

EVOLUTION: THE UNIVERSAL OPERATOR

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May 2026

Abstract

Evolution is typically understood as a biological process, but this framing obscures its deeper structure. This paper argues that evolution is a **universal operator**: a substrate-independent mechanism that transforms undifferentiated possibility into coherent, self-maintaining form. The operator has a stable, domain-invariant structure—**variation, selection, and retention**—and this structure appears across physical, biological, cognitive, cultural, and technological systems. Evolution is therefore not a process occurring *within* an environment; rather, environments themselves are products of prior evolutionary operations. This reframing dissolves the boundary between evolution and development, showing them to be different constraint regimes of the same generative mechanism. By treating evolution as the universal operator that discovers and stabilizes coherence, the paper provides a unified account of how structure emerges across scales and domains, and clarifies why biological evolution is a special case of a more general principle.

1. INTRODUCTION

Evolution is almost always framed as a biological process, a mechanism restricted to organisms, genes, and ecological environments. This framing is historically understandable but conceptually limiting. It treats evolution as something that *happens within* reality rather than something that *produces* reality's coherent forms. The result is a fragmented picture: physics explains matter, biology explains life, psychology explains mind, sociology explains culture, and technology studies explain artifacts. Each domain appears to require its own generative principle.

This paper argues that this fragmentation is an artifact of perspective, not structure. The mechanism we call “evolution” is not a biological anomaly but a **universal operator**—a substrate-independent

process that transforms undifferentiated possibility into stable, self-maintaining form. Its structure is invariant across domains: **variation**, **selection**, and **retention**. Whether the substrate is molecular, neural, conceptual, institutional, or cosmological, systems persist only by passing through this operator. Coherence is not imposed from outside; it is discovered through the elimination of incoherent alternatives.

Reframing evolution as a universal operator dissolves the boundary between biological evolution and the broader dynamics of structure formation. It reveals that environments are not external containers but products of prior evolutionary operations. It clarifies why development and evolution are not distinct processes but different constraint regimes of the same mechanism. And it provides a unified account of how coherent systems emerge, stabilize, and transform across scales.

The aim of this paper is not to metaphorize evolution but to restore its full ontological scope. Evolution is the operator that generates coherence. Biology is simply one of its most visible expressions.

2. THE OPERATOR DEFINITION

To treat evolution as a universal operator, we must first specify what an operator is. In its most general form, an **operator** is a mechanism that acts on a space of possibilities and transforms it into a space of coherent outcomes. Operators do not describe *what* exists; they describe **how structure is produced**. They are generative, not descriptive.

A **universal operator** is an operator whose structure remains invariant across substrates. Its form does not depend on whether it is acting on molecules, organisms, neural patterns, concepts, institutions, or cosmological configurations. What changes is the material; what remains constant is the mechanism that transforms that material into stable form.

Evolution has exactly this structure. Across every domain in which coherent systems emerge, persist, and adapt, the same three-step operator appears:

1. **Variation** — the generation of alternatives within a possibility space.
2. **Selection** — the elimination of alternatives that fail to satisfy coherence constraints.
3. **Retention** — the stabilization of configurations that satisfy those constraints.

These steps are not biological categories; they are **structural transformations**. Variation is the introduction of difference. Selection is the action of constraints. Retention is the stabilization of coherence. Together, they form a single operator that acts on any domain where possibilities exceed constraints.

Crucially, the operator does not require an external environment. The constraints that drive selection are themselves the products of prior evolutionary operations. This makes the operator **recursive**: it generates the very conditions under which it subsequently acts. Evolution is therefore not a process embedded within a fixed world; it is the operator that continually produces the world's coherent structure.

By defining evolution in operator form, we reveal its substrate-independence and its universality. The same mechanism that shapes biological lineages also shapes physical equilibria, cognitive representations, cultural norms, technological designs, and institutional forms. Evolution is the operator that transforms possibility into coherence wherever coherence is found.

3. WHY EVOLUTION IS UNIVERSAL

Evolution is universal because its operator structure does not depend on the material it acts upon. Wherever there is (1) a space of possibilities, (2) constraints that eliminate incoherent configurations, and (3) mechanisms that stabilize coherent ones, the evolutionary operator necessarily appears. This

makes evolution a **formal mechanism**, not a biological one. Biology is simply the domain where the operator is easiest to observe.

The universality becomes clear when we examine how coherence emerges across different physical and informational substrates. In each case, the same operator structure—variation, selection, retention—governs the transition from disorder to order:

- **Sound:** Vibrational disturbances generate variation; resonance conditions select which frequencies persist; stable modes are retained as standing waves.
- **Vibration:** Micro-perturbations introduce variation; damping and boundary conditions select viable oscillations; coherent patterns stabilize as attractors.
- **Motion:** Random trajectories explore possibility space; physical constraints eliminate impossible paths; stable orbits and flows are retained.
- **Air:** Turbulence generates variation; pressure and boundary conditions select coherent flow regimes; laminar structures persist.
- **Heat:** Microstates vary continuously; thermodynamic constraints select equilibrium distributions; retained states reflect stable energy configurations.

These are not metaphors. They are literal instantiations of the same operator acting on different substrates. The operator's form is invariant even as the material changes. What differs is the *expression* of variation, the *source* of constraints, and the *mechanism* of retention. What remains constant is the **structure of transformation**.

This invariance is what makes evolution universal. It is the operator that reality uses to discover, test, and stabilize coherent form. Any domain with excess possibility and non-arbitrary constraints will necessarily exhibit evolutionary dynamics. The operator is not optional; it is structurally required wherever coherence emerges.

By recognizing evolution as a universal operator, we dissolve the artificial boundary between natural processes and human processes, between physical order and biological order, between cognition and culture. All are expressions of the same generative mechanism acting at different scales and with different materials. Evolution is universal because coherence is universal, and evolution is the operator that produces coherence.

4. EVOLUTION AS THE GENERATOR OF COHERENCE

If evolution is a universal operator, then its deepest function is not change, adaptation, or diversification. Its deepest function is **coherence generation**. Evolution is the mechanism by which reality discovers which configurations can persist under constraint. It is the operator that filters possibility through the structure of the world until only coherent forms remain.

Coherence is not imposed from outside. It is not designed, dictated, or predetermined. Coherence is **revealed** by the elimination of incoherent alternatives. Every system that persists—whether a molecule, an organism, a concept, a social norm, or a planetary structure—exists because it satisfies the constraints that define its domain. Evolution is the operator that identifies those constraints by testing the full space of possibilities against them.

This reframing dissolves the common misconception that evolution is “blind” or “random.” Variation introduces difference, but selection is the action of **non-arbitrary constraints**. These constraints are not accidental; they reflect the deep structure of the domain. Retention is the stabilization of configurations that successfully align with that structure. The operator therefore performs a kind of **distributed inference**: it discovers what works by eliminating what does not.

Coherence is the invariant outcome of this process. Systems that persist must be internally consistent, externally compatible, and dynamically stable. Evolution is the operator that enforces these requirements. It is not a mechanism that occasionally produces coherence; it is the mechanism that

necessarily produces coherence whenever possibility exceeds constraint.

By recognizing evolution as the generator of coherence, we can unify phenomena that are typically treated as unrelated. Physical equilibria, biological adaptations, cognitive representations, cultural norms, and technological designs all emerge from the same operator acting on different substrates. What differs is the material; what remains constant is the operator's function: to discover and stabilize coherent form.

Evolution is not a process within a coherent world. It is the operator that **makes the world coherent**.

5. EVOLUTION WITHOUT ENVIRONMENT

The traditional account of evolution assumes an external environment that imposes constraints on organisms. Variation occurs within the organism; selection is applied by the environment; retention stabilizes successful traits. This framing is intuitive but structurally incomplete. It treats the environment as a fixed, external backdrop rather than as a dynamic product of the same operator acting at different scales.

If evolution is a universal operator, then the environment cannot be external to it. The environment is itself the outcome of prior evolutionary operations. Physical laws, chemical gradients, ecological niches, social structures, technological infrastructures, and conceptual frameworks are all **evolved constraints**—stabilized results of earlier rounds of variation, selection, and retention. They are not independent of the operator; they are expressions of it.

This reframing dissolves the organism–environment dualism. Organisms do not evolve *within* environments; organisms and environments co-evolve as mutually constraining products of the same operator. The environment is not a container but a **co-generated constraint surface**. Selection is not imposed from outside but arises from the interaction of evolving systems with the constraints produced

by prior evolution.

This makes the evolutionary operator **recursive**. Each round of evolution generates new constraints that shape subsequent rounds. The operator continually produces the conditions under which it acts. This recursion explains why evolution appears directional without being teleological: constraints accumulate, and accumulated constraints narrow the space of viable configurations. The system becomes progressively more structured because coherence compounds.

Understanding evolution without environment also clarifies the relationship between evolution and development. Development is evolution under increasingly tight constraints; evolution is development under loosened constraints. Both are expressions of the same operator acting at different levels of freedom. The distinction between them is not ontological but parametric.

By removing the assumption of an external environment, we reveal evolution as a self-structuring operator. It does not act within a world; it **produces** the world's structure by recursively generating and refining the constraints that define coherence. Evolution without environment is evolution understood at its natural scale: not as a biological mechanism but as the universal operator that shapes reality.

6. EVOLUTION AS THE UNIVERSAL DEVELOPMENTAL ENGINE

If evolution is the universal operator that generates coherence, then development is not a separate process. Development is evolution under a different constraint regime. The distinction between the two is not ontological but parametric: both are expressions of the same operator acting with different degrees of freedom.

Evolution operates when constraints are loose. It explores wide possibility spaces, tests configurations against the structure of the domain, and stabilizes those that satisfy coherence requirements.

Development operates when constraints are tight. It channels possibility along narrow, predetermined pathways, ensuring that the system reliably reaches a coherent end-state. Evolution discovers viable forms; development reliably instantiates them.

This relationship becomes clear when we examine how constraints accumulate. Each round of evolution generates new stable configurations—physical laws, chemical regularities, biological architectures, cognitive schemas, cultural norms. These stabilized outcomes become the constraints that shape subsequent rounds. As constraints accumulate, the system's degrees of freedom narrow. The operator shifts from exploratory to developmental mode. What was once open-ended becomes canalized.

This is why development appears directional while evolution appears open. They are the same operator acting under different conditions. When constraints are sparse, variation dominates. When constraints are dense, retention dominates. The system transitions smoothly from evolutionary exploration to developmental execution as coherence compounds.

Understanding evolution as the universal developmental engine dissolves the boundary between biological development and the broader dynamics of structure formation. Planetary systems develop. Chemical networks develop. Cognitive architectures develop. Institutions develop. In each case, the system follows a trajectory shaped by accumulated constraints—constraints that were themselves produced by earlier rounds of evolution.

This reframing also clarifies why development is so reliable. It is not a separate mechanism but the late stage of a recursive operator that has already discovered the coherent pathways. Development is evolution with the search space collapsed. It is the execution phase of a mechanism that has already done its exploratory work.

Evolution is the universal operator; development is its constrained expression. Together they form a single generative engine that produces coherent structure across all scales of reality.

7. IMPLICATIONS ACROSS DOMAINS

If evolution is the universal operator that generates coherence, then its implications extend far beyond biology. Every domain in which stable structure emerges does so because the same operator is acting on different substrates under different constraint regimes. What appear to be distinct sciences—physics, biology, psychology, sociology, technology—are in fact different expressions of a single generative mechanism.

7.1 Physics: Coherence as Constraint Discovery

Physical systems evolve by exploring microstate possibilities and stabilizing configurations that satisfy the constraints of the domain.

- Equilibria are retained states.
- Phase transitions are shifts in constraint regimes.
- Attractors are stable solutions discovered through elimination of incoherent trajectories.

Matter itself is the result of evolutionary filtering at cosmological and quantum scales.

7.2 Chemistry: Reaction Networks as Evolutionary Search

Chemical systems generate variation through reaction pathways, select via thermodynamic and kinetic constraints, and retain stable compounds and cycles.

- Catalytic networks evolve toward coherence.
- Metabolic precursors emerge through iterative filtering.
- Chemical stability is retained coherence under constraint.

The boundary between chemistry and biology is not sharp; it is a gradient of constraint accumulation.

7.3 Biology: A Special Case of the Operator

Biological evolution is the most visible expression of the operator because it occurs at a scale where variation, selection, and retention are explicit.

- Genetic variation explores possibility.
- Ecological constraints select viable forms.
- Development retains coherent phenotypes.

But biology is not the origin of evolution; it is one of its products.

7.4 Cognition: Thought as Evolution in Representational Space

Cognitive systems generate representational variation, select via internal and external constraints, and retain stable concepts, beliefs, and strategies.

- Learning is evolutionary filtering.
- Memory is retained coherence.
- Reasoning is constrained variation.

The mind is an evolutionary engine operating on symbolic and sub-symbolic substrates.

7.5 Culture: Norms, Languages, and Institutions as Evolved Structures

Cultural systems evolve through social variation, normative selection, and institutional retention.

- Languages stabilize through iterative filtering.
- Norms persist because they satisfy social constraints.
- Institutions are retained solutions to recurring coordination problems.

Culture is evolution acting on shared representations and collective behavior.

7.6 Technology: Design as Guided Evolution

Technological systems evolve through intentional variation, functional selection, and material retention.

- Prototypes explore possibility.
- Constraints select viable designs.
- Standards and infrastructures retain coherence.

Engineering is evolution with human-guided variation and accelerated selection.

7.7 Civilization: Large-Scale Coherence Through Recursive Constraint

Accumulation

Civilizations evolve as layered constraint systems:

- physical → biological → cognitive → cultural → institutional → technological Each layer is the retained coherence of the layer beneath it, and each layer becomes the constraint surface for the next. Civilization is evolution stacked recursively.

Across all domains, the same operator is at work. What differs is the substrate, the source of variation, the nature of constraints, and the mechanism of retention. What remains constant is the operator's function: **to discover and stabilize coherent form.**

8. THE UNIVERSAL OPERATOR AND GOD

If evolution is the universal operator that generates coherence, then the question of why the universe

exhibits coherent structure at all becomes unavoidable. The existence of stable forms, lawful regularities, developmental trajectories, and recursively layered constraints demands an account of the generative principle behind them. In a separate paper, *Evolution as the Generative Signature of God*, this question was addressed directly: evolution was interpreted as the mechanism through which the divine signature becomes manifest in the structure of reality.

The present paper does not repeat that argument. Instead, it clarifies the operator-level foundation that makes such an interpretation possible. By showing that evolution is substrate-independent, recursive, and coherence-generating, we reveal why it has historically been associated with deeper metaphysical or theological significance. A mechanism that produces order across all domains naturally invites questions about the source, meaning, and scope of that order.

The relationship between the two papers is therefore architectural, not redundant.

- **This paper** establishes evolution as the universal operator that generates coherent structure.
- **The prior paper** interprets the universality and coherence of that operator as evidence of a deeper generative principle traditionally associated with the divine.

The two arguments are compatible but independent. One is structural; the other is interpretive. One describes how coherence emerges; the other explores what the existence of such a mechanism implies. By separating them, we preserve the scientific clarity of the universal operator thesis while acknowledging its broader philosophical resonance.

Evolution, understood at its natural scale, is not merely a biological mechanism but the generative engine of coherent reality. Whether one interprets this engine as a divine signature is a further step—one that lies outside the scope of the present paper but is made intelligible by it.

9. CONCLUSION

Evolution has long been treated as a biological mechanism, a process confined to organisms and their environments. This paper has argued that such a framing is far too narrow. Evolution is not a subsystem of biology; biology is a subsystem of evolution. The mechanism we call evolution—variation, selection, and retention—is a **universal operator**, a substrate-independent process that transforms undifferentiated possibility into coherent, self-maintaining form.

Across physical, chemical, biological, cognitive, cultural, technological, and civilizational domains, coherence emerges through the same operator acting under different constraint regimes. What differs is the material; what remains invariant is the structure of transformation. Evolution is the mechanism by which reality discovers which configurations can persist. It is the generator of coherence, the engine of development, and the recursive process that produces the very constraints under which it subsequently acts.

By dissolving the organism–environment dualism and reframing development as evolution under tightened constraints, we reveal a single generative mechanism operating across scales. This mechanism does not act within a pre-given world; it **produces** the world’s structure by iteratively filtering possibility through constraint. Coherence compounds, constraints accumulate, and systems transition from open-ended exploration to canalized development. The result is the layered, hierarchical, self-consistent structure of reality.

Understanding evolution as the universal operator restores its full ontological scope. It is not a metaphor, not an analogy, and not a biological curiosity. It is the fundamental mechanism by which coherent systems emerge, stabilize, and transform. Biology is one expression of this operator; physics is another; cognition and culture are still others. The universality of evolution is not an extension of Darwinism but a recognition of the deep structure of generative processes.

Evolution is not a process within reality. **Evolution is the operator that makes reality coherent.**

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