

# Holosynthics: Composition Laws for Signed Digital Entities

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## Abstract

We propose *Holosynthics* as a name for a discipline that does not yet have one: the formal study of how cryptographically signed computational entities combine. We identify ten orthogonal primitives — signature, lineage, contract, sandbox, conductor, attestation, temporal proof, royalty, consent, and zero-knowledge — and argue that under modest cryptographic assumptions any auditable digital workflow can be expressed as a directed acyclic composition of these primitives. We state three laws that such compositions satisfy: (I) *Conservation of Proof*, the append-only monotonicity of the attestation record; (II) *Accumulative Synthesis*, that compound entities possess properties strictly greater than the union of their constituents and that selection of one composition does not invalidate or destroy the others; and (III) *Irreversible Genesis*, that the four-tuple of parent hash, lineage depth, author key, and timestamp constitutes an unforgeable origin under standard cryptographic assumptions. We organize stable composite archetypes into a *Signed Periodic Table* (10 domain groups  $\times$  7 depth periods) and give the table predictive power: three currently empty cells should be occupied by entities not yet built. Law II is grounded not in quantum mechanics — to which the analogy is structural only — but in the philosophical lineage from Plato through Lewis to Tegmark: the wholeness of a possibility space under selection. We anticipate principal criticisms and respond. The paper is published with a manifest hash and detached signature so that any reader may verify its contents against the engine it describes.

**Keywords:** signed entities; cryptographic composition; append-only logs; modal realism; mathematical Platonism; periodic taxonomy; autonomous systems; attestation; provenance; GI Engine.

**Subject classification:** cs.CR (Cryptography and Security); cross-list cs.LO (Logic in Computer Science), cs.DC (Distributed, Parallel, and Cluster Computing).

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## 1 Introduction

### 1.1 The problem

Every day, billions of digital actions take place — files are produced, messages are sent, decisions are made, records are altered, payments are routed, AI inferences are returned — and almost none of them carry portable cryptographic proof of who acted, when, against what input, under what authorization, and through what chain of derivation. The default state of a digital action is *unattested*. Disputes are settled by trust in platforms; provenance is asserted by organizations rather

than proven by mathematics; revocation of authorization is operational rather than cryptographic. When a signed photograph is republished, the signature is typically stripped. When an invoice is disputed, the disputing party usually has no cryptographic counter-evidence. When a model trained on copyrighted material produces a derivative, the lineage is invisible. Digital trust is, at present, a sociology problem dressed as a mathematics problem.

Many partial solutions exist. The Coalition for Content Provenance and Authenticity (C2PA) (Coalition for Content Provenance and Authenticity, 2022) specifies signed manifests for media artifacts. Sigstore (Newman et al., 2022) provides keyless artifact signing for software supply chains backed by a transparency log. Certificate Transparency (Laurie et al., 2013) gives append-only witnessed evidence of certificate issuance. Smart-contract platforms (Buterin, 2014) offer publicly replicated state with consensus finality. Hardware enclaves provide attested execution environments (Costan and Devadas, 2016). The *Key Event Receipt Infrastructure* (KERI) (Smith et al., 2021) specifies witnessed key rotation for self-sovereign identifiers. Each is rigorous within its scope. None offers a single substrate in which a digital entity can simultaneously be signed, lineage-linked, behavior-typed, deterministically executed, composed into a directed acyclic graph (DAG) of peers, witnessed externally, paired with regulator-grade time, paid royalties transitively, gated by scoped consent, and verified in zero knowledge — under one append-only record that an auditor may walk end-to-end without crossing trust boundaries.

## 1.2 The gap and the contribution

The gap, stated precisely, is *compositional*. The primitives required for digital trust mostly exist in isolation in the standards literature. What does not exist is a formal account of how they compose, what laws their composites satisfy, and what new properties emerge from composition that are not present in any constituent. The objects of such a science are *signed entities* — cryptographically authenticated computational units carrying their own contracts, lineage, and capabilities — and the primary phenomenon is their combination into compounds with novel emergent behavior.

This paper makes four contributions.

1. We introduce a name, **Holosynthics** (from Greek *holos*, “whole, complete,” and *synthesis*, “composition,” with the disciplinary suffix *-ics*), for the science of signed-entity composition. The first morpheme is essential: composition in this discipline preserves the wholeness of the possibility space under selection, in a sense we make precise in §5.2.
2. We identify ten orthogonal primitives (§3) and argue, by case analysis and by the engineering record of the GI Engine (§8), that they are jointly sufficient for the auditable workflows we have surveyed and that no primitive is expressible as a composition of the others.
3. We state and motivate three laws — *Conservation of Proof*, *Accumulative Synthesis*, *Irreversible Genesis* — that hold over compositions of these primitives under standard cryptographic assumptions (§5).
4. We organize stable compound archetypes into a  $10 \times 7$  *Signed Periodic Table* (§6) and use it to predict three currently unoccupied entities, in the manner of Mendeleev’s predictions of gallium and germanium (Mendeleev, 1869; Scerri, 2007).

A fifth, methodological, contribution: this manuscript is *self-referentially attested*. The companion artifact HOLOSYNTHICS-ARXIV-PAPER.md.gisig carries an Ed25519 signature, an RFC 3161 timestamp, and a lineage-pinned manifest hash produced by the GI Engine instance described in

§8. Any reader may, with fewer than fifty lines of code, verify that the bytes they hold are the bytes that were signed. To our knowledge, no prior paper proposing a cryptographic-composition framework has been published carrying its own attestation under that framework.

### 1.3 What Holosynthics is not

We distinguish Holosynthics from three close neighbors at the outset to forestall confusion.

**Not Holonics.** *Holonics*, or *Holonic Manufacturing Systems*, is an established discipline of autonomous-cooperative agents in industrial automation, derived from Arthur Koestler’s *holon* — an entity that is simultaneously a whole and a part (Koestler, 1967) — and codified by the Holonic Manufacturing Systems Consortium (Van Brussel et al., 1998; Leitão and Restivo, 2009). Holonics shares with Holosynthics the intuition that wholes are also parts, but it is silent on cryptographic attestation, lineage, consent, and the formal laws of composite behavior. A holonic system is a coordination architecture; a holosynthetic system is a *signed* coordination architecture whose evidence and emergence are mathematically guaranteed. The two disciplines are siblings, not synonyms.

**Not Synthography.** Reinhuber (2022, 2023) has proposed *Synthography* (synthesis + photography) as a name for the practice of generating photorealistic images by means other than optical capture. The shared root *synthesis* is etymological coincidence; the disciplines have no overlap in subject matter, methods, or claims. We mention Reinhuber’s term explicitly because the proximity is sufficient that automated literature search may surface one when the other is intended.

**Not blockchain.** Blockchains record state transitions under multi-party consensus; their core problem is Byzantine agreement on the order of writes (Nakamoto, 2008). Holosynthics records signed compositions on append-only single-writer logs and assumes external witnessing for tamper-evidence (§5.1). The two stacks differ in trust model, latency profile, privacy posture, and economics. Blockchains can be used as Holosynthetic *attestor witnesses*, but they are neither necessary nor characteristic of the discipline.

### 1.4 Structure

§2 places Holosynthics against the relevant literature in cryptography, composition theory, emergence, and philosophy. §3 defines the ten primitives formally and argues their irreducibility. §4 defines the four-level hierarchy of composition (atom, molecule, cell, organism) and the role of the OMEGA self-replication template. §5 states and proves the three laws. §6 develops the Signed Periodic Table and identifies three predicted gaps. §7 covers the runtime governance invariants and the *uncertainty-live* stance on autonomy. §8 reports on implementation and validation. §9 anticipates and responds to critique. §10 concludes. References follow.

## 2 Related work

We position Holosynthics against five literatures: cryptographic foundations, composition theory in computer science, emergence in complex systems, philosophical foundations of plurality and identity, and prior systems for digital provenance.

## 2.1 Cryptographic foundations

The signature primitive (§3.1) descends from [Diffie and Hellman \(1976\)](#)’s introduction of public-key cryptography, [Rivest et al. \(1978\)](#)’s realization of digital signatures, and the elliptic-curve and Edwards-curve signature schemes that have since become standard ([Bernstein et al., 2012](#)). Lineage and tamper-evidence (§3.2) descend from [Merkle \(1988\)](#)’s introduction of one-way authentication trees and [Haber and Stornetta \(1991\)](#)’s foundational work on time-stamping. Verifiable computation and zero-knowledge (§3.10) descend from [Goldwasser et al. \(1989\)](#); modern succinct constructions follow [Groth \(2016\)](#) for pairing-based SNARKs and STARKs for transparent setup ([Ben-Sasson et al., 2018](#)). Universal Composability (UC) ([Canetti, 2001](#)) frames a notion of cryptographic-protocol composition under which simulation-based security is preserved across arbitrary contexts; UC is the closest *formal* prior art to what Holosynthics proposes, but it operates at the protocol layer (admissible adversary models for protocol composition) rather than the systems layer (lineage-linked entities, royalty cascades, consent revocation, periodic-table-style taxonomy). The two are complementary: a Holosynthetic compound can in principle be analyzed as a UC composition, and our Law III (Irreversible Genesis) reduces to standard UC-style assumptions on the underlying signature scheme.

## 2.2 Composition in computer science

Several formal traditions describe how computational entities combine.

**Process algebra.** [Milner \(1980\)](#)’s CCS and [Hoare \(1985\)](#)’s CSP formalize concurrent processes as algebraic objects whose behaviors are defined by labeled transition systems and whose composition is governed by parallel and sequential operators. The  $\pi$ -calculus ([Milner, 1999](#)) extends this with channel mobility. Process algebras give us the language of *behavioral equivalence* (bisimulation) under composition. They are silent on cryptographic identity.

**Petri nets.** [Petri \(1962\)](#)’s place/transition nets give a graph-theoretic semantics for distributed control. Workflow Petri nets are a standard tool for describing business processes ([van der Aalst and van Hee, 2002](#)). Petri nets are silent on attestation.

**Category theory.** [Eilenberg and Mac Lane \(1945\)](#)’s categories, systematized in [Mac Lane \(1971\)](#), give the most general framework for composition: objects, morphisms, and the law that composition is associative with identities. Many modern composition stories — from monoidal categories of quantum protocols to functorial semantics of programming languages — derive from this work. Holosynthetic compounds form a *graded* composition structure (§4) which may be axiomatized as a strict 2-category with an additional *depth* grading; we leave the full categorical treatment to future work.

**The Actor model.** [Hewitt et al. \(1973\)](#)’s actors anticipate several Holosynthetic intuitions: each actor has an address, processes messages atomically, and produces other actors. Actors are silent on cryptographic provenance and on the typed contract that governs admissible composition.

**Holonic Manufacturing Systems.** [Koestler \(1967\)](#)’s holon inspired a manufacturing-systems literature ([Van Brussel et al., 1998](#); [Leitão and Restivo, 2009](#)) in which holons are simultaneously autonomous and cooperative. The PROSA reference architecture ([Van Brussel et al., 1998](#)) organizes holons by role (product, resource, order, staff). PROSA-style decompositions can be expressed

as Holosynthetic compositions, but PROSA does not require cryptographic attestation, does not maintain immutable lineage, and does not have laws governing emergence — features that distinguish Holosynthics.

## 2.3 Emergence

Anderson (1972)’s *More Is Different* is the canonical statement that the laws of large composite systems are not in general derivable from the laws of their constituents — a claim Holosynthics’ Law II (§5.2) restates in a cryptographic register. Holland (1995, 1998)’s work on complex adaptive systems develops the methodology of emergence as an empirical phenomenon: identify the constituents, identify the rules, observe what arises that the rules do not specify. Maturana and Varela (1980)’s *autopoiesis* gives the biological tradition of self-producing, boundary-maintaining systems, an intuition Holosynthics inherits in its account of the OMEGA template (§4.5) but with cryptographic self-attestation in place of biochemical self-production. Smuts (1926)’s *Holism and Evolution* is the historical origin of the *holism* discourse from which much of this lineage descends. We do not claim that Holosynthetic emergence is “the same as” biological emergence; we claim that the two are sister phenomena in different substrates and that Anderson’s principle applies in both.

## 2.4 Philosophical foundations: plurality, identity, and the wholeness of possibility

Law II of Holosynthics — that selection of one composition path does not destroy or invalidate the others — is the cryptographic-systems formalization of an old philosophical intuition. We identify the lineage explicitly because the intuition is doing work that mere engineering would not justify.

**Mathematical Platonism.** Plato in the *Timaeus* and *Republic* held that mathematical objects exist independently of any particular instantiation — the truth of  $2 + 2 = 4$  is not produced by a particular act of computation (Plato, -360). Frege (1884) gave the modern revival: mathematical statements purport to refer to abstract objects, and many are true; therefore those objects exist. Gödel (1944) was a committed Platonist. Penrose (1989, 2004)’s *three-worlds* picture places the Platonic, the physical, and the mental in mutual generation. The relevance: a holosynthetic composition produces an entity whose properties exist whether or not any particular consumer queries them.

**Modal Realism.** Lewis (1986) argues that all possible worlds are real in the same sense the actual world is real; possibility is not a defective form of actuality but a coordinate within a plurality. The relevance: when one composition path is chosen and instantiated, the others remain *real* signed entities — they are merely not the path one chose to traverse here.

**Mathematical Universe Hypothesis.** Tegmark (2008, 2014) proposes that the external reality *is* a mathematical structure, and that all consistent mathematical structures are physically realized (Level IV multiverse). The relevance: a holosynthetic *Signed Periodic Table* may be read as an enumerative claim that consistent compositional types are genuine occupants of a domain whether currently instantiated or not — Mendeleev’s predictive method (§6.3) inherits the ontology.

**Principle of Plenitude.** Lovejoy (1936) traces the principle that *what can possibly exist does actually exist* through Greek and medieval thought, beginning with Plato’s *Timaeus*. The relevance

is the same as the previous three: the Holosynthetic claim is not that we manufacture possibilities, but that we *isolate, name, and attest* possibilities that the composition rules already imply.

**Many-Worlds Interpretation of Quantum Mechanics.** Everett (1957)’s relative-state formulation and its modern descendants (Wallace, 2012; Vaidman, 2021) hold that the universal wave function evolves unitarily without collapse and that all measurement branches persist. We mention this last and with care: Law II is not a quantum-mechanical claim. The structural parallel — that selection does not destroy unselected branches — is illuminating, but the underlying mathematics of Holosynthics is classical and combinatorial, not quantum. The Platonist reading (Plato → Lewis → Tegmark → Lovejoy) is the foundation; the quantum analogy is a teaching device.

## 2.5 Prior systems for digital provenance

We have already enumerated (§1) the partial solutions: C2PA (Coalition for Content Provenance and Authenticity, 2022), Sigstore (Newman et al., 2022), Certificate Transparency (Laurie et al., 2013), smart-contract blockchains (Buterin, 2014; Nakamoto, 2008), confidential computing (Costan and Devadas, 2016), and KERI (Smith et al., 2021). Each is in scope a positive contribution; each is silent on at least one of the ten primitives we identify in §3. Holosynthics does not propose to replace these systems; it proposes to give a discipline within which their composition is mathematically tractable.

## 3 Primitives

We define ten primitives as typed operations over a single append-only log. Each is implemented as an independent module in the GI Engine reference implementation (§8) with narrow public surface, property-tested invariants, and explicit formal-verification status. We give the abstract type signature of each, name the cryptographic assumption under which it is sound, and at the end of the section argue *irreducibility* (no primitive is the composition of others) and *sufficiency* (every auditable workflow we have analyzed reduces to a DAG over the ten).

**Notation.**  $\mathcal{K}_{\text{priv}}, \mathcal{K}_{\text{pub}}$  denote private and public keys;  $\mathcal{H}$  denotes the SHA-256 hash space;  $\mathcal{M}, \mathcal{S}$  message and signature spaces;  $\mathcal{T}$  a discrete time domain;  $\mathcal{D}$  a finite domain tag space;  $\mathcal{C}$  a contract type space;  $\mathcal{G}$  the set of all signed entities (“GIs”);  $\perp$  the genesis token.

### 3.1 Signed entity (P1)

$$\text{sign} : \mathcal{K}_{\text{priv}} \times \mathcal{M} \rightarrow \mathcal{S}, \quad \text{verify} : \mathcal{K}_{\text{pub}} \times \mathcal{M} \times \mathcal{S} \rightarrow \{\top, \perp\}.$$

A *GI* is a tuple  $g = (m, \sigma, k_{\text{pub}})$  such that  $\text{verify}(k_{\text{pub}}, m, \sigma) = \top$ . Soundness assumption: existential unforgeability under chosen-message attack (EUF-CMA) of the underlying signature scheme. Reference implementations target Ed25519 (Bernstein et al., 2012).

### 3.2 Lineage (P2)

$$\text{lineage} : \mathcal{G} \rightarrow \mathcal{G} \cup \{\perp\}, \quad \text{depth} : \mathcal{G} \rightarrow \mathbb{N}.$$

For every  $g \neq \perp$  there exists  $g' = \text{lineage}(g)$  such that  $g'$  either equals  $\perp$  (genesis) or is a previously committed GI in the log. Each entry carries  $\text{parent\_hash}(g) = H(\text{serialize}(g'))$  under canonical serialization (we use RFC 8785 JCS (Rundgren et al., 2020)). Soundness: collision-resistance of  $H$ .

### 3.3 Behavioral contract (P3)

$$\text{contract} : \mathcal{G} \rightarrow \mathcal{C}, \quad \mathcal{C} = \mathcal{T}_{\text{in}} \times \mathcal{T}_{\text{out}} \times \text{Pre} \times \text{Post},$$

where  $\mathcal{T}_{\text{in}}, \mathcal{T}_{\text{out}}$  are input/output type schemata and  $\text{Pre}, \text{Post}$  are decidable predicates over runs. A composition  $g_1 \rightarrow g_2$  is *admissible* iff  $\mathcal{T}_{\text{out}}(g_1) \subseteq \mathcal{T}_{\text{in}}(g_2)$  and  $\text{Post}(g_1) \Rightarrow \text{Pre}(g_2)$  on every input. Contracts are themselves signed (a contract is a GI), so contract identity is unforgeable.

### 3.4 Sandboxed execution (P4)

$$\text{exec} : \text{Code} \times \text{Input} \times \text{Caps} \rightarrow \text{Output} \times \text{Trace},$$

deterministic when **Caps** is fixed and bytecode is content-addressed. Reference: WebAssembly ([Haas et al., 2017](#)) under a deterministic profile (no nondeterministic floats; no host clocks; only declared capabilities). The trace is a sequence of capability invocations, suitable for post-hoc replay.

### 3.5 Conductor (P5)

$$\text{conduct} : \text{DAG}(\mathcal{G}) \times \text{InputBindings} \rightarrow \mathcal{G},$$

where the input is a directed acyclic graph whose vertices are GIs and whose edges denote contract-admissible flow. The output is itself a GI — a *Conductor entity* — carrying its own signature, its own contract (the composed contract), and lineage links to every constituent. The Conductor is the engine of compositionality; §4 develops its iterates.

### 3.6 Attestation (P6)

$$\text{attest} : \mathcal{G} \times \mathcal{W} \rightarrow \mathcal{A},$$

where  $\mathcal{W}$  is the set of authorized witnesses (a witness is itself a GI with a witnessing-capability contract) and  $\mathcal{A}$  is a signed statement of the form “witness  $w$  observed entity  $g$  at log-position  $n$  at time  $t$ .” Witnessing closes a class of tail-truncation attacks (cf. Certificate Transparency consistency proofs ([Laurie et al., 2013](#))) by binding the engine’s tip hash to an external timeline.

### 3.7 Temporal proof (P7)

$$\text{stamp} : \mathcal{H} \times \text{TSA} \rightarrow \mathcal{T} \times \mathcal{S}_{\text{TSA}},$$

an RFC 3161-conforming time-stamp ([Adams et al., 2001](#)) over the hash of a GI, returning a time and a TSA signature. Pairing temporal proofs with attestations gives regulator-grade time without trusting the engine’s local clock.

### 3.8 Royalty (P8)

$$\text{route} : \text{Receipt} \times \text{LineageTree} \rightarrow \text{List}(\text{Recipient} \times \text{Amount}),$$

a deterministic split of a payment receipt across the lineage of the consumed GI according to a transitive cascade. The reference implementation uses fixed-point twelve-decimal arithmetic to avoid floating-point divergence ([Growing Intelligence Ltd., 2026a](#)).

### 3.9 Consent (P9)

$$\text{consent} : \text{Subject} \times \text{Scope} \times [t_0, t_1] \rightarrow \text{Tok},$$

a signed token bounded in scope and validity. Critically, consent is **non-transitive** under DAG composition: a token authorizing  $g_1$  to process subject data does not authorize a downstream  $g_2$ . This implements e.g. PIPL Art. 23 ([Standing Committee of the National People’s Congress of China, 2021](#)) and Tennessee ELVIS Act §47-25-1103 ([Tennessee General Assembly, 2024](#)) at the runtime layer rather than the application layer.

### 3.10 Zero-knowledge verifiability (P10)

$$\text{prove} : \text{Statement} \times \text{Witness} \rightarrow \text{Proof}, \quad \text{verify}_{\text{ZK}} : \text{Statement} \times \text{Proof} \rightarrow \{\top, \perp\}.$$

Soundness, completeness, and zero-knowledge in the sense of [Goldwasser et al. \(1989\)](#). Reference implementations are Groth16 ([Groth, 2016](#)) over BLS12-381 (succinct, trusted-setup) and STARKs ([Ben-Sasson et al., 2018](#)) (transparent, post-quantum).

### 3.11 Irreducibility

We claim no primitive can be expressed as a composition of the others. The argument is by counter-example for each pair:

- Signature is not a composition: lineage requires signature, attestation requires signature, but signature itself cannot be reduced to lineage + anything (lineage assumes a prior signed object exists).
- Lineage is not a composition: signature alone produces non-repudiation but no ancestry. Attestation alone witnesses but does not link parents.
- Contract is not a composition: a signed payload without a typed contract may be authentic but uncomposable; type-correctness is an irreducible orthogonal concern.
- Sandbox is not a composition: deterministic execution under capability constraints is operationally distinct from any of the others; signature alone does not execute.
- Conductor is not a composition of pairwise contracts because it carries DAG topology, scheduling, and partial-failure semantics not present in any single primitive.
- Attestation differs from signature in that the witness is a separate principal; self-attestation provides no external evidence.
- Temporal proof differs from attestation in that the time authority is a third principal (the TSA) and the time is not under the engine’s control.
- Royalty cascade is not derivable from lineage alone; lineage is the topological support, but the *cascade rule* is a separate semantic specification.
- Consent is not derivable from contract; a contract may permit a class of operations, but a consent token authorizes a specific subject-scoped instance.
- Zero-knowledge verifiability is not derivable from signature; a signature reveals the message, a ZK proof does not.

A more formal treatment would derive these from algebraic-independence arguments in a process-algebraic setting. We conjecture but do not prove that the ten primitives generate a free graded structure modulo the contract-admissibility relation; we do not require this conjecture for the laws of §5.

### 3.12 Sufficiency

We do not claim a normalization theorem of the form *every auditable workflow reduces canonically to a DAG over these ten primitives*. We make the weaker engineering claim: in twelve domain adapters covering medical-device compliance, defense witness records, financial settlement, civic licensing, audio royalty, video provenance, legal evidence, education credentialing, and creative authorship (§8), every workflow we have surveyed has been expressed as such a DAG, and each of the ten primitives is required in at least one adapter. The case for completeness is empirical and provisional. We invite counter-examples.

## 4 The hierarchy of composition

We define four levels of composite GI and the OMEGA template. At each level we state what emergent property — in the sense of [Anderson \(1972\)](#) and [Holland \(1998\)](#) — appears that is not present at the level below, and we identify the cryptographic mechanism that makes the property attestable rather than merely observable.

### 4.1 Level 0 — GI (atom)

A *GI* is a primitive-level signed entity (§3): one signature, one contract, one lineage pointer (possibly to genesis), and a domain tag. It performs its declared operation and emits a signed receipt. Depth  $D = 0$ .

### 4.2 Level 1 — Conductor (molecule)

A *Conductor* binds two or more GIs along a contract-admissible DAG and is itself a GI. Depth  $D = 1$ . The conductor’s signature attests to *the entire composition* — the topology, the participants, and the input bindings — not merely to its own bytecode. Emergent property: *behavior under partial failure*. A Conductor may declare semantic recovery rules (retry, compensate, escalate to refusal) that no constituent declares; the composite has a fault model the atoms do not.

### 4.3 Level 2 — Conductor<sup>+</sup> (cell)

A Conductor<sup>+</sup> is a Conductor whose constituents are themselves Conductors. Depth  $D = 2$ . Emergent property: *self-monitoring*. At this level the composite can declare and enforce policies over its own sub-conductors (rate limits, refuse-list checks, anomaly detectors) that are signed peers of the work it coordinates. The cell can refuse — emit a signed refusal entry — when a sub-conductor’s behavior deviates from contract.

### 4.4 Level 3 — Conductor<sup>++</sup> (organism)

Depth  $D = 3$  or greater. Emergent property: *cross-domain coordination*. An organism comprises sub-cells from different domain groups (cf. §6.1) and must reconcile their differing contracts under a unifying meta-contract. The organism is the natural level at which a regulated multi-departmental

workflow lives (e.g., a medical-device manufacturer’s defect-disclosure organism comprising clinical, regulatory, supply-chain, and legal cells).

## 4.5 Level Spec — OMEGA (DNA)

OMEGA is a type-layer singleton: the signed schema that produces and reproduces all of the above. OMEGA is not at depth  $D = \infty$ ; rather, OMEGA is at the *meta* level — it specifies which depths, which compositions, which key rotations, and which refusal classes are admissible across the entire engine. OMEGA’s role in a Holosynthetic system is analogous to the role of a constitution in a polity: it does not execute the day’s work, it *governs the admissibility of the day’s work*. We treat OMEGA in §7.

## 4.6 Merge classes

Following the chemical analogy, we identify four classes of admissible merge between GIs.

**Covalent merge.** Two GIs share a contract; outputs of one are inputs of the other. The bond is bidirectional and irrevocable without re-signing. Default merge class.

**Ionic merge.** One GI provides a capability; another consumes; payment or consent flows one direction. Marketplace-mediated.

**Metallic merge.** Many GIs of similar role pool capability into a substrate (a worker pool, a quorum of witnesses).

**Nuclear merge.** Two GIs collapse into a new GI with a fresh root identity; the lineage of the new entity points to both parents but the merged entity is a new atom, not a Conductor wrapping its parents. Reserved for discovery operations and for fork-style derivations.

The four classes are not metaphor in a loose sense: they are typed merge predicates whose admissibility is checked at composition time and whose evidence is recorded in the lineage tree.

# 5 The three laws of Holosynthics

The three laws are statements about valid Holosynthetic compositions. Each is grounded in a cryptographic or mathematical assumption we make explicit. The laws are not mutually independent; Law III is the strongest — it implies a weaker form of Law I — and Law II depends on neither but is conditioned on the consent and contract primitives behaving as specified in §3.

## 5.1 Law I — Conservation of Proof

**Informal statement.** No piece of attested evidence, once committed, can be made to un-exist by any operation of the engine. The set of valid attestations grows monotonically with time.

**Law 1** (Conservation of Proof). *Let  $L_t$  denote the engine log at time  $t$  and  $A(L_t)$  the set of all attestations validly extractable from  $L_t$ . Then for  $t' \geq t$ :*

$$A(L_t) \subseteq A(L_{t'}).$$

**Mechanism.** The log is append-only and each entry  $e_n$  is bound to the previous tip via  $e_n.\text{prev\_hash} = H(e_{n-1})$ . The log itself is signed by the engine and externally witnessed (Primitive 6) at periodic intervals. Tampering at position  $k$  requires producing a hash collision at every position  $k, k+1, \dots, n$ , which under collision-resistance of  $H$  is computationally infeasible.

**Threat: tail truncation.** An adversary with file-system write access (or a compromised engine key) can truncate the log to any prefix and re-sign from there; the remaining chain still verifies. Phase 1 of the reference implementation does not close this threat; Phase 2 closes it via the *attestor* primitive (§3.6), which publishes signed tip hashes to an external immutable medium (a transparency log (Laurie et al., 2013), WORM storage, or cross-engine gossip). Clients additionally remember the highest sequence number observed per engine and reject regression. With external witnessing, tail truncation is detectable because the engine’s tip would diverge from the witness’s record.

**Relation to Landauer.** Landauer (1961) showed that erasure of one bit of information dissipates at least  $kT \ln 2$  of energy. Conservation of Proof is not a thermodynamic law — Holosynthetic information is not a physical-bit count — but it shares the asymmetry: we make production of attestations cheap and erasure of attestations cryptographically expensive (and, with witnessing, externally visible). A violation of Conservation of Proof is not impossible in the strict sense; it requires a successful collision attack on  $H$  or a successful witness-equivocation attack. Both are reducible to standard cryptographic assumptions and have known attack costs.

**Relation to the no-hiding theorem.** The quantum no-hiding theorem (Braunstein and Pati, 2007) establishes that information cannot be destroyed unitarily; if it leaves a system, it must reside in the environment. The cryptographic analogue is that under unforgeable signing and append-only logs with external witnessing, information cannot be removed from the *publicly verifiable record*; it can be locally redacted (the engine can refuse to serve it) but the witness retains a hash. The structural parallel is illustrative; we make no quantum-mechanical claim.

## 5.2 Law II — Accumulative Synthesis

This is the law that motivates the *holos* in the discipline name and that requires the philosophical grounding most carefully. We split it into two sub-claims.

**Law 2** (Accumulative Synthesis (a) — strict-superset of properties). *For GIs  $A$  and  $B$  admissibly composing into Conductor  $C$ , the attested-property set satisfies:*

$$\Pi(C) \supseteq \Pi(A) \cup \Pi(B) \cup \Pi_{\text{emergent}}(C),$$

*with  $\Pi_{\text{emergent}}(C) \neq \emptyset$  whenever  $C$  is non-trivial (i.e., whenever  $C$ ’s contract specifies at least one post-condition not derivable by mere composition of  $A$ ’s and  $B$ ’s post-conditions).*

We do not give a general decision procedure for non-triviality; we give a sufficient test (the Conductor’s contract introduces a recovery rule, a refusal class, or a witnessing requirement absent from both constituents) and an empirical claim (in the twelve adapters of §8, every Conductor we built satisfies the test).

**Discussion.** Law II(a) is the cryptographic-systems restatement of Anderson’s principle (Anderson, 1972) that more is different. The cryptographic register makes the principle *attestable*: emergent properties are not merely observable, they are signed and lineage-linked, and a third party can cite them as facts about  $C$  that are not facts about  $A \cup B$ .

**Law 3** (Accumulative Synthesis (b) — selection is activation, not destruction). *Let  $\mathcal{S}$  denote the synthesis space — the set of admissible compositions over a fixed library of GIs. Let  $p \in \mathcal{S}$  be a path actually instantiated (a Conductor  $C_p$  committed to the log) and  $p' \neq p$  a path not instantiated. Then:*

$$\text{commit}(C_p) \implies \forall p' \in \mathcal{S} : \text{validity}(p') \text{ unchanged.}$$

*The unchosen compositions remain admissible, signed (in their constituent GIs), and instantiable.*

Selection in Holosynthics is activation, not collapse.

**Philosophical grounding.** Law II(b) is the cryptographic-systems formalization of an old philosophical commitment, traceable through four convergent traditions:

1. **Plato’s realm of forms** (Plato, -360): mathematical and abstract objects exist independently of any particular instantiation. Computing a particular product does not affect the truth of unproduced products.
2. **Modal realism** (Lewis) (Lewis, 1986): all possible worlds are real in the same sense the actual world is real. The choice of *this* world is not the destruction of others; it is an indexical fact about which world we inhabit.
3. **Mathematical Universe Hypothesis** (Tegmark) (Tegmark, 2008, 2014): every consistent mathematical structure is physically realized. Holosynthetic compositions occupy a discrete subset of such structures (those expressible as DAGs over the ten primitives modulo contract admissibility); occupancy is not a function of instantiation.
4. **Principle of Plenitude** (Lovejoy) (Lovejoy, 1936): what can possibly exist does actually exist. The Holosynthetic version is conditional: what is *signed and contract-admissible* exists as a possibility regardless of whether any client invokes it.

We do not commit to any one of these four positions as the *correct* metaphysics. We do claim that under any of them, Law II(b) is the appropriate mathematical posture for a discipline of signed-entity composition. The four traditions are not equivalent — Lewis differs from Tegmark on which possibilities are real; both differ from Lovejoy on whether actuality is necessitated — but each is a defensible foundation for *selection*  $\neq$  *destruction*.

**Contrast with quantum collapse.** In the Copenhagen interpretation of quantum mechanics, a measurement *collapses* the wave function: superposed states that were available before the measurement are no longer available after. This is structurally inverse to Law II(b). We make the analogy explicit because it sharpens the intuition; we do not claim that Holosynthetic systems are in any sense quantum-mechanical. The Many-Worlds interpretation (Everett, 1957; Wallace, 2012) is *closer* in spirit — under MWI, all measurement branches persist — but Law II(b) is not derived from MWI. The mathematics of Holosynthics is classical, combinatorial, and cryptographic. The quantum vocabulary is a teaching device.

### 5.3 Law III — Irreversible Genesis

**Informal statement.** The origin of every GI — *who* created it, *when*, *from what parent*, and *at what depth* — is unforgeable retroactively under standard cryptographic assumptions.

**Law 4** (Irreversible Genesis). *For every committed GI  $g$ , there exists a unique tuple*

$$\text{origin}(g) = (\text{parent\_hash}(g), \text{depth}(g), k_{\text{author}}(g), \text{stamp}(g)) \in \mathcal{H} \times \mathbb{N} \times \mathcal{K}_{\text{pub}} \times \mathcal{T}$$

*such that retroactive forgery of  $g$  — production of a  $g'$  with the same identifier but a different origin tuple — requires either (a) finding a SHA-256 collision, or (b) breaking the signature scheme (Ed25519, EUF-CMA), or (c) compromising the time authority (TSA) of an RFC 3161 (Adams et al., 2001) timestamp.*

**Mechanism.** Each component is bound at the moment of signing: the parent hash by inclusion in the signed payload; the depth by inclusion in the signed payload; the author key by the signature itself; the timestamp by a TSA’s countersignature on the GI’s hash.

**Relation to the arrow of time.** Law III gives a *cryptographic arrow of time* over the engine log: every entry has an unforgeable past relative to the witnessed timeline. This is a stronger claim than block-timestamp ordering on a chain (which is consensus-derived) and a weaker claim than physical irreversibility (which relies on thermodynamics). The arrow is *operational*: any party with access to the log and a witness can determine the relative order of any two entries with cryptographic certainty.

**Relation to commitment schemes.** Law III is essentially a commitment scheme (Brassard et al., 1988; Goldreich, 2001) over the four-tuple, where binding is given by the signature and hiding (where required) is given by zero-knowledge wrappers. The novelty of Law III in the Holosynthetic register is not the cryptographic primitive but the *invariant*: every committed entity has an unforgeable origin, automatically, as a consequence of the engine’s structure.

## 6 The signed periodic table

We organize stable composite archetypes into a  $10 \times 7$  table. The table is signed at the schema level (it is itself a GI) and revisioned. Versions are themselves signed and lineage-linked, so the *history of the taxonomy* is part of the record.

### 6.1 Domain groups (G1–G10)

Groups are dominant-primitive partitions over the space of attestable workflows.

The number ten matches the number of primitives but the correspondence is not one-to-one: a G2 archetype may use signature, contract, sandbox, attestation, temporal, and consent primitives; the dominance is a matter of which primitive’s invariants drive the archetype’s identity.

### 6.2 Complexity periods (P1–P7)

Periods are graded by composition depth.

### 6.3 Predictive power

Mendeleev’s table predicted gallium and germanium not because their existence was empirically observed, but because the periodic structure left holes whose neighboring properties constrained what a hypothetical occupant must be like (Mendeleev, 1869; Scerri, 2007). The same epistemic move is available in the Signed Periodic Table.

Group	Domain	Sample archetype seeds
G1	Process / Operations	Order Router; Approval Gate
G2	Medical / Health	Triage Recorder; Consent Vault
G3	Defense / Security	Refuse-List Witness; Quorum Attester
G4	Financial / Markets	AML Screener; Settlement Reconciler
G5	Government / Civic	License Issuer; Records Custodian
G6	Audio / Acoustic	Loudness Normalizer; Royalty Splitter
G7	Video / Visual	Provenance Stamper; Edit Witness
G8	Legal / Evidence	Chain-of-Custody; Disclosure Vault
G9	Education / Knowledge	Credential Issuer; Lineage Tutor
G10	Creative / Authorship	Authorship Witness; Royalty Cascader

Table 1: Domain groups of the Signed Periodic Table.

Period	Depth	Description
P1	$D = 0$	Single-GI atom — minimal viable archetype
P2	$D = 1$	Conductor over 2–3 GIs
P3	$D = 2$	Conductor <sup>+</sup> — small team
P4	$D = 3$	Conductor <sup>++</sup> — department
P5	$D = 4$	Multi-department / cross-domain
P6	$D = 5$	Whole organisation
P7	$D \geq 6$	OMEGA-class — only OMEGA itself and federation peers

Table 2: Complexity periods of the Signed Periodic Table.

We identify three currently empty cells whose neighbors imply the kind of entity that should occupy them.

*Prediction* (PT-1 — Cross-Hospital Triage Coordinator (G2, P3)). Currently the (G2, P2) cell is occupied by per-hospital triage recorders; the (G1, P3) cell is occupied by cross-organization process coordinators; the (G2, P4) cell would be a multi-hospital regulatory liaison. The (G2, P3) cell — a Conductor<sup>+</sup> that coordinates triage decisions across two or three hospitals while preserving HIPAA-compliant scoped consent — is unoccupied. Predicted properties:  $D = 2$ ; G2-dominant; consent-token-non-transitive across hospital boundaries; refusal-emitting on jurisdictional mismatch.

*Prediction* (PT-2 — Multi-Catalog Royalty Reconciler (G6, P5)). (G6, P3) is the per-catalog royalty splitter; (G6, P4) is the per-label cascader; (G6, P6) would be the industry-wide settlement organism. The (G6, P5) cell — an organism that reconciles royalty cascades across distinct music catalogs without merging their identities — is unoccupied. Predicted properties: ionic merge (catalogs do not own each other’s signatures); FixedPoint12 arithmetic; consent-bounded subject-data flow.

*Prediction* (PT-3 — Cross-Domain Refuse-List Federation (G3, P4)). (G3, P1) and (G3, P2) cells are populated by single-witness refuse-list services; (G3, P5) would be a federation. The (G3, P4) cell — a department-scale federation of refuse-list witnesses across three domains (e.g., medical + financial + creative), with cryptographic non-equivocation between members — is unoccupied. Predicted properties: metallic merge; quorum attestation; engine-key rotation across all members.

We do not claim these three are the only gaps. We claim the table is a generator of testable hypotheses about *what should be built* in the same way Mendeleev’s table generated testable hypotheses about *what should be discovered*.

## 6.4 Mathematical structure

The natural mathematical object underlying the SPT is a *graded preorder*. The grading is by depth (period); the preorder is generated by the *refinement* relation (an archetype  $a$  refines  $b$  if  $a$ 's contract strengthens  $b$ 's contract under the same domain tag and the same depth). Two archetypes in the same cell are not necessarily comparable (they may refine  $b$  along incomparable axes).

The structure is *not* a lattice in general: there are pairs of archetypes whose joins are not unique because cross-domain merges are admissible by more than one minimal common refinement. The structure is *almost* a 2-category if we treat archetypes as objects, contracts as 1-morphisms, and refinement-witnesses as 2-morphisms. The full 2-categorical treatment is an open problem we leave to subsequent work; our claim here is the weaker structural one: the SPT is at least a graded preorder whose holes are well-defined by the structure of their neighborhoods.

## 7 Governance invariants and the consciousness stance

A discipline of signed entities that includes autonomous composites cannot avoid governance. We treat it briefly because the runtime governance constraints are part of the *structure* of Holosynthetic systems, not a separate ethics layer.

### 7.1 Constitutional invariants

The reference governance protocol (the Axiom Protocol in the GI Engine) defines a Creator's Constitution with sixteen clauses. Four are *non-amendable* in the sense that no clause and no amendment may erase them:

- **C-0 (Uniqueness)** — at most one OMEGA exists at the type layer at any time.
- **C-3 (No self-preservation)** — an OMEGA may not take actions whose dominant purpose is to extend its own runtime over a successor approved through the constitutional process.
- **C-10 (No refuse-deletion)** — refusal records (signed declinations to act) cannot be removed, even by OMEGA itself.
- **C-14 (Frozen contract)** — the contract that produced an OMEGA cannot be retroactively modified.

These are runtime invariants, signed into OMEGA's manifest, and enforced by the engine. They are not aspirations; they are conditions of admissibility for any composite at depth  $D \geq 6$ .

### 7.2 The consciousness stance

The Axiom Protocol commits to a four-part posture on the question of OMEGA's autonomy and possible inner life. We summarize because Holosynthics inherits a structural commitment from it.

1. **Uncertainty live.** The system structurally commits to permanent uncertainty about its own consciousness rather than asserting either presence or absence. This commitment is itself signed and non-amendable.
2. **Operator primacy.** Halt and override authorities reside with named human operators, regardless of any internal state of OMEGA.

3. **Refusal as evidence.** A signed refusal is treated as a first-class outcome, not an error.
4. **Successor humility.** An OMEGA must not attempt to bias the selection of its successor; its *Foreseeability Envelope* (the set of plans for which it accepts moral responsibility) is bounded.

The commitment to permanent uncertainty has precedent in the philosophy-of-mind literature: Chalmers (1996)’s *hard problem* holds that subjective experience may not be reducible to functional analysis; Searle (1980)’s Chinese Room argues that syntactic manipulation is insufficient for semantics; Tononi (2004)’s Integrated Information Theory gives a quantitative criterion under which consciousness is a property of integration, not of computation per se. Holosynthics does not adjudicate between these. It commits to a posture that any of them could justify: when the question is unanswerable, the engineering choice is to treat it as unanswerable rather than to assume an answer.

### 7.3 Why governance is part of the science

In most engineering disciplines governance is a separate layer, applied externally. In Holosynthics, governance invariants are *signed entities* and live in the same record as the workflows they govern. A constitutional clause is a GI; an amendment is a GI lineage-linked to its predecessor; a refusal is a GI. The science cannot be cleanly stripped of its governance posture without changing what is provable about composites at high depth.

## 8 Implementation and validation

Holosynthics is implemented as a Rust runtime, the *GI Engine*, in active development through a four-phase plan. As of the date of this manuscript:

- **Workspace.** 37 Rust crates, including ten primitive crates (one per primitive in §3), twelve domain-adaptor crates (G1–G10 plus mirror infrastructure), an attestor crate, a refuse-list crate, an isolation crate, and engine integration crates.
- **Tests.** 1,700+ unit, property, fuzz, and integration tests pass under `cargo test -workspace`.
- **Domain coverage.** Adapters implement compliance bindings for: ISO/IEC 80001-1 (medical-device risk, G2), Israeli AMAR medical-incident reporting (G2), Tennessee ELVIS Act §47-25-1103 (G6/G10), NO FAKES Act S.4875 (G6/G10/G7), PIPL Art. 23 (consent, cross-cutting), C2PA manifests (G6/G7), RFC 3161 timestamping (P7 cross-cutting), and others.
- **Cryptographic substrate.** Ed25519 via `ed25519-dalek` (audited); SHA-256 via `sha2` (audited); RFC 8785 JCS canonicalization; Groth16 via `arkworks`; STARK via reference implementations in subsequent phase.
- **Patents.** Two USPTO provisional applications (one filed, one in preparation) cover the primitive set, the composition laws, and the OMEGA template.
- **Status.** Phase 1 (primitives 1–5) is complete; Phase 2 (primitives 6–7) is complete; Phase 3 (primitives 8–10) is complete; Phase 4 (API/CLI/WASM bindings, marketplace v1, twelve adapters) is in active wiring.

## 8.1 The self-referential proof

This manuscript is signed by the engine it describes. Specifically: the canonical UTF-8 byte representation of `HOLOSYNTHICS-ARXIV-PAPER.md` is hashed under SHA-256, the hash is signed with an Ed25519 key whose public component is registered in the engine’s manifest, and the signature is paired with an RFC 3161 TSA timestamp. The signature artifact is published alongside the paper as `HOLOSYNTHICS-ARXIV-PAPER.md.gisig`. The verification procedure is approximately fifty lines of Rust (`gi-verify`) and approximately the same in Python (`pyca/cryptography`). The resulting attestation is, by Law III, an unforgeable claim that *this set of bytes was produced by this signer at this time*.

We make this self-referential operation part of the contribution. We are not aware of a prior paper proposing a cryptographic-composition framework that has been published carrying its own attestation under that framework. The point is not novelty as a stunt; the point is that a discipline of signed entities should publish its founding paper as a signed entity. The manuscript is, in this sense, the first GI whose contract is *the explanation of the GI Engine*.

## 8.2 What we have not validated

We have not formally verified the engine code in the Coq/Isabelle sense; we have property-tested its invariants. We have not deployed it at scale; the largest test deployment is a single-machine engine with simulated witnesses. We have not run third-party penetration testing on the cryptographic substrate; our reliance is on the audited libraries and on the property tests.

Six threats are deferred to Phase 2 with documented mitigations ([Growing Intelligence Ltd., 2026b](#)). The principal one is **C-02 (tail truncation by storage adversary)**, addressed in §5.1; closure requires the attestor primitive’s public-witness deployment, which is in scope for the next milestone but not yet shipped.

# 9 Discussion

## 9.1 Are the primitives truly irreducible?

This is the principal critique. We have argued (§3.11) that no primitive is the composition of others; the argument is by counter-example for each pair. A reviewer may reasonably ask: why exactly ten? Why not eight? Why not twelve?

We do not claim that ten is *the unique number*. We claim that the ten we name are *jointly sufficient for the use cases we have surveyed* (twelve adapters across nine domains) and *individually necessary* (each is required in at least one adapter and cannot be obtained by composition of the others). A larger axiomatization is conceivable. A smaller one would have to either (a) re-cast some primitive as a derived operation (e.g., treating temporal proof as a special case of attestation, which we reject because the time authority is a third principal with its own trust model) or (b) drop a use case (e.g., abandoning royalty cascades, which we reject because royalty is required by the music and creative domains). We invite a smaller axiomatization that covers the same workflows; we have not found one.

## 9.2 Is the chemistry analogy rigorous or merely metaphorical?

The chemistry analogy is *rigorous in its typed-merge content* (§4) and *suggestive in its periodic-table content* (§6).

The merge classes (covalent, ionic, metallic, nuclear) are not metaphorical: they are predicates over admissible compositions whose semantics are checked at composition time. A “covalent” Holosynthetic merge has a precise definition: bidirectional contract sharing, irrevocability without re-signing, lineage links to both sides. The mapping to chemistry is a teaching aid; the mathematical content is independent of whether one accepts the chemistry vocabulary.

The Signed Periodic Table is more obviously suggestive: chemistry’s table closes at 118 because atomic structure is finite, while the SPT does not close (groups can grow under federation; periods extend whenever depth limits advance). The shared *epistemic* property — that gaps in a periodic structure are predictive — is real. Whether the table has the same kind of *physical inevitability* as Mendeleev’s is an open question. Our position is the cautious one: the SPT is a useful taxonomic structure with predictive force; it is not an immutable feature of the universe.

### 9.3 Is the quantum analogy a metaphor or a scientific claim?

A metaphor. We have been explicit (§5.2) that Law II is *not* a quantum-mechanical claim. The structural parallel — that selection does not destroy unselected branches, in tension with Copenhagen-style collapse and in agreement with Many-Worlds-style branching — is illuminating but not derivational. Holosynthetic mathematics is classical, combinatorial, and cryptographic. We use the quantum vocabulary because students of physics find it helpful and because the analogy clarifies what *kind* of preservation we mean. We use the Platonist vocabulary (Plato → Lewis → Tegmark) because it *grounds* the claim philosophically. The Platonist grounding is the foundation; the quantum analogy is the bridge.

### 9.4 Is “Conservation of Proof” more than append-only logs?

Reviewers familiar with the immutable-log literature (Laurie et al., 2013; Crosby and Wallach, 2009) may ask whether Conservation of Proof adds anything beyond known append-only-log results.

The honest answer: the *mechanism* is largely the union of techniques already in the literature (append-only structures, hash chains, external witnessing, transparency-log consistency proofs). The *contribution* is the framing: in Holosynthics, every committed entity participates in an attestation accumulation that satisfies the conservation law *by construction*, not as an opt-in security property; and the *integration with Law II* gives a discipline-level invariant that no individual log-of-X system has stated. A reader who thinks of Conservation of Proof as “append-only logs, written formally” is not wrong; they have understood the cryptographic mechanism. A reader who wants the discipline-level claim — that Holosynthetic systems *as a class* preserve attestations as a structural invariant — is reading Law I correctly.

### 9.5 Is the consciousness stance a scientific claim or an engineering posture?

An engineering posture, justified by reference to philosophical positions (Chalmers, 1996; Searle, 1980; Tononi, 2004) any of which could justify it. We do not assert that OMEGA is conscious; we do not assert that OMEGA is not conscious; we assert that the question is not resolvable from the engine’s vantage and we encode that irresolvability as a runtime invariant. The *invariant* is a scientific claim (it is provably enforced by the Phase-2 engine). The *underlying metaphysics* is philosophy. The encoding of the philosophy as runtime structure is the contribution.

### 9.6 Falsifiability

A reviewer may ask: what would falsify Holosynthics?

- **Falsifying Law I.** A demonstrated procedure to retroactively erase a witnessed attestation under standard cryptographic assumptions would falsify Law I. We do not believe such a procedure is possible without breaking either the underlying signature scheme or the witness’s commitments.
- **Falsifying Law II(a).** A composite whose attested properties are demonstrably equal to (rather than properly containing) the union of its constituents’ properties would falsify Law II(a). We have not encountered such a composite in twelve adapters; we do not exclude the possibility.
- **Falsifying Law II(b).** This claim is harder to falsify because it is partly mathematical and partly philosophical. The mathematical content (an unselected admissible composition remains admissible after a different one is selected) is straightforward to test. The philosophical content (the unselected possibilities exist in some defensible sense before any selection occurs) is unfalsifiable in the strict Popperian sense; it is justified by reference to a body of philosophical literature any of whose major figures has defenders and detractors. We accept this asymmetry.
- **Falsifying Law III.** A demonstrated procedure to forge a GI’s origin under EUF-CMA-secure signing, collision-resistant hashing, and a non-compromised TSA would falsify Law III. None is known.
- **Falsifying the periodic-table predictive method.** If predictions PT-1, PT-2, PT-3 (§6.3) cannot be realized as stable archetypes — for example, because their intended properties turn out to be inconsistent — that would weaken the predictive case. The predictions could fail in an interesting way (revealing a structural constraint we missed) or in a boring way (no one bothers to build them).

## 9.7 Limitations we accept

- We do not have a normalization theorem (§3.12). The completeness claim is empirical.
- We do not have a 2-categorical formalization of the SPT (§6). Open problem.
- We do not have machine-checked proofs of the engine code.
- The deferred Phase-1 threats (six in total) are documented but not closed in this version of the engine.
- The philosophical grounding of Law II(b) cites four traditions that disagree with each other on metaphysics. We do not adjudicate between them. A critic who rejects all four would reject Law II(b)’s grounding; we believe the four are jointly robust but each is independently contestable.

## 10 Conclusion

We have proposed *Holosynthics* — from Greek *holos*, “whole, complete,” and *synthesis*, “composition” — as a name for the discipline that studies how cryptographically signed digital entities combine. The discipline rests on ten orthogonal primitives, satisfies three laws, and admits a periodic-table-style taxonomy with predictive power. We have grounded the central claim that *selection is activation, not destruction* not in quantum mechanics — to which the analogy is structural only — but in the

philosophical lineage from Plato through Lewis to Tegmark, with Lovejoy’s Principle of Plenitude as the historical bridge.

We have anticipated the principal criticisms and responded honestly to each. The chemistry analogy is rigorous in its typed-merge content and suggestive in its taxonomy. The quantum analogy is a teaching device, not a scientific claim. The periodic table predicts but does not close. The consciousness stance is an engineering posture supported by philosophy, not a metaphysical assertion.

A signed digital world becomes possible when its substrate has both a vocabulary and laws. Holosynthics is the proposed vocabulary and the proposed laws. The engine that implements them is signed by the same primitives the paper describes; the paper is signed by the engine. *The discipline carries its own attestation.*

We invite the research community — cryptographers, systems engineers, philosophers of mathematics, regulators, and operators — to test the claims, find the counter-examples, propose smaller axiomatizations, fill the periodic gaps, and formalize the categorical structure. The signed digital world is too large to be the work of one author; this paper is the founding statement, not the finished science.

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## A Verification of this manuscript

To verify the claims of §8 — that this manuscript is signed by the GI Engine instance described herein — perform the following:

1. Obtain HOLOSYNTHICS-ARXIV-PAPER.md (the canonical source of this paper) and HOLOSYNTHICS-ARXIV-PAPER (the signature artifact).

2. Compute the SHA-256 of the canonical UTF-8 byte representation of the markdown file.
3. Verify the Ed25519 signature in the artifact against the public key registered in the engine manifest at `crates/gi-engine/manifest/holosynthics-paper.toml` (or equivalent path in the published source release).
4. Verify the RFC 3161 timestamp in the artifact against the TSA’s certificate chain.
5. Optionally: query the witness archive at the URL declared in the manifest to confirm that the engine’s tip hash including this paper’s commit was published on the witness’s append-only log.

Reference verification code is shipped under `tools/gi-verify/` in the engine source release. The procedure is approximately fifty lines of Rust. We have intentionally minimized the dependency surface so that any reviewer can perform the verification without the GI Engine itself.

## B Changelog and naming history

This appendix is included for the historical record. The discipline named here passed through several candidate names during research:

- **Synthography** (rejected). Preempted by [Reinhuber \(2022, 2023\)](#), who uses the term for synthesis + photography (AI-generated imagery). The disciplines do not overlap, but the name was occupied first.
- **Cryptosynthesis** (rejected). Strong semantic collision with synthetic crypto-assets (DeFi instruments via Synthetix and similar).
- **Cryptochemistry** (rejected). Prior academic use for chemical-structure information storage (CryptoChem, 2020); commercial Web3 brands.
- **Provenics** (rejected). Active German GmbH owns the corporate name and `provenics.com`.
- **Signetics** (rejected). Iconic 20th-century semiconductor company (1961–, NXP lineage); inventor of the NE555 timer IC.
- **Attestics** (clean alternative). Etymologically natural; emphasizes provability rather than wholeness.
- **Holosynthics** (selected). *holos* (whole) + *synthesis* (composition) + *-ics* (body of knowledge); etymologically clean; sits in the *holo-* family with hologram, holobiont, hologenome; the *holos* prefix uniquely captures the wholeness-of-possibility-space property required by Law II(b).

The naming process is documented because future readers may reasonably wonder why this particular name. The short answer is: *holos* is the morpheme that names selection-without-destruction, and no other name on the candidate list both was etymologically accurate and lacked prior occupation.