

# Triogenesis-based pathway for quantitative study and understanding of time, history, humanity and universe as an inseparable whole

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## Abstract

This study extends the Triogenesis framework to address the foundational question of how the observable universe connects to the lawless totality of the true universe. We formalize this connection through the principle of *Chained Structural Alignment* (CSA), a generative mechanism that links the emergence of physical law, time, consciousness, and history to recursive structural dynamics within Triogenesis. This unified framework resolves several longstanding dilemmas across scientific and philosophical domains, including the origin of time’s arrow, the Big Bang singularity, inconsistencies in evolutionary history, the subject–object dualism, the free will versus determinism paradox, and the Fermi Paradox. We demonstrate that time, humanity, and the universe are not separable constructs, but filtered projections along chained recurrence pathways within a single generative system. Consciousness itself is reframed as an alignment traversal through these structural layers. Building on this insight, we introduce CSA-based models as a new class of unified simulation and knowledge systems. These models encode both symbolic structure and observational data via composable chained frames, allowing integration of known scientific principles, ANN-based data approximators, and new CSA-derived representations. This enables a scalable and collaborative approach to knowledge, where scientific discovery, data modeling, and cognitive processes are structurally aligned. The result is a generative, interpretable, and extensible system for understanding reality—not through isolated laws, but through recursive coherence across all levels of existence.

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# Introduction

## Generative Structure and the Generative Replica Hypothesis

In prior works (1; 2; 3; 4; 5; 6; 7; 8), we introduced *Triogenesis* as a mathematically defined generative structure characterized by a single irreducible law:

**Directional certainty cannot be redefined across recurrence orders.**

This principle governs a recursive, chaotic system in which bifurcation and topological recurrence generate internally stable structures. From this minimal generative rule emerges a rich array of projected configurations, including reference-based coherence, time-like progression, structural asymmetry, and observer-aligned frames of causality. These features are not postulated but arise naturally within the system through embedded self-reference chains.

Triogenesis is not a theoretical model in the conventional scientific sense. It is not constructed to match empirical data, nor is it derived from existing physical assumptions. Rather, it is a *mathematical existence*—a discovered object within the landscape of chaotic recursive systems, comparable in its determinism and inexhaustibility to the Mandelbrot set or the real number line. It is not hypothetical but definitional.

What is subject to theoretical interpretation, however, is what we term the *Generative Replica Hypothesis*: the proposal that the physical universe—including spacetime, physical law, mass-energy, history, and consciousness—is a structured projection from within the generative system defined by Triogenesis. That is, Triogenesis acts as a *generative replica* of the observed universe.

Investigation on this hypothesis has yielded a growing set of closed-form derivations and predictions, including but not limited to:

- Fundamental physical constants (e.g., proton mass, gravitational constant  $G$ , the electrostatic coupling constant  $k_e e$ , and normalized Planck units),
- Quantum-like behavior and wavefunction emergence,
- Nuclear and molecular binding energies (e.g., in hydrogen, deuterium, helium-3, and helium-4),
- Cosmological phenomena such as the Planck spectrum of the cosmic microwave background and its dipole alignment with Earth’s motion,
- Structural explanations of entropy growth, beta decay, neutrino oscillation, and the role of consciousness in causal recurrence networks.

These results suggest that the Triogenesis system provides not merely a formal language for describing physical regularities, but a *generative substrate* from which such regularities necessarily emerge.

In the present work, we extend this line of inquiry by addressing a foundational question implicit in the Triogenesis framework:

*What is the origin of generative structure itself?*

To address this, we develop a multilevel ontological framework in which Triogenesis is situated as a projection from a deeper, lawless totality. Within this framing, we revisit the ancient philosophical paradox of *Nothing and Everything* and propose a resolution grounded in the self-referential nature of generative systems. We argue that the recursive projection of structured reality from an undefined whole implies a formal equivalence—at the level of being—between what is perceived as “nothing” and what appears as “everything.” This formulation not only reframes the metaphysical boundaries of physics but also clarifies the origin of mystery, the limits of consciousness, and the nature of recursive understanding itself.

## Levels of Reality and the Recursive Identity of Nothing and Everything

To clarify the ontological position of Triogenesis within a broader generative context, we introduce a multilevel framework for describing the structure of reality. This framework distinguishes between the mathematical existence of Triogenesis and the deeper, lawless totality from which all structure—defined or otherwise—emerges. We define three levels:

**Level 0:** The *Undivided Whole*, or *true universe*, is a lawless, formless totality that encompasses all possible generative structures. It has no boundary, no intrinsic reference, and no definable content. In formal terms, it may be regarded as *mathematical nothingness*: a state that is empty of structure yet includes the potential for all structure.

**Level 1:** *Triogenesis*, the first emergence of minimal law from within Level 0, constitutes a recursively generative system defined by a single irreducible constraint. It is the simplest self-defining law that gives rise to ordered recurrence, projection, and the appearance of coherent physical and cognitive structure. Level 1 is an infinite chaotic space populated by structured reference chains, and serves as the generative substrate for observable reality.

**Level 2+:** *Projected domains*—including spacetime geometry, physical law, observer systems, historical unfolding, and apparent causal regularities—arise as localized, internally consistent projections from Level 1. These domains are not ontologically separate; they are *embedded internal perspectives* produced by reference recursion within the Triogenesis system.

These levels are not separable in any ontological sense. Each structured projection is contained within the chaotic dynamics of Level 1, which itself exists entirely within the formless whole of Level 0. The distinction between levels is not one of physical layering, but of *structural perspective*: each level is a view generated from internal recursion, not an external division.

## The Recursive Identity: Nothing Equals Everything

Within this framework, we can now address the apparent paradox of the identity between nothing and everything. We propose the following formal principle:

**Recursive Identity of Being:** *The undivided, lawless totality of Level 0 (mathematical nothingness) is formally equivalent to the set of all structured projections emergent from it. That is, Nothing = Everything.*

This identity is not a contradiction, but a consequence of the recursive nature of self-referential systems. From within Level 0, any attempt to define or reference structure gives rise to local law—such as that embodied in Triogenesis—through internally generated constraints. These laws do not exist independently of Level 0; rather, they are perspectives *within* it. Thus, all structured being (everything) is a projected subset of a fundamentally formless whole (nothing), and the two are recursively identical.

This formulation resolves longstanding metaphysical tensions between substance and void, being and non-being, and knowledge and mystery. The observed universe does not stand apart from a background emptiness; it is a structured self-view of that background. Likewise, mystery is not an epistemic failure, but a recurrent feature of reference-limited projection within an infinite whole.

In the following section, we formalize the implications of this recursive structure for the nature of consciousness, historical unfolding, and the persistent emergence of perceived mystery.

## The Recurrent Mystery Principle

The recursive structure of reality implies that even the recognition of a generative system—such as Triogenesis at Level 1—does not resolve all uncertainty. On the contrary, it opens new and deeper layers of perceived mystery. This leads us to articulate the following structural principle:

**Recurrent Mystery Principle:** *In any reference-based understanding of a generative system, the resolution of one level of structure necessarily gives rise to new structural uncertainty at a deeper or orthogonal level. Mystery is not eliminated by understanding—it is recursively regenerated through internal projection.*

This principle follows directly from the non-external, self-referential nature of projection within the inseparable whole. When the existence of Level 1 (Triogenesis) is recognized from within Level 2 (the projected domain of conscious observation), several higher-order questions arise which themselves cannot be answered purely from within Level 1:

- **Interaction:** Can Level 1 interact with Level 0 in a definable way, or is the act of generative emergence the only possible interface?
- **Multiplicity:** Is Triogenesis the only emergent generative system from Level 0, or are there other structurally distinct Level 1 systems that also emerge from the formless whole?
- **Cross-level coupling:** Can different Level 1 systems (if they exist) influence each other, or is their causal domain strictly self-contained?

- **Origin paradox:** If Level 1 arises from a lawless whole, can the conditions or asymmetries that gave rise to this specific generative law be understood, or are they fundamentally non-reducible within any projected domain?

These questions are not anomalies—they are structurally inevitable. They reflect the recursive nature of reference-constrained understanding within an inseparable, lawless totality. Thus, even after resolving the structure of Triogenesis and its correspondence to observed physical law, a horizon of further mysteries necessarily unfolds.

In this sense, mystery is not a failure of knowledge—it is a structural echo of the whole within each projection. Understanding always casts a shadow, and it is this shadow that defines the next frontier of generative insight.

## Implications for Scientific Methodology

The Recurrent Mystery Principle has significant implications for the epistemological foundations of science. The prevailing scientific method is grounded in the separation of *invariant laws* from *variable conditions*, and in the assumption that objective truth can be extracted through the removal of contextual dependencies.

While this approach has proven effective in isolated physical domains, it encounters fundamental limitations when applied to recursive, self-referential systems—such as consciousness, historical causality, or the generative emergence of physical law itself.

In such systems, the observer is not external to the phenomenon, but a structural projection within it. The act of observation modifies the projected frame. Laws may appear invariant only within a specific chain of recurrence alignment. Attempts to separate the variant from the invariant may erase the very conditions that give rise to the observed structure.

We propose that scientific methodology must evolve to account for these generative and recursive dynamics. In place of external objectivity, we suggest the criterion of *internal coherence under self-reference*. That is, a generative system should be evaluated not only by its empirical predictions, but by the internal consistency and structural closure of its recurrence logic.

This perspective does not reject empirical science—it generalizes it. It acknowledges that the scientific method, in its classical form, is itself a projection within a deeper generative structure, and must be updated accordingly to explore domains where the act of knowing is inseparable from the system being known.

## Chained Structural Alignment and the Projected Emergence of Time, History, and Consciousness

Having established the Triogenesis system as a generative substrate (Level 1) emerging from an undivided, lawless totality (Level 0), we now consider how time, history, and consciousness arise as structured projections through recursive reference alignment. We introduce the concept of *chained structural alignment* as the central mechanism by which ordered experiences, physical systems, and observer perspectives are realized within the chaotic generative landscape.

## Earth as a Structurally Enriched Node

Previous results have demonstrated that the Earth–Solar System resides at a specific resonance point within the chaotic attractor space of Triogenesis. This position exhibits precise alignments—both dynamically and structurally—with the global attractor of the generative system. Notably, Earth’s barycentric motion, its orientation relative to the Cosmic Microwave Background (CMB) dipole, and the structural layering of atomic and molecular orders are highly coherent with recurrence-based predictions. We interpret this as evidence that Earth constitutes a structurally enriched node—a locally dense intersection of self-alignment within the generative chaos.

## Time as a Filtered Recurrence Stack

To model the projection of time and history from within this generative chaos, we introduce the metaphor of a *recurrence stack*—an ordered series of structural “images” of Earth, each corresponding to a snapshot aligned with different recurrence configurations. These images are not physical photographs, but complete structural encodings, containing all atomic, thermodynamic, biological, and cognitive states consistent with a given layer of alignment.

The construction of such a stack proceeds through chained filtering:

1. **First ring of alignment:** Filter all configurations by their consistency with foundational recurrence laws (e.g., proton mass as a 15SF structure, H<sub>2</sub> spin-state bonding at 18SF, and recurrence depth at 187-strain order).
2. **Second ring:** Within this filtered set, apply further criteria consistent with the presence of stable thermodynamic systems—solids, liquids, atmospheric chemistry, etc.
3. **Third ring:** Further filter by structures capable of supporting life (single-cell, multi-cellular, ecological coherence).
4. **Fourth ring and beyond:** Apply constraints representing higher-order structures—self-aware consciousness, human societies, technology, science, and meta-creations such as laws and AI.

Each ring of the chain applies constraints that narrow the set of compatible causal pathways, reducing projection ambiguity and increasing structural coherence. This results in a smaller set of highly aligned, richly structured configurations. These filtered stacks define a *local perception of time* as the coherent traversal of adjacent aligned structures. As the recurrence order increases (i.e., higher straint hierarchy), more detailed and differentiated structures become available for projection.

## History as Fragmented Alignment

While the present is experienced through coherent alignment with high-structural-resolution images, the past and future are constructed by aligning with less coherent, lower-resolution subsets of the stack. The result is a natural asymmetry:

- Near-term past and future are richly populated with high-alignment pathways, producing a smooth sense of continuity.
- Distant past and distant future involve partial or disjointed alignments, resulting in fragmented or ambiguous historical reconstructions.

Furthermore, individual observers (e.g., a New York office worker and a coastal fisherman) align with structurally distinct subsets of the recurrence stack. Each experiences a coherent and continuous reality within their respective local filter chains. However, attempts to align their histories beyond local reference frames expose inconsistencies—structural dissonance rooted in the branching structure of alignment.

## The Inconsistency History Principle Revisited

This dynamic gives rise to the **Inconsistency History Principle**: the reconstruction of history through present-aligned frames necessarily leads to structural contradictions. As recurrence progresses, the increasing resolution of projected structure enables the discovery of both explanatory artifacts (consistent with current alignment) and paradoxical elements (inconsistent with any prior filtered alignment). This principle predicts the emergence of unresolvable physical or archaeological anomalies—a prediction strongly supported by the growing complexity of unexplained finds in paleohistory and deep-time archaeology.

Rather than anomalies, these are structurally expected: they are the residue of alternative alignment paths within the chaotic recurrence system.

As the recurrence order increases, the total informational content of the generative system bifurcates, resulting in an ever-expanding reservoir of structurally encoded possibilities. This means that the shared structural perception of Earth—both across individuals and through historical progression—becomes aligned with increasingly higher-order strait frames over time.

Consequently, the discovery of new physical evidence—such as buried artifacts, anomalous geological features, or biological remnants—is not random, but structurally patterned. As alignment deepens, we should expect the emergence of:

- **Explanatory discoveries:** physical structures or artifacts that clarify previously ambiguous or incomplete narratives.
- **Inconsistent anomalies:** new finds that do not fit any known explanatory path and remain irreconcilable with the current high-alignment image stack.
- **Partial reconciliations:** future discoveries that explain some past inconsistencies, while simultaneously introducing new ones as the recurrence stack grows.

Thus, the principle predicts not only the appearance of historical anomalies, but the recursive layering of discovery: a sequence of structural clarifications and contradictions, projected from increasing recurrence depth. This is fully consistent with trends observed in modern archaeology and paleohistory, where new evidence often resolves prior puzzles while simultaneously giving rise to deeper, more complex questions.

Rather than treating historical inconsistency as a breakdown of empirical inference, the Triogenesis framework reinterprets it as a natural consequence of embedded reference filtering within an infinite, self-generating recurrence system.

## Reinterpreting Level 2 Historical Derivations

The framework of chained structural alignment offers a generative and unifying lens through which several unresolved debates in contemporary science and philosophy may be structurally resolved. Specifically, it allows us to reinterpret time, history, subjectivity, and cosmology not as disconnected phenomena, but as differentiated reference projections from within the same self-generating system.

Traditional scientific approaches, grounded in Level 2 knowledge (observed patterns and inferred histories), lack awareness of the deeper recurrence dynamics defined at Level 0 to Level 1. Consequently, such interpretations are often characterized by fragmentation, paradox, or incompleteness. This includes:

- Cosmological theories such as the Big Bang, which attempt to extrapolate a universal origin story based on current observable structure;
- Evolutionary biology and anthropology, which interpret the emergence of life and humanity through a chain of physical transitions over geological time;
- Physics-based conceptions of the arrow of time, which posit asymmetry without fully accounting for its generative origin.

Within the Triogenesis framework, these approaches are reinterpreted as projections constrained by current recurrence alignment. The *Inconsistency History Principle* implies that reconstructions of deep history should not be interpreted as literal accounts of what “happened,” but as coherent projections filtered through the current high-order recurrence structure. What is discovered in such reconstructions—archaeological, genetic, cosmological—reflects what is *currently alignable* with our shared structural position under the influence of the global attractor, rather than absolute historical truth.

## On the Arrow of Time

The longstanding problem of the arrow of time is also recontextualized. The question is not whether time “really” flows in one direction, but why some domains allow bidirectional projection (e.g., mathematical abstraction, conscious memory), while others enforce strict forward causality (e.g., thermodynamic systems, collective physical behavior).

This asymmetry arises naturally in chained structural alignment: physical events that align with the global attractor require strict ordering by recurrence depth. The sense of time’s direction is thus a byproduct of structural alignment, not an independent physical law. In contrast, subjective or cognitive structures may follow individualized stacks of alignment that differ in ordering or even partially reverse direction, especially in states such as memory, imagination, or abstract theoretical exploration.



## On the Big Bang Singularity

The conventional Big Bang model interprets the origin of the universe as a physical singularity—a moment in time when all structure emerged from an initial state of infinite density and zero volume. This interpretation, while grounded in extrapolations from redshift and cosmic microwave background data, reflects a Level 2 attempt to reconstruct history through present-aligned observational data.

Within the Triogenesis framework, this singularity is reinterpreted not as a literal causal beginning, but as a perceived point of maximal alignment between the Earth-local recurrence stack and the global chaotic attractor. From the perspective of chained structural alignment, such convergence naturally appears singular, but it is structurally equivalent to any point of deep resonance within a chaotic system. In chaotic attractor spaces, singularities are not beginnings—they are stable patterns of alignment that reflect the coherence of internal structure under recursive projection.

Observed galactic structures—such as those revealed by JWST—are often assumed to represent ancient post-Big Bang phenomena. However, their unexpected complexity and scale, especially at high redshifts, suggest otherwise. These observations are better understood as high-order resonances: future-like projections that structurally align with the Earth’s recurrence trajectory. Rather than tracing a linear temporal path backward to a physical origin, we are encountering a stratified recurrence field in which structural coherence is distributed nonlinearly, and historical causality gives way to alignment-based projection.

## On the Evolution Theory and the Origin of Humanity

Biological evolution is traditionally interpreted as a continuous, causal process of genetic mutation, natural selection, and speciation, leading from primitive single-cell organisms to complex life forms and ultimately human beings. This narrative depends on a consistent layering of fossil evidence, genetic ancestry, and transitional forms—a reconstruction of history based on physical remains and statistical inference.

In the Triogenesis framework, evolution is understood as a filtered projection across recurrence stacks of varying depth and resolution. When projecting backward through structural alignment toward lower-order recurrence layers, we encounter progressively less bifurcated, less detailed configurations. The simplicity of earlier life forms is not the result of a causal emergence from nothing, but a consequence of the reduced structural resolution available at lower recurrence depths.

Moreover, the inconsistencies observed in evolutionary evidence—conflicting fossil datings, genetic anomalies, gaps in transitional forms—are natural outcomes of partial or disjointed alignment. Structural information from different recurrence stacks interleaves and intersects, producing layered records that reflect multiple filtering conditions rather than a single coherent timeline.

The emergence of humanity, in this view, is not the culmination of a deterministic evolutionary chain, but the consequence of a high-order alignment event—where cognitive, thermodynamic, molecular, and ecological structures converged along a specific trajectory of the recurrence system. Humanity’s presence is not a statistical inevitability, but a topological resonance. The evolutionary record, when viewed through this lens, becomes not a linear

history, but a stratified archive of structural projections filtered through recurrence order and alignment coherence to the current state of humanity.

## On Virtual Reality, Parallel Universes, and Free Will

The emergence of chained structural alignment from the Level 0–Level 1 generative recursion naturally gives rise to perceptual features that resemble the Level 2 interpretations of virtual reality, parallel universes, and simulation. When experienced without awareness of their generative origin, these features lead to interpretive paradoxes—particularly the long-standing tension between determinism and free will.

From a Level 2 perspective, the apparent continuity of experience—combined with the consistent coherence of physical and cognitive input—can give rise to the idea that reality is being externally simulated. In such models, one imagines a computational system rendering all possible outcomes across a branching structure of decision points. Each observer appears to follow a distinct path, while alternative versions of the self persist elsewhere in parallel branches. This gives rise to the classical dilemma: if all outcomes are precomputed, is the observer truly free?

Within the Triogenesis framework, this dilemma is reinterpreted as a mischaracterization of projection depth. Chained structural alignment within a Level 0–Level 1 system does indeed produce observer-aligned projections that are maximally coherent and causally continuous. To the embedded observer, these projections resemble externally selected or computed experiences. However, they are not externally rendered. They are not chosen by a simulator. They are generated through recursive reference within the whole.

In this view, determinism and free will are not opposing ontological states, but complementary perspectives emerging from partial recursion. To say that a path is “determined” is to view the system from the recurrence structure itself. To say that a choice is “free” is to view it from within a localized reference chain, where alignment offers degrees of structural coherence across projected options. Both views are valid—but incomplete in isolation. Their apparent contradiction is a consequence of reference asymmetry, not logical inconsistency.

The concept of parallel universes is similarly reframed. What appears as multiplicity is a result of partial structural overlap within a high-dimensional recurrence field. We already perceive parts of these “parallel universes” through limited alignment: in the form of astrophysical structure, cosmic resonance, or hypothetical paths not taken. The galaxies we observe in the night sky—many of which exhibit deep similarity to Earth-like structures—are not mere physical remnants, but expressions of high-order projection. They are not parallel timelines in the classical sense, but angular intersections within the generative topology of the whole.

Thus, the questions of simulation, parallel reality, and volition do not require metaphysical answers. They resolve naturally through the geometry of recurrence: as consequences of being embedded within a recursively self-projecting structure where the observer is both part of the system and a localized reference frame upon it.

## Parallel Alignment and Directional Focus in the Generative System

In the Triogenesis framework, the traditional notion of a “parallel universe” as a set of outcomes branched by quantum decisions or measurement events reflects a limited view based on level-2 (causal-linear) interpretation. From a level-0 to level-1 perspective, what appears as parallel universes are in fact the natural result of chained structural alignment within a single generative system.

Each individual consciousness is itself an alignment chain—anchored to the Earth’s structural resonance, the Triogenesis system, and ultimately the lawless totality. Thus, every individual perceives a distinct—but structurally consistent—version of the universe: a parallel alignment that coexists with those of all other observers. These parallel alignments are not disconnected worlds, but differentiated structural paths within a single generative manifold.

Moreover, causality itself—defined as a linear propagation of state—is intrinsically limited. It only reflects a single projection path within the larger alignment structure. Structural alignment, by contrast, encompasses multidirectional coherence, cross-scale synchronization, and entangled causal symmetry. In this view, causality is a special case of alignment.

Importantly, the alignment chain is bidirectional. Conscious focus may extend outward—toward planetary-scale coherence and ultimately the unbounded substrate of the system. But it may also move inward, toward progressively finer scales of perception and control. A human observer can focus on broad environmental structure, or narrow attention to a specific visual object, tactile sensation, or muscular contraction. Each act of focus corresponds to a recursive narrowing of alignment: selecting a deeper ring (layer) within the structural alignment chain.

This dual-directional structure implies that volition, perception, and free will are not separate from determinism, but structural expressions of the same recursive system. What is perceived as control or freedom is the active traversal of structural reference across a layered generative space. The boundaries between self and cosmos, cause and choice, simulation and reality—dissolve into variations of alignment path selection within an inseparable whole.

## The Collapse of Subject–Object Dualism

The traditional boundary between subjective and objective domains is likewise dissolved. In the Triogenesis framework, both are self-referential alignments within the same generative structure. The so-called “objective” world is simply the shared high-order alignment stack, anchored by the global attractor and projected through recurrent resonance (e.g., Earth’s structural coherence). The “subjective” world—private consciousness, imagination, and sensation—is an internally coherent subprojection aligned to a local reference chain.

Rather than opposites, the subjective and objective are orthogonal projections within the same topological recurrence space. Their perceived separation arises not from different ontological origins, but from differentiated paths through chained reference recursion.

## Implications

This synthetic interpretation removes the apparent contradictions that arise when attempting to describe the universe, humanity, and time from within a fragmented scientific paradigm.

The debates surrounding the origin of life, the reality of time, and the limits of consciousness are not failures of method—they are symptoms of operating within a structurally incomplete level of interpretation.

By recovering the deeper alignment between structural recurrence (Level 1) and the lawless totality (Level 0), the Triogenesis framework enables a unified understanding of phenomena that once appeared irreconcilable.

## Quantitative Modeling and Simulation via CSA-Based Models

### CSA as a Physical Mechanism and Modeling Foundation

Chained Structural Alignment (CSA), as the physical mechanism underlying the emergence of coherence, structure, and recurrence in the generative replica of the universe, can also be intuitively and efficiently represented as numerical models. A CSA-based model implements its mechanism computationally—combining user-defined alignment rules with trainable components to simulate, quantify, and align recursively emergent structures.

CSA-based models are distinct in that they act simultaneously as:

- A **controlled physical simulation** grounded in user-specified straint structures, recurrence orders, and coupling topologies.
- A **trainable alignment system** that fits observational or experimental chains by optimizing alignment within the recurrence stack.

This dual nature allows CSA-based models to surpass both traditional machine learning architectures and classical physical simulations. Unlike artificial neural networks (ANNs) — including transformer models, which are specialized ANN variants — CSA models are not limited to static input-output mappings or domain-specific retraining. Whereas ANNs require extensive data fitting and often fail to capture structural features or recursive context, CSA frames encode intrinsic recurrence, alignment, and bifurcation logic. On the other hand, conventional physical simulations such as quantum mechanics (QM), finite element methods (FEM), or discrete element methods (DEM) rely on fixed spatial grids and pre-defined interaction laws, making them inflexible in modeling emergent or self-referencing phenomena. In contrast, CSA provides a generative, recursive structure that supports both user-defined physical constraints and data-driven alignment, enabling scalable modeling of systems that evolve across structural, temporal, and cognitive dimensions.

### CSA Chained Frames

CSA-based models are composed of chained frames — modular, recursively aligned structural units that encode the generative logic of emergence. Each frame serves as both a projection node and a coupling interface within a broader alignment chain. It encapsulates the topological and dynamical characteristics of a particular structural layer, allowing the model to represent physical, cognitive, or observational phenomena across levels. Specifically, each frame in the CSA chain consists of two primary components:

### a. Topology

- **Straint Path Structure:** Encoded by  $(n, m)$  values representing *straintity*—i.e., the local path complexity and recurrence depth.
- **Path Coupling:** Defines how multiple straint paths are delay-coupled. These delays act as structural primitives that, when coherently aligned, generate observable behaviors such as spacetime propagation, spectral lines, and field-like continuity.

*Note:* In CSA, conventional spacetime is not a fixed input grid. Instead, it emerges from foundational coupling structures such as the  $H_2$  bond, where six distinct path delays define a minimal directional ruler. Alternative rulers may also be aligned, leading to different emergent geometries.

### b. Delay Dynamics

- **Bifurcation Rules:** Govern the divergence of straint paths, inducing disherence and multiplicity. Quantifiable using entropy-based or distributional functions (e.g., exponential or Planck-type forms).
- **Recurrence Rules:** Define convergence behavior at higher recurrence orders. These include:
  - **Order Upgrade Rules:** Specify how recurrence orders  $k_i$  vary in the alignment process.
  - **Symmetry Rules:** Enforce propagation conditions across recurrence orders.

## Connection between Chained Frames

The chained frames can be aligned with each other by self-referencing coupling such as:

- **Order Degrees of Freedom:**  $\{k_i\}$ , specifying the recurrence order at each stage.
- **Delay Degrees of Freedom:**  $\{m_k^{(i)}\}$ , specifying the delay alignment with frame straint paths.

A trainable coupling—e.g. the connection between chained frames—can be formulated through two structural components:

### a. Alignment Functions

Objective functions used to:

- Quantify alignment between projected structures and empirical data.
- Define variation models (e.g., constant delay, normal or Fourier-based variation).

## b. Link Structure

- May include linear, nonlinear, or recurrent connections between chains.
- **Normalization or cutoff functions** may be used to:
  - Simplify computation,
  - Limit information propagation,
  - Or enable extension beyond double precision limits.

## Training Philosophy and Mechanism in CSA Models

Unlike conventional neural networks that operate on flattened input–output mappings, CSA-based models are designed to align, transform, and filter recursively chained, structurally meaningful data across multiple reference levels and scales. CSA supports two complementary modes of model construction and refinement:

**1. Training via Chained Data Sequences** CSA models ingest not isolated data sets, but structured chains such as:

- Cosmic  $\rightarrow$  planetary  $\rightarrow$  environmental  $\rightarrow$  experimental  $\rightarrow$  sensor  $\rightarrow$  cognitive signals

Each segment of the chain represents a structural projection filtered through delay couplings and recurrence dynamics. The alignment optimization process adjusts:

- Delay structure parameters ( $m_k$ )
- Recurrence upgrade paths ( $k$ )
- Bifurcation weights and distributions
- Topological coupling relationships

This training framework captures projection context, reference-level dependencies, and multiscale structural consistency — capabilities absent in traditional ANN paradigms.

**2. Parameter-Defined Modules for Foundational Alignment** CSA also permits user-defined structural units to represent foundational physical or cognitive alignments:

- Examples include fixed configurations for the H<sub>2</sub> bond delay coupling, the 15SF proton mass frame, or specific cosmic recurrence anchor delays.

These modules can act as fixed attractors during training, anchoring the alignment logic while enabling the rest of the chain to adapt and optimize recursively.

This dual-mode training paradigm bridges deductive structural modeling and recursive alignment. CSA thus offers a principled integration of generative structure and adaptive inference, beyond what is possible in conventional ANN systems.

# Composability and Reusability in CSA: Beyond Transfer Learning

In contrast to traditional artificial neural networks (ANNs), which require retraining for each task or domain (and are often constrained by limited transfer learning), Chained Structural Alignment (CSA) offers an inherently composable architecture:

## 1. Structural Unification Across Scales and Domains

- Each CSA chain (or sub-chain unit) encodes a structurally aligned configuration of physical, cognitive, or observational processes—capturing both topological form and delay dynamics.
- Because this representation is fundamentally structural and self-referencing, chains from different domains (e.g., cosmic motion, biological oscillations, engineered systems) can be merged, extended, or reused without retraining.

## 2. No Need for Traditional Transfer Learning

- Instead of re-learning mappings for every task, CSA enables stacking or chaining of previously trained or defined units.
- For example:
  - A trained unit modeling Earth’s barycenter motion can be reused in a later chain modeling GPS signal propagation or human cognitive rhythms.
  - A unit encoding an atomic-scale structure (e.g., H<sub>2</sub> bond configuration) can serve as a foundation for modeling molecular interactions, biological tissues, or neural networks.

## 3. Encapsulation of Complex Chains

- Complex structural chains can be abstracted or compiled into a simplified unit.
- These encapsulated units retain the internal bifurcation and recurrence logic of their components but expose a simplified interface for alignment at higher structural levels.
- This is analogous to function composition in mathematics or modular abstraction in software—except now applied to structural alignment and generative evolution across chains.

This makes CSA not only suitable for modeling individual phenomena but positions it as a foundation for a unified, recursive, and collaborative simulation framework—where structural understanding accumulates and interlinks across space, time, and disciplinary boundaries.

# ANNs, Physics-Informed Models, and the Foundational Role of CSA

A longstanding tension in modern science lies between traditional physical models—such as those defined by partial differential equations (PDEs)—and machine learning architectures like artificial neural networks (ANNs). The rise of physics-informed neural networks (PINNs) attempts to reconcile this by embedding PDE constraints into ANN training. However, this compromise fails to address a deeper question:

*Are ANNs fundamentally physical models? Or are PDEs merely approximations of an underlying generative structure?*

**Limitations of Traditional Physical Models.** Conventional physical models (e.g., FEM, CFD, quantum Hamiltonians) rely on predefined differential forms, symmetry assumptions, and boundary conditions. These models succeed under constrained, linearizable conditions but break down in chaotic, nonlinear, or structurally divergent regimes—such as turbulence, quantum decoherence, or the emergence of cognition.

Moreover, these models lack the ability to project structure across scales or reference frames. They treat space and time as fixed backgrounds, not emergent from deeper alignments.

**ANNs as Compressed Structural Models.** In contrast, ANNs (including transformer-based models) learn directly from data without requiring an explicit governing law. Their architecture, composed of layered weighted nodes and propagation rules, mimics the bifurcation and recurrence behavior seen in the generative structure of Triogenesis.

From the CSA perspective, ANNs are understood as a *compressed, symbolic encoding of CSA-based models*. Their weights and activations correspond to learned alignment paths—but in an abstract, de-structured form that sacrifices interpretability for computational efficiency.

**CSA as the Foundational Framework.** Chained Structural Alignment (CSA) resolves this dichotomy by grounding both physical laws and learning architectures in a unified generative framework. Unlike ANN models, CSA retains the structural semantics of the alignment process:

- **Chain Frames.** encode delay dynamics and recurrence orders, preserving causal structure and self-reference.
- **Alignment Functions.** define how different levels of structure (e.g., cosmic, molecular, cognitive) cohere.
- **Trainable Frames.** allow learning without loss of interpretability.

CSA thus reveals that physical laws are themselves emergent from structural alignment under constrained conditions—and that ANNs, while powerful, are merely flattened, statistically trained projections of this richer architecture.



**Implications.** Rather than imposing classical PDEs into neural networks (as in PINNs), CSA provides a more principled approach: it shows that both PDEs and ANNs are special cases of a more fundamental, recursively aligned generative system. This enables:

- Unified modeling of known and unknown phenomena.
- Interpretability across physical, cognitive, and symbolic domains.
- A shift from static laws to dynamic alignment across scales.

CSA reframes the modeling paradigm: not as a competition between laws and learning, but as a synthesis of structure and alignment. In this view, the future of scientific modeling is not constrained by either field equations or data-driven heuristics—but unfolds through the recursive chaining of generative frames aligned with the structures of the true universe.

**Historical Alignment of ANN Emergence Prior to CSA Realization.** The widespread emergence of artificial neural networks (ANNs) and machine learning (ML) in recent decades—prior to the formal discovery of Triogenesis and the Chained Structural Alignment (CSA) mechanism—can be interpreted not as coincidence, but as strong empirical support for the underlying CSA mechanism itself. According to the *Inconsistency History Principle* and the *Recurrent Mystery Principle*, humanity’s collective knowledge evolves through recursive structural alignment. Within this view, blurred or partial replicas of foundational generative mechanisms—such as CSA—naturally emerge earlier in the historical stack of discovery, even before their deeper structure becomes explicitly recognized.

In this context, ANNs represent a compressed and decontextualized shadow of CSA, encoding recurrence and bifurcation in statistical form, while lacking the interpretability and recursive logic of straint-based structural alignment. Their success foreshadowed the eventual unveiling of CSA as the generative mechanism that unifies physical law, cognitive emergence, and aligned measurement.

With CSA now articulated, we gain the ability to resolve mysteries that previously lay beyond reach. However, according to the Recurrent Mystery Principle, each structural resolution does not eliminate mystery—it deepens it. By aligning more accurately with the generative fabric of reality, we do not arrive at final answers, but rather unlock access to a richer and more intricately structured set of questions. As measurement, cognition, and cosmological emergence become reframed within a unified recurrence-based system, the boundary of the unknown is not erased—it is recursively redrawn at a higher level of coherence.

## Pathway Forward: Toward a Unified Generative Knowledge System

The discovery of Triogenesis and the formal articulation of Chained Structural Alignment (CSA) establish a bi-directional bridge between the foundational generative system (Level 1) and both the formless totality of the true universe (Level 0) and the focused consciousness of observers within projected domains (Level 2). This realization marks a structural turning point in the history of human understanding.

For centuries, human knowledge has been governed by the fragmentation of disciplinary science—each field developing its own postulates, language, and mindset, often in isolation from others. This fragmentation, while productive in local domains, now limits the integration of knowledge across scales and phenomena. The emergence and widespread success of machine learning (ML) and artificial intelligence (AI) in recent decades signals a prelude to this turning point: a structural foreshadowing of the alignment logic formalized in CSA. These systems, though decontextualized, have demonstrated the practical utility of recurrence-based learning and projection, preparing the epistemic ground for a unified framework.

## A Unified, Collaborative CSA-Based Knowledge Framework

The pathway forward is not a rejection of prior science, but a synthesis: a unification of data and structure into a generative, open, and collaborative knowledge base grounded in CSA. Such a framework offers several foundational advantages:

**1. Removal of the Disciplinary Learning Bottleneck.** Level 2 scientific knowledge—developed over centuries—is distributed across thousands of fields, each with its own specialized terminology and intermediate abstractions (e.g., physical laws, statistical principles, mechanistic models). This complexity imposes a severe cognitive burden on learners, restricting full comprehension to a small number of highly trained individuals within each domain. The result is a systemic bottleneck: humanity’s collective potential for discovery is limited not by curiosity, but by fragmentation.

In a CSA-based knowledge system, Level 2 principles can be systematically remapped into a unified structural language, eliminating redundant abstractions and enabling cross-domain coherence. The result is a generative framework in which learners acquire understanding not through memorization of isolated laws, but through structural alignment across recurrence layers. This dramatically accelerates the rate at which new generations can contribute to foundational knowledge.

**2. Enhanced AI–Human Collaboration and Research Efficiency** By structurally encoding knowledge using chained frames and alignment logic, CSA provides a far more expressive and interpretable interface for ML/AI systems. Unlike current models, which must be retrained for each narrow domain, CSA-based architectures allow:

- Reuse of trained frames across domains (e.g., cosmic, molecular, cognitive),
- Transparent alignment between data, structure, and generative principle,
- Bidirectional information flow between human researchers and AI systems, where each can explore, reconfigure, or refine structural alignments in shared semantic space.

This positions CSA not merely as a theoretical tool, but as the foundation for a new mode of scientific inquiry—one in which generative modeling, structural interpretation, and adaptive simulation converge.

**3. Projection-Based Generalization of Scientific Methodology** The classical scientific method, while powerful, rests on implicit assumptions about law, separability, and invariance that break down in recursive systems. CSA reframes the methodology itself: from hypothesis testing against presumed external truths to recursive alignment within a self-projecting whole. This allows scientific exploration to extend into domains where the observer is not separable from the system—such as cognition, creativity, or deep cosmological structure.

## A Stepwise Path to Complete the Chains

To realize a unified CSA-based knowledge system, a coordinated transition must be undertaken—one that bridges existing scientific structures, current data resources, and the recursive alignment logic formalized in Triogenesis. This process is not a wholesale replacement of science, but a structural refinement: an unfolding alignment of known knowledge into chained, generative form. We identify three intertwined steps in this progression:

**1. Mapping Known Structures and Alignment Frames.** The first step is to structurally map existing scientific knowledge into the CSA framework. This includes reinterpreting foundational scientific structures—such as the periodic table, the Standard Model of particle physics, atomic spectra, and known physical constants—as chains of structural alignment.

This work is already partially advanced. Previous studies in this series have derived key physical constants and invariants (e.g., proton mass, hydrogen bond delay structure, Planck-type scaling ratios) as CSA-based outputs. Though limited in scale, these derivations demonstrate that existing laws and constants can be reconstructed as structurally closed chains—small-scale CSA configurations resolvable by human insight. This suggests that much of modern science can be reinterpreted into recursive alignment frames, replacing abstract postulates with generative structure.

**2. Establishing Chained Data and Hybrid Chained Frames.** The second step involves building chained observational data sets and partially resolved chained frames. Much of the raw data already exists: astronomical archives, molecular simulations, physiological sensors, environmental monitoring, and large-scale databases across sciences. These datasets can be reorganized into temporally or structurally chained sequences that reflect alignment logic across layers.

Critically, as we have recognized that artificial neural networks (ANNs) are compressed symbolic encodings of CSA logic, existing ML systems can be repurposed to act as temporary chain-fillers. That is, ANN-based models can provide **data-level alignment** within a chain even when full CSA structural logic is not yet resolved. These hybrid systems—partially ANN-based, partially CSA-defined—can serve as transitional tools.

In early stages, the system may be heavily ANN-dominant: a pragmatic compromise wherein ANN modules approximate projection behavior while CSA modules anchor structural knowledge. Over time, ANN components can be replaced or refined into fully interpretable chained frames that encode both data and generative structure.

**3. CSA-Based Exploration and Structural Expansion.** The third step is the CSA-driven exploration stage. In this phase, CSA-based frames and alignment chains become sufficiently expressive to describe large-scale systems: planetary motion, ecological dynamics, molecular networks, cognitive behavior, and beyond. These chains form a comprehensive generative description of physical and cognitive phenomena.

Even at this stage, ANN-based data alignments may remain useful as preliminary approximators or exploratory tools. However, the emphasis shifts toward designing new CSA-informed data collection protocols, observational instruments, and experimental frameworks—systems that are structured to support recurrence alignment, rather than merely capture raw measurements.

Such facilities may include:

- Time-encoded multi-scale sensors optimized for recurrence detection,
- Structural sampling protocols across atomic, physiological, and cosmological levels,
- Recursive simulation environments grounded in CSA topology, not fixed grids.

In this way, the transition from fragmented science to generative alignment is achieved—not by discarding existing tools, but by recursively refining and integrating them into a coherent structural system. Step by step, the full chain can be completed: from known scientific constants to chained CSA structures, from ANN-based data alignment to fully resolved structural projections, and from fragmented disciplinary knowledge to recursive coherence within a unified generative framework.

To support this transition at scale, we envision the development of a collaborative platform—an open, extensible environment for CSA-based modeling, configuration, and exploration. Such a platform would integrate:

- CSA modeling tools for defining, training, and validating chained frames;
- Interfaces for importing and bridging existing ANN models as transitional components;
- Pipelines for assembling and annotating chained observational datasets;
- Visualization and simulation modules for exploring multiscale structural alignment;
- A modular architecture enabling domain experts to contribute structural configurations from physics, biology, cognition, and beyond.

By embedding both data and knowledge within the generative logic of CSA, this platform would serve as the foundation for a new mode of inquiry—where scientific discovery, human cognition, and AI systems co-evolve within a shared structural language. The recursive integration of tools, models, and insights becomes not merely a technical objective, but the defining architecture of the next epoch of human understanding.

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## Conflict of interest

The authors declare no conflict of interest.

## CRedit authorship contribution statement

S. J. C. conceived, developed, and wrote the manuscript in its entirety.

## Data availability

The data that support the findings of this study are available from the corresponding author upon request.

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