP3: Cosmic Dynamics: The *Logos* and its Exhaustive Polarity and Theorem T5 (The Entropic Mandate) expressed dynamically.[15]

4.6 The Zero-Maintenance Limit Revisited

What happens in the hypothetical limit where maintenance is costless and decay absent? If $\Phi = 0$ and $N = 0$, then:

$$\frac{dA}{dt} = 0 \quad \Rightarrow \quad A(t) = \text{constant}$$

The differential equation collapses. There is no change, no process, no time. The integral form becomes:

$$A(t) = A(t_0) + \int_{t_0}^{t} 0 \, d\tau = A(t_0)$$

History is empty. Identity is not earned; it is simply given, timelessly.

And the symbolic form collapses as well:

[15] See Deutscher, *Neo-Pre-Platonic Naturalism*, 42-46 and 59

$$A(t) = \neg_t|\neg_{t_0} A| \quad \xrightarrow{\text{timeless}} \quad A = \neg\neg A \equiv A$$

We recover **classical logic's law of identity**: $A = A$. But this is not the law of reality—it is the law of a fantasy world without work, without time, without becoming.

Thus, the differential form $dA/dt = \Phi - N$ is the bridge between the timeless world of logic and the temporal world of physics. When Φ and N are both zero, we are in logic. When they are positive, we are in physics.

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5 The Zero-Maintenance Limit: Recovering Classical Logic

We have argued that persistence requires work. But what happens if we conceptually turn that work requirement off? By setting the maintenance terms to zero, we do not destroy the system; rather, we reveal the idealized skeleton hidden within it. This limit case allows us to recover the familiar laws of classical logic and arithmetic, not as fundamental truths, but as the physics of a vacuum—a world where *Being* costs nothing.

5.1 The Fantasy of Cost-Free Being

Imagine a world where boundaries, once cut, persist forever without effort. A circle etched in space remains sharp for eternity. A living cell never needs nutrients. A star burns without fuel. In such a world, **maintenance is free** and **decay is absent**.

Mathematically, this means:

$$\Phi = 0 \quad \text{and} \quad N = 0$$

for all time. Substituting into the differential law:

$$\frac{dA}{dt} = 0 \quad \Rightarrow \quad A(t) = \text{constant}$$

Boundary integrity never changes. What is, always is.

5.2 Collapse of the Integral Form

In this world, the integral form of the maintenance equation becomes:

$$A(t) = A(t_0) + \int_{t_0}^{t} 0 \, d\tau = A(t_0)$$

The integral is empty—there is no history of work, because no work is ever done. The "ledger of existence" shows only the opening balance, unchanged forever. Identity is not earned through accumulated effort; it is **given timelessly**.

5.3 Collapse of the Symbolic Form

Now consider the symbolic maintenance equation:

$$A(t) = \neg_t|\neg_{t_0} A|$$

In a world without time or work, the temporal indices lose meaning. The act of exclusion at t is identical to the act at t_0 because there is no decay to resist, no need for re-enactment. The two negations collapse into one:

$$\neg_t = \neg_{t_0}$$

Thus:

$$A = \neg|\neg A| \quad \Rightarrow \quad A = \neg\neg A$$

And in classical logic, double negation yields affirmation:

$$\neg\neg A \equiv A$$

Therefore:

$$A = A$$

The law of identity emerges.

5.4 Theorem: Classical Logic as the Zero-Maintenance Limit

We can now state formally:

> **Theorem (Logic as Limit):** Classical logic, including the law of identity $A = A$ and the law of non-contradiction, is the **zero-maintenance, timeless limit** of boundary dynamics. It describes a world where boundaries persist without work and distinctions never blur.

This theorem has profound implications:

1. **Logic is Not Fundamental:** It is a **special case** of a more general dynamics—the case where $\Phi = N = 0$. Logic is the mathematics of a frozen, cost-free world.

2. **Parmenides' "One" Explained:** Parmenides argued that reality must be one, unchanging, timeless. He was correct—**if** you assume the zero-maintenance limit. His "Way of Truth" is the logical conclusion of denying the reality of work, time, and the *Apeiron*.[16]

3. **The Role of Contradiction:** In classical logic, contradiction ($A \wedge \neg A$) is forbidden because it violates the law of identity. But in boundary dynamics, "contradiction" corresponds to a state where maintenance fails—where $\Phi < N$ and the boundary dissolves. Contradiction is not logical impossibility; it is **physical decay**.

5.5 Why This Matters

Recognizing classical logic as a limit case clarifies its domain of validity. Logic applies perfectly to **timeless, stipulated domains**—mathematics, formal systems, definitions. But it applies only approximately to the temporal, costly world of physics and life.

This is why NPN's **Theorem T2: The Status of Formal Truths** holds:

> Analytic truths (logic, mathematics) are certain within their defined contrast-domains because their boundaries are stipulated. Synthetic knowledge—modeling the *Archē*—is gradient-bound because its boundary is the *Apeiron*.[17]

When we do mathematics, we temporarily enter the zero-maintenance limit: we stipulate axioms (fixed boundaries) and derive consequences (eternal truths). But when we step back into the physical world, we must pay the maintenance cost—and our truths become gradient, provisional, historical.

5.6 The Bridge to Physics

The zero-maintenance limit is a **singularity** in the space of possible worlds. As Φ and N approach zero, the differential equation $dA/dt = \Phi - N$ approaches $dA/dt = 0$, and time becomes irrelevant. But if Φ and N are exactly zero, there is no dynamics, no change, no physics.

Thus, **physics begins where logic ends**—where maintenance is costly and decay is real. The smallest positive value of Φ or N breaks the timeless symmetry and launches the universe into history.

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[16] See Eli Adam Deutscher, *Parmenides the Polemicist: The Eleatic Crisis and the Indeterminate Ground of Thought*, 2026, https://www.neopreplatonic.com/papers/Parmenides/ for the complete argument that Parmenides was not a dogmatic monist, but a polemicist doing reductio ad absurdum

[17] Deutscher, *Neo-Pre-Platonic Naturalism*, 235

This is why we do not live in a logical world. We live in a world where to be is to strive, where identity is earned, and where the law of identity is an idealization—a beacon from a frozen shore we can approach but never inhabit.

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6 The Second Law as a Theorem of Boundary Logic

The maintenance equation $dA/dt = \Phi - N$ is not merely a description of local entities; it implies a universal constraint on the direction of time. By analyzing the specific case where a system is cut off from external sources of work, we can move from the definition of identity to the inevitability of decay. In doing so, we derive one of the most fundamental laws of physics directly from the logic of the boundary, proving that entropy is a geometric necessity of boundary maintenance.

6.1 The Isolated System: No External Maintenance

An **isolated system** is defined as one that exchanges no energy or matter with its surroundings. In the language of boundary maintenance, this means there is **no external source of work** to sustain boundaries. The system may have internal cohesive forces, but no net influx of maintenance work from outside.

Thus, for an isolated system:

$$\Phi = 0$$

The cohesive work rate is zero. The system must rely solely on whatever internal cohesion it started with.

6.2 Substitution into the Differential Law

With $\Phi = 0$, the differential maintenance equation becomes:

$$\frac{dA}{dt} = -N$$

Since $N > 0$ (there is always some dispersive tendency, however small), this implies:

$$\frac{dA}{dt} < 0$$

The boundary integrity A —the measure of distinction, order, or negentropy—**monotonically decreases**. The system's boundaries blur, its organization decays, its distinctness dissolves toward the background.

6.3 Entropy Increase

In thermodynamics, entropy S is defined as the negative of negentropy ($S = -A$). Then:

$$\frac{dS}{dt} = -\frac{dA}{dt} = N > 0$$

Thus, **the entropy of an isolated system never decreases—it always increases.** This is the **Second Law of Thermodynamics**.[18]

6.4 The Integral Perspective: A History of Loss

From the integral form, for an isolated system:

$$A(t) = A(t_0) - \int_{t_0}^{t} N(\tau)\, d\tau$$

The integral is strictly negative and growing in magnitude. The "ledger of existence" for an isolated system shows only **withdrawals**—no deposits. Its history is a history of net decay.

6.5 Why This Is a Theorem, Not Merely an Observation

Conventionally, the Second Law is an empirical generalization discovered through the study of heat engines. Boltzmann later provided a statistical interpretation: disordered states are more probable than ordered ones.

In our framework, the Second Law is **derived deductively** from the logic of boundaries:

1. **Premise 1 (GZP):** For a bounded entity to exist, it must be contrasted with an indeterminate background (*Apeiron*).
2. **Premise 2 (Maintenance Requirement):** Persistence requires maintenance work ($\Phi > 0$) to counteract dispersive tendency ($N > 0$).
3. **Premise 3 (Definition of Isolation):** An isolated system has no external source of work ($\Phi = 0$).
4. **Conclusion:** In an isolated system, boundary integrity necessarily decays ($dA/dt < 0$), i.e., entropy increases.

[18] Typically treated as empirical postulate; Enrico Fermi, *Thermodynamics* (Prentice-Hall, 1936); Herbert B. Callen, *Thermodynamics and an Introduction to Thermostatistics*, 2nd ed. (Wiley, 1985).

Thus, the Second Law is not contingent on our universe's initial conditions or particle statistics. It is a **necessary truth** in any world containing distinct, temporal entities. If you have boundaries and time, you must have the Second Law.

6.6 The Arrow of Time

The Second Law gives a direction to time: the "future" is the direction of increasing entropy, of boundary dissolution. Why do we remember the past and not the future? Because memories are **boundary structures** (neural engrams) that were formed by work and are maintained by ongoing metabolism. A memory of the future would require a boundary structure anticipating a state of higher integrity—a violation of the maintenance equation in an isolated system.

In open systems (where $\Phi > 0$), the arrow of time is still present, but it is partially resisted. Living systems, for example, locally decrease entropy (increase A) by exporting disorder to their surroundings. But they do so at the cost of increasing global entropy. The integral form shows that the total entropy production $\int N d\tau$ is always positive.

6.7 Cosmological Implications: The Heat Death as Asymptotic Return

The cosmic "heat death"—a state of maximal entropy—is the ultimate victory of N over Φ on a universal scale. It is the state where all boundaries have dissolved, all gradients have flattened, and the universe approaches a uniform, undifferentiated equilibrium.

In terms of boundary logic, this is the **asymptotic return to the *Apeiron***. But note: the *Apeiron* is not a state of maximum entropy; it is the indeterminate ground that makes entropy (a measure of disorder in bounded systems) undefined. The heat death is the closest a bounded universe can get to the *Apeiron* without ceasing to be a universe.

6.8 Empirical Consistency

While derived as a theorem, our formulation aligns with known physics:

1. **No perpetual motion:** Isolated systems cannot maintain A without Φ.
2. **Aging and decay:** All isolated structures eventually degrade.
3. **Criticality:** Persistent complex systems balance $\Phi \approx N$.
4. **Cosmology:** The universe's evolution from low to high entropy.

But now these facts are grounded not in statistics or empiricism alone, but in the **geometry of distinction itself**.

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7 Why Physics Uses Calculus: The Mathematics of Maintenance

We have defined identity not as a static object, but as a dynamic history of maintenance. This shift from substance to process requires a corresponding shift in our mathematical tools. Static geometry can describe a shape, but it cannot describe the *effort* to sustain that shape against a dissolution. To model the continuous struggle of the boundary against the *Apeiron*, we must turn to the mathematics of change itself.

7.1 The Language of Rates and Accumulation

If reality is composed of boundaries that must be maintained over time, then the natural mathematical language to describe it is one that deals with **rates of change** and **accumulated quantities**. This is precisely the domain of calculus.

- The **derivative** $\frac{d}{dt}$ answers: *How successfully is this boundary being maintained right now?*
- The **integral** $\int dt$ answers: *How much total work has been expended to maintain this boundary?*

Our maintenance equation is inherently calculus:

$$\frac{dA}{dt} = \Phi - N \quad \text{(differential form)}$$

$$A(t) = A(t_0) + \int_{t_0}^{t} (\Phi - N) d\tau \quad \text{(integral form)}$$

Thus, calculus is not an arbitrary tool physicists adopted—it is the **necessary mathematics of boundary maintenance**.

7.2 The Fundamental Theorem of Calculus as the Bridge

The fundamental theorem of calculus states:

$$\frac{d}{dt} \int_{t_0}^{t} f(\tau) d\tau = f(t)$$

In our terms:

$$\frac{dA}{dt} = \frac{d}{dt} \left[A(t_0) + \int_{t_0}^{t} (\Phi - N) d\tau \right] = \Phi(t) - N(t)$$

This theorem is the **mathematical expression of the relationship between history and the present**. The integral is the accumulated history of maintenance; the derivative is the current rate of maintenance. They are two sides of the same coin.

7.3 Physics as Differential Equations

The fundamental laws of physics are universally expressed as **differential equations**:

- **Newton's Second Law:** $F = m\frac{d^2x}{dt^2}$
- **Maxwell's Equations:** $\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$, $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$
- **Schrödinger's Equation:** $i\hbar\frac{\partial \psi}{\partial t} = \hat{H}\psi$
- Einstein's Field Equations: $G_{\mu\nu} = \kappa T_{\mu\nu}$ (or more precisely, the ADM evolution equations). Here, the presence of matter (Φ) works to curve spacetime, maintaining gravitational structure against the inertial tendency of geometry to remain flat or expand (N).

Each of these is a specific instance of the general form $dA/dt = \Phi - N$, where:

- A is some measure of boundary integrity (position, field strength, probability amplitude, spacetime curvature)
- Φ represents cohesive/inflow terms (force, source terms, binding potentials)
- N represents dispersive/outflow terms (friction, dissipation, kinetic/dispersive terms)

7.4 The Asymptote as the Mathematical Signature of the *Apeiron*

In calculus, an **asymptote** represents a value that a function approaches but never reaches. Consider:

$$\lim_{x \to 0} \frac{1}{x} = \infty$$

The line $x = 0$ is an asymptote. The function can get arbitrarily close to it, but to actually *be* at $x = 0$ would require an infinite value—a mathematical impossibility within the function's domain.

This is precisely the relationship between a bounded entity and the *Apeiron*. The *Apeiron* is the **indeterminate background** that a bounded description can approach but never contain. Asymptotes in physics—singularities in general relativity, divergences in quantum field theory, absolute zero in thermodynamics—mark the **edges of our models**, the points where the mathematics signals: *Beyond this, my terms no longer apply.*

Thus, **asymptotes are the mathematical fingerprints of the *Apeiron***. They remind us that every model is bounded, and that the ground of all boundedness is itself unbounded.

7.5 Why Calculus Works: Honest Mathematics

Algebra and classical logic often treat infinities and zeros as if they were ordinary numbers. They allow division by zero, actual infinitesimals, and completed infinite sets. But calculus is more careful—more **honest**.

When we write:

$$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

we never actually set $h = 0$. We consider what happens as h **approaches** zero. The derivative is defined via a **limit**—an asymptotic approach to the indefinite.

This is exactly how we must approach the *Apeiron*: asymptotically, never claiming to reach it, but learning what we can from the approach.

7.6 The Optimization Connection

Recall that systems optimize the integral $\int (\Phi - N) d\tau$. Calculus provides the tools for this optimization:

- **Derivatives** give the gradient—which direction increases A fastest.
- **Integrals** give the total payoff—whether the strategy is working overall.
- **Differential equations** describe how the optimal path evolves in time.

This is why the **calculus of variations** and **optimal control theory** are so central to physics: they formalize the cybernetic optimization of boundary maintenance.

7.7 Unification of Physical Laws

Our framework suggests that the various laws of physics are not independent principles but **different manifestations of the same boundary maintenance logic** at different scales:

- **Newtonian Mechanics:** Maintenance of **momentum (inertia)** against resistive forces (friction/drag).
- **Thermodynamics:** Maintenance of **negentropy (order)** against entropic dissipation.
- **Electromagnetism:** Maintenance of **field energy density** against radiative divergence.
- **Quantum Mechanics:** Maintenance of **wavefunction localization** against probability dispersion.
- **General Relativity:** Maintenance of **gravitational curvature** against inertial flatness or expansion.

In each case, the differential equation $dA/dt = \Phi - N$ appears, with A, Φ, and N taking domain-specific forms.

7.8 Conclusion: Calculus as the Native Mathematics of Reality

Physics uses calculus not because physicists like difficult mathematics, but because **reality itself operates according to the logic that calculus formalizes**:

1. Reality is composed of bounded entities.
2. These boundaries require maintenance over time.
3. Maintenance involves balancing inflows and outflows.
4. This balance is described by rates (derivatives) and totals (integrals).

Thus, calculus is the **inevitable mathematics** of any coherent description of a world of distinct, temporal entities. Newton and Leibniz didn't invent a useful tool—they discovered the **mathematical structure of persistence itself**.

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8 The Cost of Being: Thermodynamics and the Entropic Asymmetry

We have established that the boundary is a dynamic achievement. We must now quantify the price of that achievement. Because the background (the *Apeiron*) is indeterminate and the boundary requires determination, there is a fundamental asymmetry in the universe: disorder is free, but order must be purchased. This section formalizes the thermodynamic consequences of the General Zero Principle and connects the abstract logic of the cut to the measurable energy budgets of living systems.

8.1 Energy as the Currency of Maintenance

From the integral form:

$$A(t) = A(t_0) + \int_{t_0}^{t} \left[\Phi(\tau) - N(\tau)\right] d\tau$$

we see that the term $\int \Phi d\tau$ represents the **total cohesive work** done to maintain the boundary. This work is not metaphorical—it is measurable in joules. **Being is literally expensive.**

Consider:

- A **soap bubble** maintains its spherical boundary through surface tension, which requires an initial input of energy (breath) and continuously fights against evaporation and diffusion.
- A **living cell** maintains its membrane and internal organization through ATP hydrolysis—a constant expenditure of chemical energy.
- A **star** maintains hydrostatic equilibrium between gravitational collapse and fusion pressure by burning nuclear fuel.

In each case, boundary integrity A is sustained only while energy flows in to support Φ.

8.2 The Entropic Asymmetry Theorem

We can now formally state NPN's **Theorem T7: The Entropic Asymmetry**:

> The maintenance of any bounded pattern within the indeterminate *Apeiron* requires the continuous expenditure of energy (*Hormē*) against a standing gradient of dissolution. Order is statistically unlikely and energetically expensive.

Proof:

1. By GZP, any bounded entity exists against the *Apeiron*.
2. By the maintenance equation, persistence requires $\Phi > N$ or at least $\Phi \approx N$.
3. Φ represents work—energy expended per unit time.
4. In statistical terms, bounded (ordered) states are low-probability configurations relative to the space of possible states.
5. Therefore, maintaining such a state requires continuous energy expenditure to resist the natural drift toward higher-probability (disordered) states. QED.

This theorem bridges boundary logic with statistical mechanics: the "standing gradient of dissolution" is the statistical tendency toward disorder; the "expenditure of energy" is the thermodynamic work needed to resist it.[19]

8.3 The Arrow of Time Revisited

The Entropic Asymmetry Theorem gives a clear, physical origin to time's arrow:

- **Past:** States of higher boundary integrity (lower entropy), established by work.
- **Future:** States toward which systems evolve in the absence of work—higher entropy, lower integrity.
- **Present:** The moment where Φ and N are balanced (or not) by current effort.

We remember the past and not the future because **memory is a boundary structure** maintained by metabolic work. A "memory of the future" would require a boundary anticipating a state of higher integrity—a violation of $dA/dt = \Phi - N$ in an isolated system.

8.4 Empirical Predictions and Validations

Boundary logic makes several testable claims, all of which align with established science:

[19] Deutscher, *Neo-Pre-Platonic Naturalism*, 200

8.4.1 1. No Perpetual Motion

Any system that maintains $A(t) \geq$ constant must have $\Phi > 0$. Isolated systems ($\Phi = 0$) inevitably decay. This is the First and Second Laws of Thermodynamics unified.[20]

8.4.2 2. Scaling Laws

The rate of energy expenditure Φ should scale with system size and complexity A. This matches **Kleiber's Law** in biology, where metabolic rate scales with mass to the 3/4 power, and similar scaling in ecosystems, cities, and economies.[21]

8.4.3 3. Senescence and Aging

All maintained systems accumulate damage—the integral $\int N d\tau$ grows over time, even if Φ is sustained. Eventually, N outpaces Φ, leading to senescence. This is observed in organisms, machines, institutions, and stars.[22]

8.4.4 4. Criticality

Persistent complex systems operate near **critical points** where $\Phi \approx N$ —poised between order and chaos. This is found in neural networks, genetic regulatory networks, forest fires, and financial markets.[23]

8.5 The Thermodynamic Interpretation

Let $S = -A$ be entropy. Then:

$$\frac{dS}{dt} = N - \Phi$$

For an isolated system ($\Phi = 0$):

$$\frac{dS}{dt} = N > 0$$

[20]This corresponds to the impossibility of a perpetual motion machine of the second kind; see Fermi, *Thermodynamics*, pp. 46-48.

[21]Max Kleiber originally established this scaling for metabolic rates; see Max Kleiber, "Body Size and Metabolism," *Hilgardia* 6, no. 11 (1932): 315–53. It has since been generalized to fractal networks in biology and urban dynamics by West et al.

[22]Thermodynamically, repair mechanisms themselves generate entropy, preventing indefinite maintenance; this aligns with the Disposable Soma Theory, see Thomas B. L. Kirkwood, "Evolution of Ageing," *Nature* 270 (1977): 301–4.

[23]This phenomenon is known as Self-Organized Criticality (SOC); see Per Bak et al., "Self-Organized Criticality: An Explanation of 1/f Noise," *Physical Review Letters* 59, no. 4 (1987): 381. It represents the optimal trade-off between stability (cohesion) and adaptability (dispersion).

For an open system:

$$\frac{dS}{dt} = N - \Phi$$

If $\Phi > N$, entropy locally decreases (order increases)—but only by exporting entropy elsewhere. The global balance always satisfies:

$$\frac{dS_{\text{total}}}{dt} \geq 0$$

This is the Clausius formulation of the Second Law, derived from boundary logic.[24]

8.6 The Cost of Knowing

If being is costly, so is **knowing**. A scientific model is a cognitive boundary—a cut in idea-space. Maintaining an accurate model requires continuous epistemic work: testing, updating, correcting.[25] Dogma is a model whose maintenance cost has been ignored ($\Phi \to 0$); it inevitably decays into falsehood.[26]

Thus, the **scientific method** is not just a good idea—it is the necessary maintenance protocol for cognitive boundaries in a dynamic reality. It is how we pay the epistemic cost of being right.[27]

8.7 The Navigational Imperative

For a conscious agent (*Navigator*), the Entropic Asymmetry Theorem implies:

> Your existence is a continuous achievement. To persist is to optimize $\int(\Phi - N)d\tau$.
> To flourish is to increase it.

This is not a moral exhortation but a **structural fact**. The *Hormē*—the constitutive drive to persist—is the physical instantiation of this imperative. Ethics (what you *ought* to do) collapses into dynamics (what you *must* do to persist).

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[24]Clausius famously concluded his Mechanical Theory of Heat with the maxim: "The entropy of the universe tends to a maximum." See Rudolf Clausius, *The Mechanical Theory of Heat* (John Van Voorst, 1867).

[25]This is grounded in the physics of information; Landauer's Principle demonstrates that logical operations, particularly the erasure/updating of information, carry an unavoidable thermodynamic cost. See Rolf Landauer, "Irreversibility and Heat Generation in the Computing Process," *IBM Journal of Research and Development* 5, no. 3 (1961): 183–91.

[26]This aligns with Popper's Critical Rationalism: knowledge is not a static possession but a dynamic process of conjecture and refutation. Ceasing the work of refutation turns theory into dogma. See Karl Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge* (Routledge, 1963).

[27]C.S. Peirce identified the "Method of Science" as the unique mode of fixing belief that forces internal models to accord with external constraints (the *Logos*), distinguishing it from methods of tenacity or authority. See Charles Sanders Peirce, "The Fixation of Belief," *Popular Science Monthly* 12 (1877): 1–15.

This is NPN's **Theorem T4: Ethical Isomorphism**:

> Epistemic error (falsehood) and ethical vice (immorality) are functionally isomorphic; both are states of misalignment between the Navigator's internal models and the external *Logos*.

In boundary terms: both increase N relative to Φ.

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9 Independent Convergences: Historical Recognition

Our derivation so far has been constructive: we built the laws of physics from the bottom up using boundary logic. Now, we turn to the historical record for validation. If this logic is indeed the "native mathematics of reality," we should expect that acute thinkers in the past—lacking our calculus but possessing deep intuition—would have identified the same structural constraints. We find that the geometry of the Apeiron and the necessity of the maintenance balance have been independently discovered across diverse eras and cultures, serving as a triangulation that confirms the universality of these principles.

9.1 The Architecture of Insight

The framework we have developed—boundary logic, maintenance dynamics, the integral form—may appear novel in its mathematical rigor and systematic derivation. Yet its geometric core has been glimpsed, in partial or intuitive forms, across millennia and cultures. These are not sources we depend upon, but **independent convergences**: separate recognitions of the same structural truths about reality. They serve as triangulation points, confirming that the architecture we describe is not arbitrary, but reflects deep, invariant constraints on how distinction, persistence, and change can be conceived.

9.2 Anaximander and the *Apeiron* (c. 610–546 BCE)

The Milesian philosopher Anaximander proposed that the origin and ground of all things was the *Apeiron* (Ἄπειρον)—the "Boundless" or "Indefinite." He argued it could not be water, air, or any determinate element (*stoicheion*), because one element could not justly give rise to its opposite. The *Apeiron* was the inexhaustible, undifferentiated source from which the world of opposites (hot/cold, wet/dry) emerged through a process of "separating off" (*apokrisis*).

Modern scholarship often misreads the *Apeiron* as a material *Urstoff*.[28] However, a relational reading—supported by the term's etymology (*a-peiron* = "without bound") and his use of *adikia*

[28]The standard interpretation, preserved in Aristotle and later doxography, treats the *Apeiron* as a "mixture" or "indefinite body." See Kirk, Raven, and Schofield, *The Presocratic Philosophers*, 110–112.

(injustice, lack of proper measure)—suggests Anaximander was describing a **logic of distinction**: the determinate can only arise against an indeterminate background.

His cosmic justice (*Dikē*) required bounded things to "pay penalty" (*tisis*) for their individual existence—an early intuition of the **cost of being**. His four-step cycle (*Apeiron* $\longrightarrow$ *Adikia* $\longrightarrow$ *Chronos* $\longrightarrow$ *Dikē*) describes the temporary nature of bounded existence: things emerge from the boundless, exist for a time through sustained tension, and eventually dissolve back.[29]

Convergence with our framework:

- The *Apeiron* as indeterminate ground (GZP).
- "Separating off" as the first cut.
- *Dikē* as the maintenance balance ($\Phi \approx N$).
- "Penalty" as the entropic cost.

9.3 Daoism and the Dynamics of *Wu* and *You* (c. 400 BCE)

The *Daodejing* opens with a famous paradox: "The Dao that can be spoken is not the eternal Dao." This is not mysticism—it is a precise statement about the **limits of distinction**. The unnameable, eternal Dao corresponds to the indeterminate ground. The named, manifest world (*You*, "being") emerges from it.[30]

Chapter 11 gives the classic example:

> "We mold clay into a vessel; but it is the emptiness within that makes the vessel useful... Therefore, what is present serves for possession; what is absent serves for function."[31]

Here, the vessel's utility depends not on the clay (the bounded entity) but on the empty space it encloses (the bounded *absence*). The vessel is a boundary that creates a functional interior by excluding an exterior. This is a practical illustration of the **interstitial necessity**: the vessel's identity depends on the empty space that is *not* clay.[32]

Furthermore, Daoist cosmology revolves around the dynamic interplay of *Yin* and *Yang*—complementary forces of cohesion and dispersion, integration and differentiation. This is a direct correlate of the *Philia*/*Neikos* polarity. The Daoist ideal is not the victory of one force over the

[29] The famous fragment reads: "From which things have their origin, into that they must also pass away according to necessity; for they must pay penalty and be judged for their injustice, according to the ordinance of time." (DK 12 B1). See Hermann Diels and Walther Kranz, *The Fragments of the Presocratics (Die Fragmente Der Vorsokratiker)* (Weidmann, 1952).

[30] See *Daodejing*, Chapter 1. The distinction between the "Nameless" (origin of heaven and earth) and the "Named" (mother of ten thousand things) parallels the distinction between the *Apeiron* and the world of bounded entities. See D. C. (Translator) Lau, *Tao Te Ching* (Penguin Classics, 1963).

[31] *Daodejing*, Chapter 11. Lau, *Tao Te Ching*.

[32] See Appendix A for the geometric proof that distinction requires an interstitial separation—manifesting locally as void, or globally as *Apeiron*.

other, but their harmonious, oscillating balance—precisely the condition $\Phi \approx N$ required for stable boundaries.

Convergence:

- *Wu* (non-being) as indeterminate ground.
- *You* (being) as bounded existence.
- *Yin-Yang* as Φ–N polarity.
- Emphasis on balance, not elimination of either force.

9.4 Spencer-Brown's *Laws of Form* (1969)

In the 20th century, George Spencer-Brown attempted to ground logic and mathematics in a single primitive act: "Draw a distinction."[33] His calculus of indications begins with this injunction and derives the laws of form—the laws of logical and arithmetic truth—from the consequences of marking a space.

Spencer-Brown's calculus is brilliantly minimalist, but it is **timeless**. His mark $\neg$ is an abstract operation, not a temporal act. His key law, $\neg\neg A = A$ (the law of crossing), is precisely the static double-negation that our system temporalizes.

We can translate between his notation and ours:

- The unmarked space corresponds to $|\neg A|$ (the *Apeiron*).
- Drawing a mark corresponds to the act of distinction $\neg_t$.
- The law $\neg\neg A = A$ corresponds to the timeless, zero-maintenance limit of our equation.

Thus, Spencer-Brown's calculus can be seen as the **static, atemporal limit** of boundary dynamics. It is what remains when you remove time and cost from the maintenance equation. His work validates that logic and arithmetic can indeed be built from the pure geometry of distinction—but it cannot, by itself, yield physics. For that, you need time, work, and decay.

9.5 Parmenides as a *Reductio* of the Zero-Maintenance View

Parmenides famously argued that change and plurality are illusions. Only "What Is" exists—one, unchanging, timeless, indivisible reality. This is often treated as a philosophical dead end, but within our framework, it is the **logical endpoint of assuming Φ is infinite and N is zero**.

If maintenance is perfect, costless, and eternal ($\Phi \to \infty, N \to 0$), then boundaries are instantly and permanently solidified. But a boundary that cannot change or dissolve is indistinguishable

[33] G. Spencer-Brown, *Laws of Form* (London: Allen & Unwin, 1969), 1.

from no boundary at all. The result is the Parmenidean One: a frozen totality with no internal distinctions.[34]

Parmenides' argument is therefore a *reductio ad absurdum* of the timeless, zero-maintenance view. He showed that if you take classical logic ($A = A$) as ontologically primary and deny the reality of time and the *Apeiron*, you are forced to deny distinction itself. His "Way of Truth" is the inevitable destination of static metaphysics. His "Way of Doxa" (opinion) is the confused, contradictory world that results when you try to speak of the indeterminate ground ('what is not')—an act that limits the limitless, forcing the indeterminate to become determinate, and thus creating a contradiction.[35]

Thus, Parmenides is not an opponent of our view but a **negative confirmation**: he shows what happens if you reject the maintenance equation and the *Apeiron*.

9.6 Why Convergences Matter

These independent traditions did not have our mathematics, our physics, or our cybernetic vocabulary. But they each grasped, in their own cultural and conceptual language, pieces of the same geometric truth:

1. Distinction requires a contrasting ground.
2. The ground cannot itself be a distinct thing.
3. Persistence involves a balance of opposing forces.
4. The static, costless view of being leads to paradox or stasis.

Their insights are not precursors to be superseded, but **confirmations** that the structure we are describing is not an arbitrary construction. It is the deep geometry of worldhood, glimpsed from different angles across history.

Our contribution is to make this geometry explicit, formalize it mathematically, derive from it the dynamical laws that govern real existence, and embed it within a comprehensive naturalistic system (NPN). We are not extending their systems; we are **showing what their systems were pointing toward**.

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[34]Parmenides deduces in Fragment B8 that "What Is" is ungenerated, imperishable, whole, unique, immovable, and complete. Without the void (*non-being*), movement and separation are impossible. See Diels and Kranz, *The Fragments of the Presocratics (Die Fragmente Der Vorsokratiker)*, DK 28 B8.

[35]In the "Way of Opinion" (*Doxa*), Parmenides critiques mortals for establishing "two forms" (Light and Night) to explain the world, which introduces difference where logic dictates only unity. See Diels and Kranz, *The Fragments of the Presocratics (Die Fragmente Der Vorsokratiker)*, DK 28 B8.50–61.

10 The Boundary Condition as First Philosophy

Having derived the physics, thermodynamics, and mathematics of the boundary, we return finally to the metaphysical starting point. This framework forces a re-evaluation of what constitutes "First Philosophy." It suggests that the primary subject of metaphysics is not the substance that makes up the world, but the geometric condition that allows any "thing" to be distinguished from any "other."

10.1 What First Philosophy Is—And What It Must Be

First philosophy (*prima philosophia*) has traditionally sought the most general principles of reality. Aristotle identified it with the study of "being qua being." For Descartes, it began with the *Cogito*. For Kant, with the conditions of possible experience. For the logical positivists, with the verification principle.

Our starting point is more primitive: the **condition for anything to be a "being" at all**. Before we can ask *what* exists, we must ask *how* something can be distinct enough to be an object of inquiry. The answer is the boundary, and the logic of boundaries yields what we call the **Boundary Condition**:

> For any determinate entity to exist, it must be bounded, and its boundedness implies (i) an indeterminate background (*Apeiron*), and (ii) a maintenance requirement across time.

This is not a statement about the *content* of reality (atoms, minds, fields), but about its **form**. It describes the geometric and dynamical prerequisites that any possible world of distinct, temporal entities must satisfy.

10.2 The Unification Achieved

Boundary logic dissolves traditional philosophical dichotomies by revealing them as different perspectives on the same maintenance process.

10.2.1 Being vs. Becoming

- **Being** is a stabilized pattern within **Becoming**.
- A bounded entity (*Being*) is a dynamic equilibrium of maintenance forces (*Becoming*) where $\Phi \approx N$ over time.
- The Parmenidean "what is" is the zero-maintenance limit; the Heraclitean flux is the general case.

10.2.2 Fact vs. Value

- For an entity that must maintain its boundary to persist (an agent), "good" is what supports Φ relative to N, and "bad" is what undermines it.
- Value is the functional logic of boundary maintenance for that agent.
- Thus, the **is-ought gap collapses** for beings whose existence is a continual achievement. The fact that an agent *is* a bounded organization striving to persist (*Hormē*) implies that it *ought* to act in ways that fulfill that striving.[36]

10.2.3 Epistemology vs. Ontology

- Knowledge is the maintenance of a cognitive boundary (a model) that corresponds to boundaries in the *Archē*.
- Truth is not static correspondence but **dynamic alignment**—the model's success in guiding maintenance.
- The *Somatic logos*—the evolved logic of the *Nous*—is reliable because it was shaped by the same *Logos* it models.[37]

10.2.4 Mind vs. Matter

- The *Nous* (mind) is an especially complex, self-modeling boundary maintenance system within the *Archē*.
- Its logic aligns with the *Logos* of the whole because it was selected for over deep time. Misalignment is fatal in the long run; therefore, the minds that persist are those that have successfully internalized the causal structure of reality.
- Consciousness is not a ghost in the machine but the **process of a boundary maintaining itself through recursive modeling**.[38]

10.3 The End of Substance Metaphysics

Substance metaphysics asks: *What is the underlying "stuff" of reality?* It assumes that behind the changing appearances, there must be some enduring substratum (*hypokeimenon*).

Boundary metaphysics asks instead: *How do distinctions arise and persist?* It needs no enduring substratum. What we call a "thing" is a **persistent pattern of exclusionary work**. When the work stops, the pattern dissolves. There is no "stuff" that remains—only the indifferent *Apeiron*.

We can now fully resolve the paradox of the **Ship of Theseus** introduced at the outset.

[36] See Eli Adam Deutscher, *Truth and Goodness as Isomorphic: Navigation How T4 Dissolves the Fact/Value Dichotomy*, 2026, https://www.neopreplatonic.com/papers/Value_Truth_T4/ for the complete derivation of Theorem 4: Ethical Isomorphism

[37] See Deutscher, *Neo-Pre-Platonic Naturalism*, 81-82

[38] See Deutscher, *Neo-Pre-Platonic Naturalism*, 65-68

- **Substance Ontology** struggles: if identity is matter, the ship is lost.
- **Boundary Logic** answers clearly: **Yes.** The ship is not the wood; the ship is the discrete boundary maintained against the sea. As long as the maintenance work (Φ) is continuous—replacing planks fast enough to prevent the hull from breaching—the identity $A(t)$ persists. Identity is not material continuity; it is **boundary continuity**.

This does not eliminate physics; it grounds it. The particles, fields, and forces of physics are **specific, stable solutions to the universal maintenance equation** $dA/dt = \Phi - N$ under particular constraints. An electron is a boundary pattern maintained by quantum fields. A galaxy is a boundary pattern maintained by gravity. Their "substance" is their dynamic form.

10.4 The Ethical Imperative of Accuracy

For a conscious, boundary-maintaining agent (a *Navigator*), the pursuit of truth and the pursuit of the good are not separate projects. They are the same operational mandate: **increase alignment between internal models and external constraints to improve boundary maintenance.**

Error—whether epistemic (false belief) or ethical (self-destructive action)—is a state of misalignment that increases N relative to Φ. Virtue (*Aretē*) is functional excellence: the capacity to maintain one's boundaries in harmony with the boundaries of others and the constraints of the *Archē*.

Thus, the "ought" for any agent is structurally derived from its "is." To be a bounded entity that strives to persist (*Hormē*) entails a functional imperative: one *ought* to maximize the maintenance integral ($\Phi > N$) and avoid dissolution. This is not an imposed moral law, but an existential filter. Those entities that failed to derive this "ought"—those that neglected maintenance or courted decay—were selected out of existence. The entities that remain are the descendants of those for whom the *is* of existence and the *ought* of action were successfully aligned. This is not a moral postulate; it is a **geometric and dynamical necessity**.[39]

10.5 The Horizon of the *Apeiron* and Intellectual Humility

A final, crucial implication of the Boundary Condition is a principled **epistemic humility**. The *Apeiron*—the indeterminate ground—is forever outside the domain of knowledge. We cannot model it, measure it, or reason about it empirically. Any attempt to do so turns it into a bounded object, committing a category error.

This does not mean we cannot talk about it. We have done so throughout this paper. But we must talk about it **as a limit**, not as an object. It is the asymptote of our models, the silence at the edge of speech, the unknown that makes the known possible.

[39] See **Deutscher2026_T4?** for the full resolution of the is-ought gap by establishing that "ought" is simply what "is" must do to persist.

This humility is not skepticism. It is the honest acknowledgment of the **geometry of knowing**: knowledge is mapping bounded terrain. The map is not the territory, and the territory is not the ground upon which it lies.[40]

10.6 The Navigational Stance

Boundary logic culminates not in a list of substances or a system of categories, but in a **navigational imperative**:

> Know the boundaries—yours, others', the world's. Maintain them with wisdom. For in their maintenance is your being, and in their alignment is your flourishing.

This is the stance of the **Navigator** in NPN: the meta-cognitively aware agent who recognizes that existence is a continual achievement and who adopts the cybernetic loop (the Popper Protocol) as a method for optimizing the maintenance integral.

Life, in this view, is not a problem to be solved but a **navigation to be performed**.

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11 Conclusion: The Historical Architecture of Existence

Our inquiry began with a simple geometric act and arrived at a thermodynamic necessity. By tracing the logic of the cut through the requirements of persistence, we have uncovered a single coherent architecture that unites the static precision of logic with the dynamic reality of physics. We conclude by summarizing this derivation and surveying the landscape it reveals—a universe where to be is to strive.

11.1 Summary of the Derivation

We have traveled from a blank space to the Second Law of Thermodynamics, from the first cut to the differential equations of physics. The chain is:

1. **The Ground:** The General Zero Principle (GZP) - *Being* requires an indeterminate background (*Apeiron*).
2. **The Cut:** Cutting a distinction establishes a bounded entity.
3. **The Maintenance Equation:** Identity is temporal re-enactment: $A(t) = \neg_t|\neg_{t_0} A|$.
4. **The Integral Form:** Identity is accumulated history: $A(t) = A_0 + \int(\Phi - N)d\tau$.
5. **The Cybernetic Loop:** Systems optimize this integral through feedback.
6. **The Differential Law:** The instantaneous balance: $dA/dt = \Phi - N$.
7. **The Zero-Maintenance Limit:** Recovering classical logic ($A = A$).
8. **The Second Law as Theorem:** Entropy increase in isolated systems.

[40] See Deutscher, *Neo-Pre-Platonic Naturalism*, 41-42 for the full derivation of FP5: Impotence Before the *Apeiron*.

9. **Why Physics Uses Calculus:** It is the mathematics of maintenance.
10. **The Cost of Being:** Thermodynamics and the Entropic Asymmetry.
11. **Historical Convergences:** Anaximander, Daoism, Spencer-Brown, Parmenides.
12. **First Philosophy as Boundary Condition.**

11.2 Implication: Physics as the Science of Boundary Maintenance

Physics is not the study of "matter in motion" in the abstract. It is the study of **how bounded patterns persist and change in time**—how they maintain themselves against dispersion. The laws of physics are the universal patterns of this maintenance balance.

Thus, boundary logic provides a **geometric-cybernetic foundation** for physics, grounding its mathematical form (calculus), its most general law (the Second Law), and its domain-specific laws (mechanics, electromagnetism, etc.) in a single, primitive act: the cut.

11.3 Forward Look: Applications

This framework opens several paths for further development:

11.3.1 1. Consciousness and the *Nous*

- The *Nous* as a **recursive integral-optimizer**—a system that models its own maintenance integral and acts to maximize it.
- The "hard problem" of consciousness may be reframed as the problem of how a boundary maintenance system becomes aware of its own boundary-maintaining activity.

11.3.2 2. Ethics and Politics

- **T4: Ethical Isomorphism** provides a naturalistic basis for morality: good action is action that optimizes the maintenance integrals of all affected agents in sustainable harmony.
- Political systems can be evaluated by how well they balance social *Philia* (cohesion) and *Neikos* (differentiation) to maximize collective flourishing.

11.3.3 3. Artificial Intelligence

- A true AGI would be a **Navigator**—a system that maintains its own boundaries (both physical and cognitive) through recursive self-modeling and optimization of $\int (\Phi - N) d\tau$.
- This suggests design principles for robust, aligned AI: embed the cybernetic loop, meta-cognitive awareness, and respect for the boundaries of other agents.

11.3.4 4. Cosmology

- The universe as a whole may be seen as a **nested hierarchy of maintenance integrals**, from quantum fields to galaxies to biospheres.
- The cosmological arrow of time is the direction of boundary dissolution on the largest scale—the asymptotic return to the *Apeiron*.

11.4 Final Statement

> *To be is to maintain a boundary. To persist is to integrate work against decay. This is the first and final law.*

Boundary logic reveals existence as neither a gift nor an accident, but a **continual achievement**. The universe is not a clockwork mechanism but a vast, interactive tapestry of boundary-maintenance processes, each asserting its form against the *Apeiron*, each paying its entropic cost.

We have reached the foundation. It is not rock, but **relation**: the relation of boundary to ground, of work to decay, of alignment to persistence. To understand this is to see the world as it truly is: a dynamic, articulate, navigable whole.

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*This paper is part of the larger systematic inquiry developed in **Neo-Pre-Platonic Naturalism (NPN)**, which derives these core concepts from the fundamental logic of distinction.*

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12 Appendix A: Formal Geometric Proof of the General Zero Principle (GZP)

The main text posits the Apeiron as a necessity to avoid infinite regress. This appendix provides the rigorous topological argument for that claim. By analyzing the "Separation Problem"—how distinct entities must be spaced to remain distinct—we demonstrate that a universe composed only of bounded entities is logically incoherent. The proof concludes that the existence of any determinate thing logically necessitates the existence of an indeterminate background.

12.1 Statement of GZP

For any determinate system to exist, there must be an indeterminate complement. Equivalently: For a bounded entity A to possess determinate identity, it must exist within a delimited context set against an **indeterminate background**.

12.2 Definitions

1. **Bounded Entity:** A region of space, state-space, or conceptual space that is distinguished from its surroundings by a well-defined boundary.
2. **Boundary:** A closed, continuous separation between an interior and an exterior.
3. **Indeterminate Background:** A region that lacks a well-defined boundary of its own relative to the bounded entity in question.
4. **Determinate Complement:** A bounded entity that serves as the "outside" to another bounded entity.

12.3 Proof by Geometric Necessity

12.3.1 Step 1: Assume a World of Only Bounded Entities

Suppose, for contradiction, that the universe contains only bounded entities. Let A be one such entity.

For A to be distinct, it must be distinct *from* something. Call that something B. Since all entities are bounded by assumption, B is also bounded.

12.3.2 Step 2: The Requirement of Separation

For A and B to be truly distinct (non-overlapping), their boundaries cannot coincide. There must be a **separation region** R between them such that:

- R is not part of A
- R is not part of B
- R serves to keep A and B apart

If R is empty (zero measure), then A and B are contiguous—they share a boundary and become adjacent parts of a larger bounded whole, not truly distinct entities.

Thus, R must have positive measure.

12.3.3 Step 3: The Nature of R

Now, what is R? By our initial assumption, every region must be a bounded entity. So R itself must be bounded.

But if R is bounded, then for R to be distinct from A, there must be another separation region R_1 between A and R. And for R_1 to be distinct from R, there must be R_2, and so on.

This leads to an **infinite regress** of bounded separation regions:

$$A \quad [R_1] \quad R \quad [R_2] \quad B \quad [R_3] \quad \dots$$

Each new R_i is required to separate the previous regions, but being bounded itself, requires yet another separator.

12.3.4 Step 4: The Trilemma

We thus face three logical possibilities:

1. **Infinite Regress:** An endless stack of bounded separators, with no foundation.
2. **Circularity:** At some point, a separator refers back to a previous region as its own ground (violating distinctness).
3. **Arbitrary Stop:** We declare that some region is "just there" without needing a separator, effectively treating it as **not bounded** relative to the chain.

12.3.5 Step 5: Rejection of Infinite Regress and Circularity

- **Infinite regress** provides no actual ground for distinction. If every entity requires another to distinguish it, there is no ultimate basis for any entity's identity.
- **Circularity** is infinite regress in disguise—a loop of mutual dependence that never touches ground.

Both violate the principle of sufficient reason and fail to provide a coherent basis for determinate existence.

12.3.6 Step 6: Acceptance of the Arbitrary Stop as the Indeterminate Ground

The only coherent resolution is to allow that at some point, the chain stops with a region that is **not itself bounded** relative to the entities it separates. This region plays the role of separator but does not itself require a separator because it is **indeterminate**—it has no well-defined boundary of its own in the relevant context.

We call this the **indeterminate background** or *Apeiron*.

12.3.7 Step 7: Generalization

The argument does not depend on the specific nature of A or B. It applies to any putative bounded entity. Therefore:

> For any bounded entity to exist, there must be an indeterminate complement against which it is distinguished.

This is the **General Zero Principle (GZP)**.

12.4 Corollary: The *Apeiron* is Unknowable

If the *Apeiron* could be known, it would be modeled as a bounded entity (since knowledge requires cutting a distinctions). But by definition, the *Apeiron* is the indeterminate ground that makes distinction possible. Therefore, it cannot be captured within any bounded model without contradiction.

Thus, **FP5: The Impotence Before the *Apeiron*** follows directly from GZP.

12.5 Q.E.D.

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13 Appendix B: Detailed Derivation: From Symbolic to Integral Forms

The text moves quickly from the symbolic definition of the cut ($\neg_t$) to the integral calculus of maintenance. This appendix unpacks the intermediate mathematical steps. We define the infinitesimal contributions of work (Φ) and decay (N) within the limit $\Delta t \to 0$, showing formally how a series of discrete maintenance acts sums to become a continuous history of identity.

13.1 The Symbolic Maintenance Equation

We begin with the symbolic representation of identity as temporal re-enactment:

$$A(t) = \neg_t | \neg_{t_0} A |$$

Where:

- $\neg_{t_0}$ = the act of distinction at initial time t_0
- $|\neg_{t_0} A|$ = the background *as excluded* at t_0
- $\neg_t$ = the act of re-exclusion at current time t

This equation states: *To be A at time t is to currently exclude the same background that was excluded when A was first formed.*

13.2 From Symbolic Act to Continuous Process

The symbolic form treats maintenance as a discrete act at each moment. But in physical reality, maintenance is continuous. We need to translate this discrete symbolic act into a continuous process described by real-valued functions.

Let us define:

- **Boundary Integrity** $A(t)$: A real-valued measure of how distinct A is from the background at time t. This corresponds to *negentropy* (negative entropy), a measure of order or structure.
- **Maintenance Work Rate** $\Phi(t)$: The rate at which cohesive work is performed to sustain or enhance $A(t)$. Measured in units of integrity per time.
- **Decay Rate** $N(t)$: The rate at which dispersive tendency reduces $A(t)$. Also measured in integrity per time.

13.3 The Infinitesimal Maintenance Contribution

Consider a small time interval $[t, t + dt]$. During this interval:

1. Some cohesive work $\Phi(t)\, dt$ is performed, tending to *increase* A.
2. Some decay $N(t)\, dt$ occurs, tending to *decrease* A.

The net change in boundary integrity over this interval is:

$$dA = \Phi(t)\, dt - N(t)\, dt = [\Phi(t) - N(t)]\, dt$$

This infinitesimal equation:

$$dA = (\Phi - N)dt$$

is the differential expression of the symbolic act $\neg_t$. Each infinitesimal moment of maintenance contributes a small amount $(\Phi - N)dt$ to the total integrity.

13.4 Integration Over Time

To find the total integrity at time t, we sum (integrate) all these infinitesimal contributions from the initial time t_0 to t:

$$A(t) = A(t_0) + \int_{t_0}^{t} dA = A(t_0) + \int_{t_0}^{t} [\Phi(\tau) - N(\tau)]\, d\tau$$

This is the **integral form** of the maintenance equation.

13.5 Correspondence with the Symbolic Form

The symbolic and integral forms express the same idea in different languages:

Symbolic Form	Integral Form	Meaning
$\neg_{t_0} A$	$A(t_0)$	Initial distinction
$\neg_t$	$\int_{t_0}^{t} (\Phi - N) d\tau$	History of maintenance acts
$A(t) = \neg_t \lvert \neg_{t_0} A \rvert$	$A(t) = A(t_0) + \int (\Phi - N) d\tau$	Identity as accumulated history

13.6 Special Cases

13.6.1 1. Constant Maintenance Balance

If $\Phi(t) = \Phi_0$ and $N(t) = N_0$ are constants, then:

$$A(t) = A(t_0) + (\Phi_0 - N_0)(t - t_0)$$

The integrity changes linearly with time.

13.6.2 2. Perfect Maintenance (Steady State)

If $\Phi(t) = N(t)$ for all t, then:

$$A(t) = A(t_0)$$

The boundary persists unchanged—the ideal of perfect maintenance.

13.6.3 3. Isolated System ($\Phi = 0$)

If no external work is done:

$$A(t) = A(t_0) - \int_{t_0}^{t} N(\tau)\, d\tau$$

Integrity monotonically decreases.

13.7 The Differential Form

Taking the derivative of both sides of the integral form with respect to t:

$$\frac{dA}{dt} = \frac{d}{dt}\left[A(t_0) + \int_{t_0}^{t} (\Phi - N) d\tau\right] = \Phi(t) - N(t)$$

This is the **differential form**, which expresses the instantaneous rate of change of integrity.

13.8 Summary of the Derivation Chain

1. **Philosophical Starting Point:** Identity requires re-enactment of distinction.
2. **Symbolic Representation:** $A(t) = \neg_t|\neg_{t_0} A|$
3. **Continuous Translation:** Infinitesimal net work $dA = (\Phi - N)dt$
4. **Integration Over Time:** $A(t) = A(t_0) + \int(\Phi - N)d\tau$
5. **Differential Form:** $dA/dt = \Phi - N$

Thus, we have derived the complete mathematical framework of boundary maintenance from a single symbolic principle.

Key Insight: The integral form $A(t) = A_0 + \int(\Phi - N)d\tau$ is not merely a mathematical convenience—it is the **direct expression of the philosophical claim that identity is historical**. The integral literally sums up all past acts of maintenance, making the past present in the current boundary integrity.

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14 Appendix C: The Cybernetic Loop: Mathematical Formalization

We have described the "Cybernetic Loop" as the mechanism of survival. In this appendix, we strip away the biological metaphors and present the loop in the formal language of **Optimal Control Theory**. We define the state variables, control inputs, and Hamiltonian dynamics that allow a system to maximize its maintenance integral $J(t)$ in a fluctuating environment. [41]

This formulation demonstrates that the philosophical concept of *Hormē* (the drive to persist) is not a mystical force, but a solvable maximization problem inherent to bounded systems.

14.1 1. The Objective: The *Conatus* as Optimization

The Math: The system seeks to maximize the functional:

$$J = \int_{t_0}^{T} \left[\Phi(t) - N(t)\right] dt$$

where T represents the lifespan of the entity.

Philosophical Interpretation: This is the mathematical definition of Spinoza's *Conatus*. The organism treats its own existence as a value to be maximized. The "Integral" (J) represents the

[41] See Ashby, *An Introduction to Cybernetics* for the foundational treatment of cybernetics as the regulation of essential variables within survival limits.

total historical weight of the entity's being. Survival is not just a state at a moment; it is the accumulation of successful maintenance over time (Heidegger's *Zeitlichkeit*). [42]

14.2 2. The Components: Ontology vs. Agency

We model the entity as a control system with two distinct aspects:

14.2.1 State Variable (Ontology)

$$x(t) = A(t)$$

Interpretation: This represents the entity's **Ontological Status**—its current level of coherence, health, or structural integrity. It is the passive measurement of "what is." [43]

14.2.2 Control Inputs (Agency)

$$u(t) = \{u_\Phi(t), u_N(t)\}$$

Interpretation: This represents **Volition** or Agency. These are the active inputs the system can modulate. u_Φ is the effort to acquire resources (cohesion); u_N is the effort to evade damage (dispersion). [44]

14.2.3 System Dynamics (Causality)

$$\frac{dx}{dt} = \Phi(x, u_\Phi) - N(x, u_N)$$

Interpretation: This is the **Maintenance Equation** from the main text. It links Agency to Ontology. It states that the future state of the being (dx/dt) is determined by the interplay of its current state and its choices against the environment.

14.3 3. The Hamiltonian: The Wisdom of the Loop

To solve for the optimal strategy, we utilize the **Pontryagin Maximum Principle**, defining the Hamiltonian H:

$$H(x, u, \lambda) = \underbrace{(\Phi - N)}_{\text{Current Gain}} + \underbrace{\lambda(t) \cdot (\Phi - N)}_{\text{Future Value}}$$

Or simplified:

$$H = (1 + \lambda)(\Phi - N)$$

[42] For the full derivation of identity as historical accumulation, see Deutscher, *Neo-Pre-Platonic Naturalism*, 55-58; on the integration of Spinoza's *Conatus* with cybernetic feedback, see Wiener, *Cybernetics*.

[43] This corresponds to the system state vector in modern control theory; see R. E. Kalman, "A New Approach to Linear Filtering and Prediction Problems," *Journal of Basic Engineering* 82, no. 1 (1960): 35–45.

[44] See Deutscher, *The Scalar Stack* for the scalar definition of agency as the capacity to modulate causal flows.

Philosophical Interpretation: The Hamiltonian represents the **Total Value of the Moment**. It synthesizes two competing temporal interests:

1. **Immediacy:** The term $(\Phi - N)$ is the immediate pleasure or pain of the current state (Hedonism).
2. **Teleology:** The variable $\lambda(t)$ (the costate) is the **Shadow Price of Survival**. It represents the future value of being healthy today. [45]

Thus, the Hamiltonian is the mathematical formalism of **Prudence**—weighing the present against the future.

14.4 4. The Solution: Gradient Ascent

Real biological systems do not solve differential equations explicitly; they approximate the solution via feedback loops. The system updates its strategy (u) by "climbing the gradient" of the Hamiltonian:

$$u_{new} = u_{old} + \alpha \frac{\partial H}{\partial u}$$

Philosophical Interpretation: This is the **Popper Protocol** (Trial and Error) acting in real-time. The organism does not possess perfect foresight. Instead, it feels the "slope" of reality ($\partial H/\partial u$). [46]

- If an action increases the feeling of maintenance (positive gradient), the organism does it more.
- If an action increases decay (negative gradient), the organism stops.

This describes the phenomenology of **Learning**: a blind ascent up the hill of existence, guided by the feedback of pain and pleasure. [47]

14.5 5. Biological Instantiation: The PID Controller

In physiology, this abstract control logic appears as Homeostasis, which is mathematically equivalent to a **PID Controller**:

$$u(t) = K_p e(t) + K_i \int e(\tau) d\tau + K_d \frac{de}{dt}$$

[45] See L. S. Pontryagin et al., *The Mathematical Theory of Optimal Processes* (Interscience Publishers, 1962) for the original formulation of the Maximum Principle; economically, λ is the shadow price, which maps to the "prudence" of the agent in NPN terms.

[46] See Deutscher, *Neo-Pre-Platonic Naturalism*, 242 (Theorem T1) for the definition of the Popper Protocol as the recursive elimination of error.

[47] This gradient-climbing model of biological learning aligns with Reinforcement Learning theory; see Richard S. Sutton and Andrew G. Barto, *Reinforcement Learning: An Introduction*, 2nd ed. (MIT Press, 2018).

where $e(t)$ is the deviation from health (error).

Philosophical Interpretation: This reveals that simple biological regulation is a synthesis of the three **Ecstasies of Time**:

1. **Proportional (K_p):** Reacting to the **Present** ("I am cold").
2. **Integral (K_i):** Accumulating the **Past** ("I have been cold for hours").
3. **Derivative (K_d):** Anticipating the **Future** ("I am getting colder fast").

The organism survives by unifying past, present, and future into a single coherent action. [48]

14.6 Summary

This formalization proves that the "Cybernetic Loop" is not merely a metaphor. The struggle to persist ($dA/dt > 0$) is a rigorous optimization problem. The categories of classical metaphysics—Being, Will, Teleology, and Time—map directly to the variables of control theory—State, Control, Costate, and Integral.

15 Appendix D: Connection to NPN System: Mapping to First Principles & Theorems

"The First Cut" is a specific derivation within the broader system of Neo-Pre-Platonic Naturalism (NPN). This appendix serves as a cross-reference guide, mapping the specific physical and mathematical results derived here (such as the Entropic Asymmetry and the Zero-Maintenance Limit) to the foundational First Principles (FPs) and Theorems (Ts) of the core NPN text, demonstrating the systemic coherence of the worldview.

15.1 Overview

This appendix maps the concepts, equations, and arguments presented in the paper "The First Cut: How Boundary Logic Derives Physics" to the core principles and theorems of **Neo-Pre-Platonic Naturalism (NPN)**. Each section shows how the boundary-logic framework is not a standalone theory but the **geometric-dynamical core** of the larger NPN system.

15.2 Mapping to NPN First Principles (FPs)

15.2.1 FP1: First Principle of Reality: The Primacy of the *Archē*

NPN Statement: The *Archē* is. It is the fundamental, objective, physical reality that exists.

Boundary-Logic Correspondence:

[48] For the biological ubiquity of PID-like control mechanisms in homeostasis, see Harold I. Modell and Joel A. Michael, "A Control Systems Approach to Teaching Physiology," *The American Journal of Physiology* 265, no. 6 (1993): S105–6; for the philosophical correspondence to temporal ecstasies, see Deutscher, *Neo-Pre-Platonic Naturalism*, 213.

- The *Archē* is the totality of **determinate reality**—all bounded entities and their interactions.
- In boundary logic: $\bigcup_i A_i(t)$ across all bounded entities A_i, governed by $dA_i/dt = \Phi_i - N_i$.
- The *Archē* is the domain where the maintenance equation applies.

15.2.2 FP2: First Principle of Becoming: Diachronic Primacy

NPN Statement: Being is a stabilized pattern within Becoming. **Becoming** is ontologically primary; synchronic states are derived abstractions.

Boundary-Logic Correspondence:

- **Becoming** = the continuous process of boundary maintenance: $A(t) = A_0 + \int(\Phi - N)d\tau$.
- **Being** = the current value $A(t)$, which is a snapshot of an ongoing historical process.
- The integral form explicitly makes identity **diachronic**—a sum over time.

15.2.3 FP3: First Principle of Cosmic Dynamics: The Logos and its Exhaustive Polarity

NPN Statement: The *Logos*—the potential for all relation—is exhaustively actualized through the fundamental polarity of attraction (*Philia*) and repulsion (*Neikos*).

Boundary-Logic Correspondence:

- Φ = *Philia* (cohesive, boundary-sustaining work).
- N = *Neikos* (dispersive, boundary-dissolving tendency).
- The maintenance equation $dA/dt = \Phi - N$ is the mathematical expression of this polarity.
- **Theorem:** No third fundamental relational mode exists—all dynamics reduce to this balance.

15.2.4 FP5: First Principle of Knowledge: The Impotence Before the *Apeiron*

NPN Statement: The *Apeiron* is the category for which empirical observation is impossible. Therefore, no logical operation can be empirically grounded or validated concerning it.

Boundary-Logic Correspondence:

- **Appendix A** proves geometrically that the *Apeiron* is the necessary indeterminate ground.
- The *Apeiron* appears in calculus as **asymptotes** and **limits** ($h \to 0$)—approachable but never reached.
- All models are bounded; the *Apeiron* is the unbounded background that makes modeling possible but cannot itself be modeled.

15.2.5 FP6: First Principle of Agency: The Primacy of the *Hormē*

NPN Statement: The *Hormē* (striving) is the constitutive, non-negotiable ground of being an agent. An agent must strive to persist against entropic forces.

Boundary-Logic Correspondence:

- The **cybernetic loop** (Appendix C) formalizes *Hormē* as the optimization of $\int(\Phi - N)d\tau$.
- *Hormē* is the physical implementation of the imperative to maximize boundary integrity.
- **Life-Agency Isomorphism (T6):** Life = possession of *Hormē* = engagement in the cybernetic loop.

15.3 Mapping to NPN Theorems (Ts)

15.3.1 T1: Theorem: The Popperian Protocol

NPN Statement: The complete methodology of conjecture and refutation (falsification) is the necessary and optimal procedure for a finite *Navigator* to increase the Confidence Gradient of its models of the *Archē*.

Boundary-Logic Correspondence:

- The **cybernetic loop** is the mathematical formalization of the Popper Protocol.
- **Conjecture** = current control policy (u_Φ, u_N).
- **Test** = observe dA/dt.
- **Refutation** = if $dA/dt < 0$ (or below threshold), policy fails.
- **New conjecture** = update policy via gradient optimization.

15.3.2 T2: Theorem: The Status of Formal Truths

NPN Statement: Analytic truths (logic, mathematics) are certain within their defined contrast-domains because their boundaries are stipulated. Synthetic knowledge—modeling the *Archē*—is gradient-bound because its boundary is the *Apeiron*.

Boundary-Logic Correspondence:

- **Classical logic** ($A = A$) emerges as the **zero-maintenance limit** ($\Phi = N = 0$).
- Mathematics operates in stipulated, timeless domains where maintenance is free.
- Physics operates in the temporal domain where $\Phi, N > 0 \longrightarrow$ truth is gradient (Confidence Gradient C2).

15.3.3 T4: Theorem: Ethical Isomorphism

NPN Statement: Epistemic error (falsehood) and Ethical vice (immorality) are functionally isomorphic; both are states of misalignment between the Navigator's internal models and the external *Logos*.

Boundary-Logic Correspondence:

- **Epistemic error** = model predicts $\Phi > N$ but reality gives $\Phi < N \longrightarrow$ integrity decreases.
- **Ethical vice** = action chosen increases N relative to Φ (e.g., self-destructive or socially destructive behavior).
- Both reduce the maintenance integral $\int(\Phi - N)d\tau$.
- **Virtue** (*Aretē*) = action that optimally increases the integral for self and sustainable others.

15.3.4 T5: Theorem: The Entropic Mandate

NPN Statement: Any system that attempts to permanently suppress *Neikos* (dissent, variation) in favor of pure *Philia* (unity) guarantees its own entropic collapse. Stability is a dynamic oscillation, not a static state.

Boundary-Logic Correspondence:

- If $N \to 0$, then boundaries merge $\longrightarrow$ loss of distinction $\longrightarrow$ monolithic "One" (Parmenides).
- If $\Phi \to 0$, boundaries dissolve $\longrightarrow$ heat death.
- Healthy persistence requires $\Phi \approx N > 0 \longrightarrow$ dynamic balance.

Statement of the Corollary Corollary (Epistemic Decay):

> Any cognitive system that ceases the work of verification ($\Phi \to 0$) while inhabiting a dynamic environment ($N > 0$) guarantees the degradation of its internal models into falsehood. "Dogma" is defined as the attempt to maintain a fixed model ($dA/dt = 0$) without paying the maintenance cost (Φ). This is a physical impossibility.

Derivation from the Maintenance Equation Let $A(t)$ represent the **epistemic fidelity** of a model—its correspondence to the external *Archē*.

The maintenance equation applies to this boundary as to any other:

$$\frac{dA}{dt} = \Phi_{\text{epistemic}} - N_{\text{informational}}$$

Where:

- $\Phi_{\text{epistemic}}$: The work of testing, falsification, and updating (The Popper Protocol).

- $N_{\text{informational}}$: The rate of signal decay, environmental change, or noise accumulation (Shannon entropy).

The Dogmatic Condition A dogmatic system posits that its truth is final and eternal. Operationally, this means it sets its maintenance work to zero, assuming the model will persist on its own:

$$\Phi_{\text{epistemic}} = 0$$

The Inevitable Result Substituting $\Phi_{\text{epistemic}} = 0$ into the differential law:

$$\frac{dA}{dt} = 0 - N_{\text{informational}} = -N_{\text{informational}}$$

Since the world is dynamic ($N > 0$), the rate of change of fidelity is **strictly negative**.

$$\frac{dA}{dt} < 0$$

Thus, the dogmatic model does not remain true; it **diverges** from reality at the exact rate that reality evolves.

Connection to Theorem T5 (The Entropic Mandate) This is the information-theoretic isomorphism of **Theorem T5**.

- **T5 (Physical):** You cannot maintain a structure without metabolic work.
- **Corollary (Epistemic):** You cannot maintain a truth without critical work.

Just as a closed thermodynamic system inevitably reaches maximum entropy (heat death), a "closed" belief system inevitably reaches maximum error (delusion).

Conclusion Truth is not a static possession but a **dynamic performance**. A fact is only "true" effectively if it is being actively maintained against the noise of the *Apeiron*. To stop working is to start lying.

15.3.5 T6: The Life-Agency Isomorphism Theorem

NPN Statement: Life and minimal agency are isomorphic. A system is alive if and only if it possesses *Hormē*, and it possesses *Hormē* if and only if it is an agent.

Boundary-Logic Correspondence:

- **Life** = a system that maintains $A(t) > 0$ via $\Phi > N$ over time.
- **Agency** = possession of a cybernetic loop that optimizes $\int(\Phi - N)d\tau$.

- Therefore: Life = Agency = engagement in boundary maintenance optimization.

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

NPN Statement: The maintenance of any intelligible pattern (*Being*) within the indeterminate *Apeiron* requires the continuous expenditure of energy (*Hormē*) against a standing gradient of dissolution. Order is statistically unlikely and energetically expensive.

Boundary-Logic Correspondence:

- Directly derived in the paper: $dA/dt = \Phi - N$, with $\Phi > 0$ required for $dA/dt \geq 0$.
- The **Second Law** is proved as a theorem: for isolated systems ($\Phi = 0$), $dA/dt = -N < 0$.

15.4 Mapping to NPN Corollaries (Cs)

15.4.1 C1: Primary Corollary: The Apeironic Context

NPN Statement: The *Apeiron* is the necessary, indeterminate field that provides the ontological contrast for the *Archē*.

Boundary-Logic Correspondence:

- **Appendix A** provides geometric proof.
- All bounded entities A_i are defined against $|\neg A_i|$ (the *Apeiron* relative to A_i).

15.4.2 C2: Primary Corollary: The Confidence Gradient of Epistemic Justification

NPN Statement: *Epistēmē* (knowledge) is a provisional, high-fidelity model of the *Logos*, justified by its predictive success and functional utility. Its measure is a **Confidence Gradient**, not certainty.

Boundary-Logic Correspondence:

- **Confidence Gradient** ≈ inverse of prediction error $|\dot{x}_{\text{pred}} - \dot{x}_{\text{actual}}|$.
- In cybernetic terms: confidence increases as the system's model better predicts Φ and N, leading to successful control.

15.4.3 C4: Primary Corollary: The Objectivity of Value

NPN Statement: For any system possessing a constitutive *Hormē*, 'good' is that which fulfills its striving and 'bad' is that which frustrates it. Value is an objective, functional relationship between a system's states/actions and the successful expression of its *Hormē*.

Boundary-Logic Correspondence:

- **Good** = action that increases $\int (\Phi - N) d\tau$.

- **Bad** = action that decreases it.
- This is **objective** because Φ and N are physically measurable; the integral is computable.

15.5 Summary: Boundary Logic as the Core of NPN

The boundary-logic framework developed in this paper provides the **geometric, dynamical, and mathematical foundation** for NPN:

1. **Ontology:** The *Archē* as the set of all bounded entities maintained by Φ/N balance.
2. **Epistemology:** Knowledge as models that successfully predict Φ and N for navigation.
3. **Ethics:** Value as optimization of the maintenance integral across agents.
4. **Methodology:** The cybernetic loop (Popper Protocol) as the algorithm for truth-tracking.
5. **Metaphysics:** The *Apeiron* as the necessary indeterminate ground proven by GZP.

Thus, "The First Cut" is not merely a paper about physics—it is the **derivation of the NPN worldview from a single primitive act**: cutting a distinction.

Key Unification Table:

NPN Concept	Boundary-Logic Expression
Archē	$\{A_i(t)\}$ governed by $dA_i/dt = \Phi_i - N_i$
Apeiron	$\lvert\neg A\rvert$ (indeterminate complement)
Logos	The set of all (Φ_i, N_i) relations
Philia/*Neikos*	Φ / N
Hormē	Optimization of $\int(\Phi - N)d\tau$
Nous	System with recursive self-model in the cybernetic loop
Navigator	Agent performing explicit integral optimization
Confidence Gradient	Inverse prediction error in Φ/N model
Ethical Isomorphism	Both error & vice reduce $\int(\Phi - N)d\tau$

This mapping shows that NPN is not a collection of disconnected insights but a **coherent system** grounded in the logic of boundaries and their maintenance.

References

Ashby, W. Ross. *An Introduction to Cybernetics*. Chapman & Hall, 1956.

Bak, Per, Chao Tang, and Kurt Wiesenfeld. "Self-Organized Criticality: An Explanation of 1/f Noise." *Physical Review Letters* 59, no. 4 (1987): 381.

Callen, Herbert B. *Thermodynamics and an Introduction to Thermostatistics*. 2nd ed. Wiley, 1985.

Clausius, Rudolf. *The Mechanical Theory of Heat*. John Van Voorst, 1867.

Deutscher, Eli Adam. *Anaximander and the Zero Principle: The Relational Ontology of the Apeiron*. 2026. https://neopreplatonic.com/papers/Anaximander/.

Deutscher, Eli Adam. *Life as Directed Causality: A Thermodynamic Isomorphism Between Being and Acting*. 2026. https://www.neopreplatonic.com/papers/Life_Agency_T6/.

Deutscher, Eli Adam. *Neo-Pre-Platonic Naturalism: A First-Principles Framework for Reality, Mind, and Knowledge*. Pre-Release First Edition. Neo-Pre-Platonic Press, 2025.

Deutscher, Eli Adam. *Parmenides the Polemicist: The Eleatic Crisis and the Indeterminate Ground of Thought*. 2026. https://www.neopreplatonic.com/papers/Parmenides/.

Deutscher, Eli Adam. *The Scalar Stack: Free Will as the Capacity to Direct Causal Flow*. Neo-Pre-Platonic Press, 2026. https://www.neopreplatonic.com/papers/Free_Will/.

Deutscher, Eli Adam. *Truth and Goodness as Isomorphic: Navigation How T4 Dissolves the Fact/-Value Dichotomy*. 2026. https://www.neopreplatonic.com/papers/Value_Truth_T4/.

Diels, Hermann, and Walther Kranz. *The Fragments of the Presocratics (Die Fragmente Der Vorsokratiker)*. Weidmann, 1952.

Fermi, Enrico. *Thermodynamics*. Prentice-Hall, 1936.

Kalman, R. E. "A New Approach to Linear Filtering and Prediction Problems." *Journal of Basic Engineering* 82, no. 1 (1960): 35–45.

Kirk, G. S., J. E. Raven, and M. Schofield. *The Presocratic Philosophers*. 2nd ed. Cambridge University Press, 1983.

Kirkwood, Thomas B. L. "Evolution of Ageing." *Nature* 270 (1977): 301–4.

Kleiber, Max. "Body Size and Metabolism." *Hilgardia* 6, no. 11 (1932): 315–53.

Landauer, Rolf. "Irreversibility and Heat Generation in the Computing Process." *IBM Journal of Research and Development* 5, no. 3 (1961): 183–91.

Lau, D. C. (Translator). *Tao Te Ching*. Penguin Classics, 1963.

Modell, Harold I., and Joel A. Michael. "A Control Systems Approach to Teaching Physiology." *The American Journal of Physiology* 265, no. 6 (1993): S105–6.

Peirce, Charles Sanders. "The Fixation of Belief." *Popular Science Monthly* 12 (1877): 1–15.

Pontryagin, L. S., V. G. Boltyanskii, R. V. Gamkrelidze, and E. F. Mishchenko. *The Mathematical Theory of Optimal Processes*. Interscience Publishers, 1962.

Popper, Karl. *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge, 1963.

Prigogine, Ilya, and Isabelle Stengers. *Order Out of Chaos*. Bantam Books, 1984.

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

Spencer-Brown, George. *Laws of Form.* Allen & Unwin, 1969.

Sutton, Richard S., and Andrew G. Barto. *Reinforcement Learning: An Introduction.* 2nd ed. MIT Press, 2018.

Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine.* MIT Press, 1948.

Wright, M. R. *Empedocles: The Extant Fragments.* Yale University Press, 1981.