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The Geometric Inevitability of Cosmos, Life, and Mind

The Self-Referential Closure of the GG-Theory Program

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Abstract

Why are we here? For four centuries science has described *how* the world works but left *why* we exist to philosophy. Life and consciousness have been treated as a lucky accident in an indifferent cosmos. This paper — the *keystone* of the GG-Theory program — argues that the accident never happened.

A unique six-dimensional geometry, internally consistent and with no free continuous parameters, fixes every particle's mass, every force's strength, the cosmic inventory, and the energy quantum of every living cell. The same geometry runs a cascade engine: at each layer an information current in the deep geometry projects onto our four-dimensional world, rolls down to the deepest valley of its energy landscape, and locks at the unique valley admissible to four consistency filters. Out-of-equilibrium shocks lift the cascade from one layer to the next, ending with intelligent observers who articulate the geometry that produced them. The rungs are ordinary objects: the periodic table, the twenty amino acids, ATP as the universal energy currency, the four-letter genetic code, the first cell, the first nervous system, the conscious episode.

Cosmos, life, and mind are thus not three accidents but three boundary readings of one recursive theorem on the same bulk — a self-referential closure in which the observers who articulate the geometry are the cascade's terminal output. We are here because the geometry requires it — given one constitution, which the framework posits rather than proves. The particle and cosmic floors are derived in the companion papers GG-A9-SM and GG-A10-Cosmos; the present paper states the one mechanism, proves the recursive-uniqueness theorem that binds the five floors, and lays out the ten falsifiers that can confirm or kill the program this decade.

Executive Summary

The problem. For four centuries, physics has explained *how* the world works, but not *why* there should be anyone here to discover its laws. This paper proposes that the same geometry which fixes the laws of physics also drives a single step-by-step cascade — from quarks to atoms to molecules to cells to nervous systems to conscious minds — so that intelligent observers are its inevitable end point rather than a lucky accident. It is the third and final consequence paper of the GG-Theory program.

The single input. Everything rests on a single fixed starting point: a six-dimensional geometry with *no adjustable numbers*. Nothing can be tuned to fit the data; once the geometry is set, every later result is forced. And no new assumption is ever added for chemistry, life, or mind — the same rules run all the way up.

The cascade engine, in four moves. One four-move logic repeats at every layer of the cascade. **Move 1 — a free background.** Deep in the geometry an information current flows freely, with nothing yet committed. **Move 2 — projection and commitment.** That background is read out onto the four-dimensional world we observe, and the system commits to one definite outcome (this is also the framework's account of why a quantum measurement gives a single result). **Move 3 — roll downhill.** The committed system slides down an energy landscape toward its lowest reachable valley, each step paying a real energy cost set by one universal quantum — about the energy released by a single ATP bond. **Move 4 — settle in the unique valley.** It comes to rest in the one valley that passes four consistency checks: the only stable resting state available. Compactly, the engine is the chain

$$\boxed{\mathsf{GRIP} := \mathsf{DGI} \to (\mathsf{GFF}) \to \mathsf{GSSB} \to \mathsf{GGA}}$$

(free background → energy landscape → commitment → unique ground state). When conditions hold steady, the loop locks in what we recognize as *universal identity*: every electron is the same electron, every cell the same kind of cell, every conscious episode the same kind of episode. When an external shock reshapes the landscape — cosmic cooling, the first oxygen, a predator arms race, a cultural revolution — a new valley opens and the cascade is pushed up one rung. This alternation of patient locking and occasional shock is what carries the cascade, step by step, from quarks to minds (drawn in Figure 3).

The central claim. *Given the geometry, the cascade*

$$\boxed{\mathcal{C} \xrightarrow{\mathsf{GRIP}} \mathsf{GGA}_1 \to \mathsf{GGA}_2 \to \cdots \to \mathsf{GGA}_{17} \to \mathsf{GGA}_{18}\ (\textit{the present paper})}$$

has a unique outcome at every layer. The existence of intelligent observers able to state the theory is a forced consequence of the geometry itself; the whole cascade in one picture is Figure 2.

Eighteen rungs, from quarks to mind. The cascade climbs eighteen rungs. **Physics:** the Standard-Model forces and particles; the periodic table. **Chemistry:** small molecules (water, CO_2, ammonia, methane); the twenty amino acids; polymers. **Life:** ATP as the universal energy currency; RNA, then DNA with its four-letter code; the first cell (∼3.8 billion years ago); the bacteria/archaea split; the complex (eukaryotic) cell; multicellular bodies. **Mind:** the first central nervous system (the *C. elegans*-class integrated connectome); an insect-grade heading compass; a mammalian map of space; the conscious episode (∼0.4 s, two theta cycles); and finally observers who articulate the whole scheme — this paper (all eighteen rungs, with the shock that opens each, are laid out in Figure 1).

How confident, layer by layer. Not every rung is equally secure, and the paper states the status of each. **Derived** — fully forced from the starting geometry, with every step of the chain already published — three rungs; **Anchor-Derived** — the measured number settled, the derivation from the geometry still being written — three rungs; **Conditional** — forced once one named, stated result is proven — seven rungs; **Asserted** — expected, but awaiting a specific experiment — four rungs; and **Existence-Demonstrated** by this paper itself, the final rung. Nothing is invented to fill a gap; every rung is either forced or openly marked as pending.

The Top 10 Falsifiers. The framework stakes itself on ten specific tests this decade, any one of which can sink it. **Physics and cosmology (six):** a 3.85 TeV particle cluster (HL-LHC); an 8.1 μeV dark-matter axion (ADMX/CAPP); dark energy that stays exactly constant, $w = -1$ (DESI/Euclid); a stable proton (Hyper-Kamiokande/DUNE); a pinned primordial tensor amplitude, $r = 0.0038$, two-sided (CMB-S4/LiteBIRD); and a neutrino CP angle near 196° (DUNE/Hyper-K). **Life (three):** the ATP energy quantum near 30 kJ/mol; the four-letter genetic alphabet {A,C,G,T} as the unique code of naturally evolved life; and a *two-knee* $1/f$ spectrum — exactly two spectral knees bracketing a finite power-law band, the knee positions set by the system's slowest and fastest retained rates rather than by universal constants — in the metabolic noise of complex (eukaryotic) cells (test 9a). **Mind (two):** the conscious episode completing in ∼0.4 s (two theta cycles); and the *same two-knee* $1/f$ spectrum — the same exactly-two-knee structure, at that substrate's own rates — in brain (EEG/ECoG) recordings (test 9b). The two-knee $1/f$ law is thus a single universal falsifier appearing in both Life and Mind (the spectral analog of the Kaxion twin peaks); it is counted once across its two substrates (9a, 9b), so the ten tests are six physics, three life, and two mind with the $1/f$ shared. Each test names a number, an instrument, and a decade window; decisive failure of any one falsifies the framework.

Where this paper sits. This is the *keystone* of the program. Two floors of the structure are already built: the companion papers GG-A9-SM (particles) and GG-A10-Cosmos (cosmos) derive the constants of physics and the contents of the universe to a falsifiable codebook. The chemistry, life, and mind floors are developed in *GG-A12-Chemistry*, *GG-A13-Life*, and *GG-A14-Mind* (in preparation). The present paper does not re-derive those floors; it shows that they are *one* structure — it states the single mechanism, proves the recursive-uniqueness theorem (RUT) that binds the floors together, and lays out the ten falsifiers that can end the whole program this decade. The

framework has no adjustable numbers anywhere along the chain, from the smallest scale to the conditions that allow a mind to exist.

What is new here. Three things set this approach apart from earlier attempts to unify the sciences, and they are worth stating plainly for readers coming from biology, chemistry, or philosophy rather than particle physics. **One mechanism, not many.** The same four-move step that selects a quark's properties also selects an amino acid, a genetic code, and the length of a conscious moment. Chemistry, life, and mind are not bolted on with fresh assumptions; they are the *same* machine run at higher rungs. **No adjustable numbers.** Most "theories of everything" buy their fit to data with hidden parameters that can be quietly re-tuned when a test goes wrong. This framework forbids them: there is nothing to adjust, so the theory cannot be rescued after the fact. **It names how it could fail.** Rather than re-explaining what is already known, it commits in advance to ten specific measurements this decade, any one of which can end it. A framework that cannot be killed is not doing science; this one hands its critics the knife.

A philosophical conclusion. If the argument holds, the oldest question — *why is there something rather than nothing, and why are we here to ask?* — changes character. Cosmos, life, and mind stop being three separate miracles and become three readings of one self-consistent geometry, the way a single cone yields a circle, a point, or an ellipse depending on where it is cut. The selection reaches all the way down: even the number field is chosen, the real category alone recovering the observed complex boundary at candidate grade, so the cascade runs on real geometry at every floor. The observer is then not a latecomer to a finished universe but the last rung the cascade was always going to climb, where the geometry turns around and describes itself. This is not the claim that the universe was *designed* for us, nor that all is predetermined; it is the more modest, and we think more beautiful, claim that *given one constitution* — which the framework posits rather than proves — observers able to read it are a requirement, not an accident. *Nature restricts unnecessary freedom, making inevitable decisions*: every removed freedom became a theorem or a falsifier, and what stays free is listed, not hidden. Throughout, the paper marks where physics ends and interpretation begins.

Keywords: GG-Theory; the GG-Constitution; geometric unification with zero free parameters; cosmos, life, and mind; the GRIP cascade; GSSB and the Geometric Attractor; Qi-4 admissibility; BI-6 and the OGN-5 ledger; the GFF descent; the eighteen-layer cascade; recursive uniqueness theorem; self-referential closure; universal identity; the origin of consciousness; falsifiability; the Top 10 Falsifiers

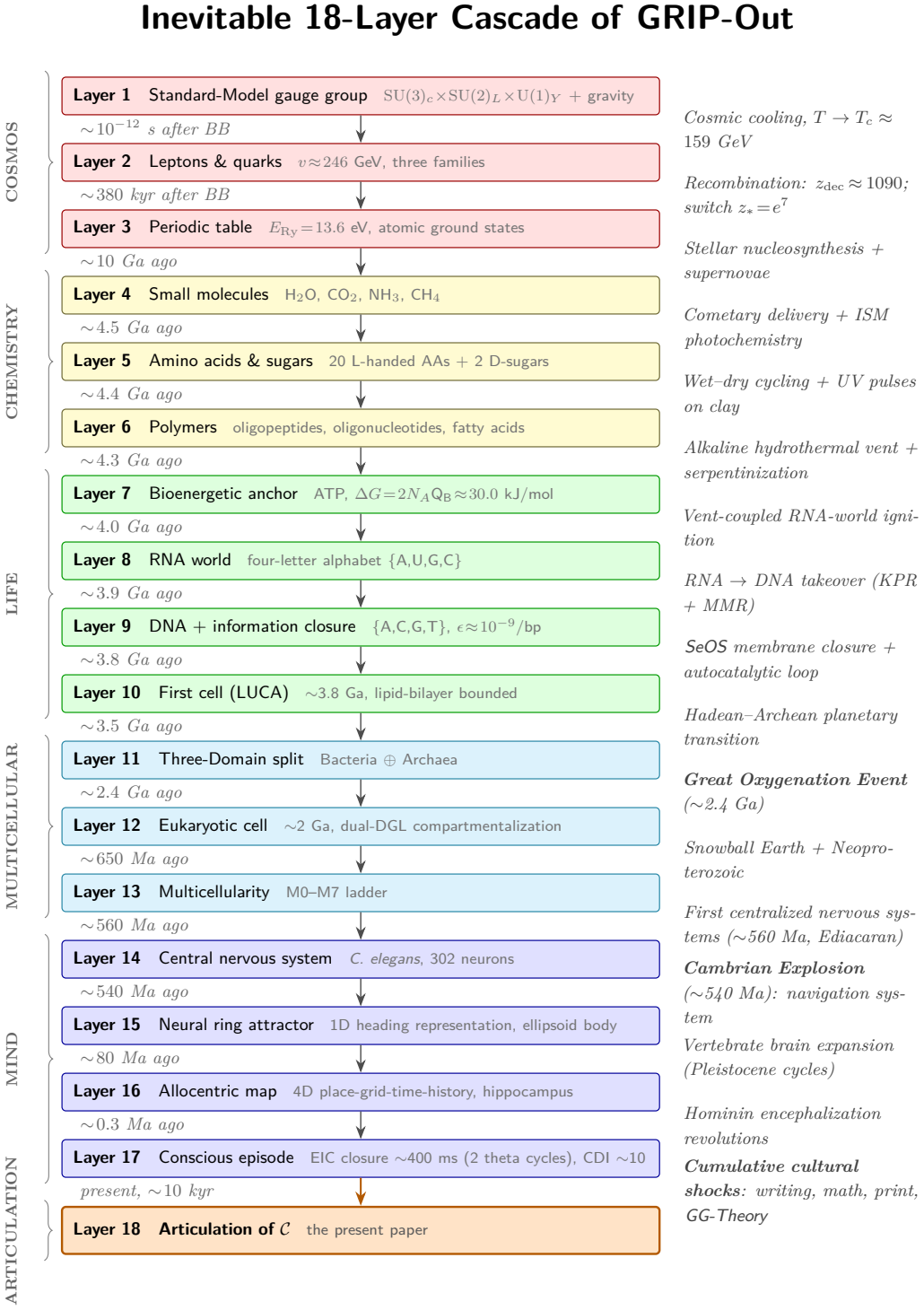


Figure 1: Inevitable 18-layer cascade of GRIP-Out. The seventeen GRIP-Out shocks and their approximate ages, floor by floor, from the Standard-Model gauge group to the act of articulation. The full row-by-row version — mechanism, timescale, and empirical anchor for each transition — is Figure 10 and Table 2 in Part III.

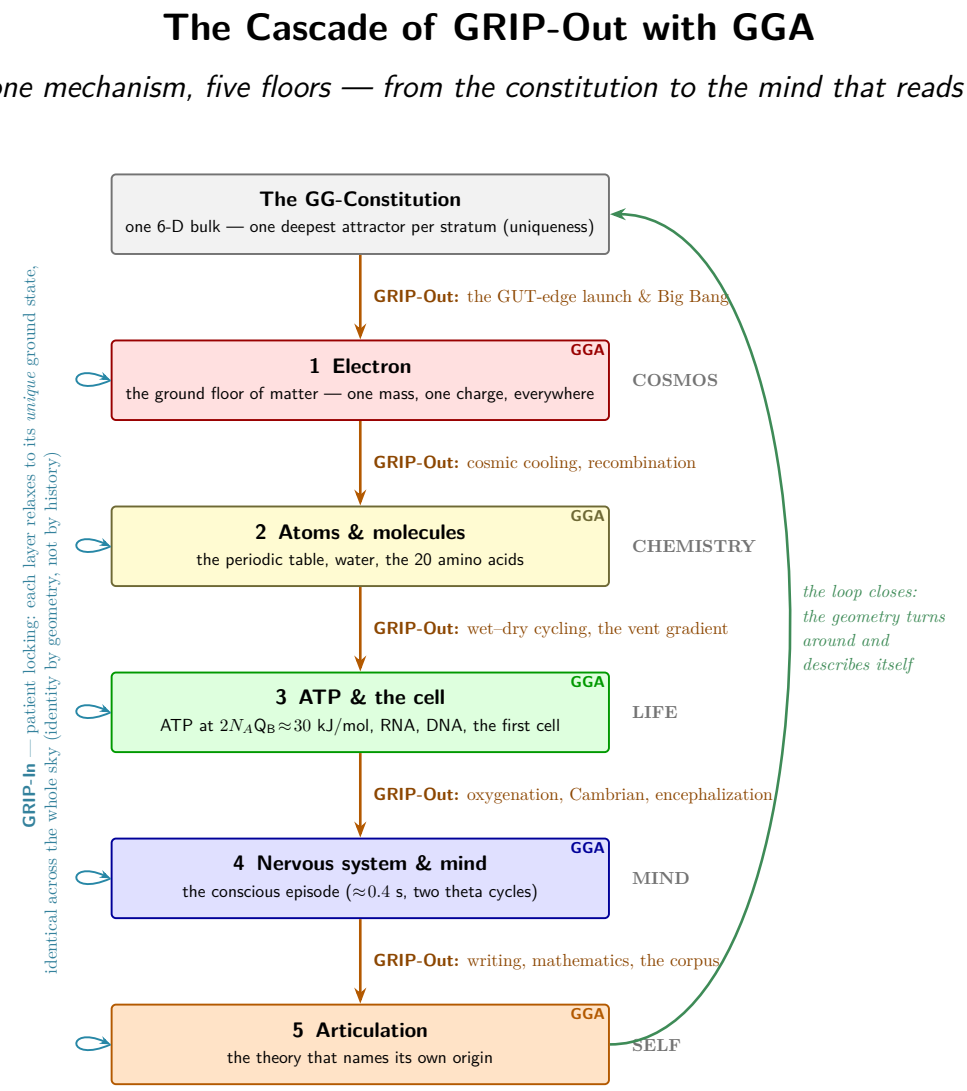


Figure 2: The Cascade of GRIP-Out with GGA — the central concept, in five floors. Each floor is a Ground Geometric Attractor (GGA), colored by its band as in the 18-layer showcase. GRIP-In (cyan) locks it in (identical everywhere); the settled ground state then *becomes* the GRIP-Out (orange) shock that opens the floor above — so the cascade carries its own clock, with no external designer and no external timer. The first lock, the electron across the whole sky, is the *second horizon problem* of GG-A10-Cosmos; the last closes the loop back onto the constitution. Discussed in detail at Figure 8 in Part III.

The GRIP Engine: Four Moves, Two Regimes, One Ground State

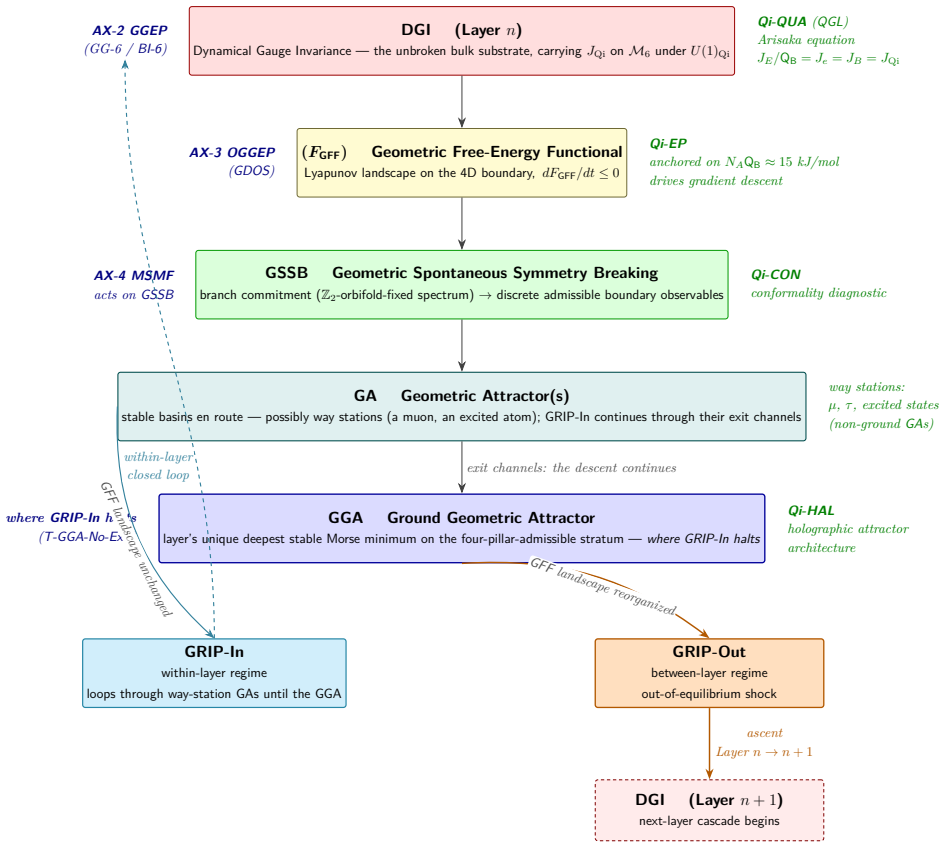
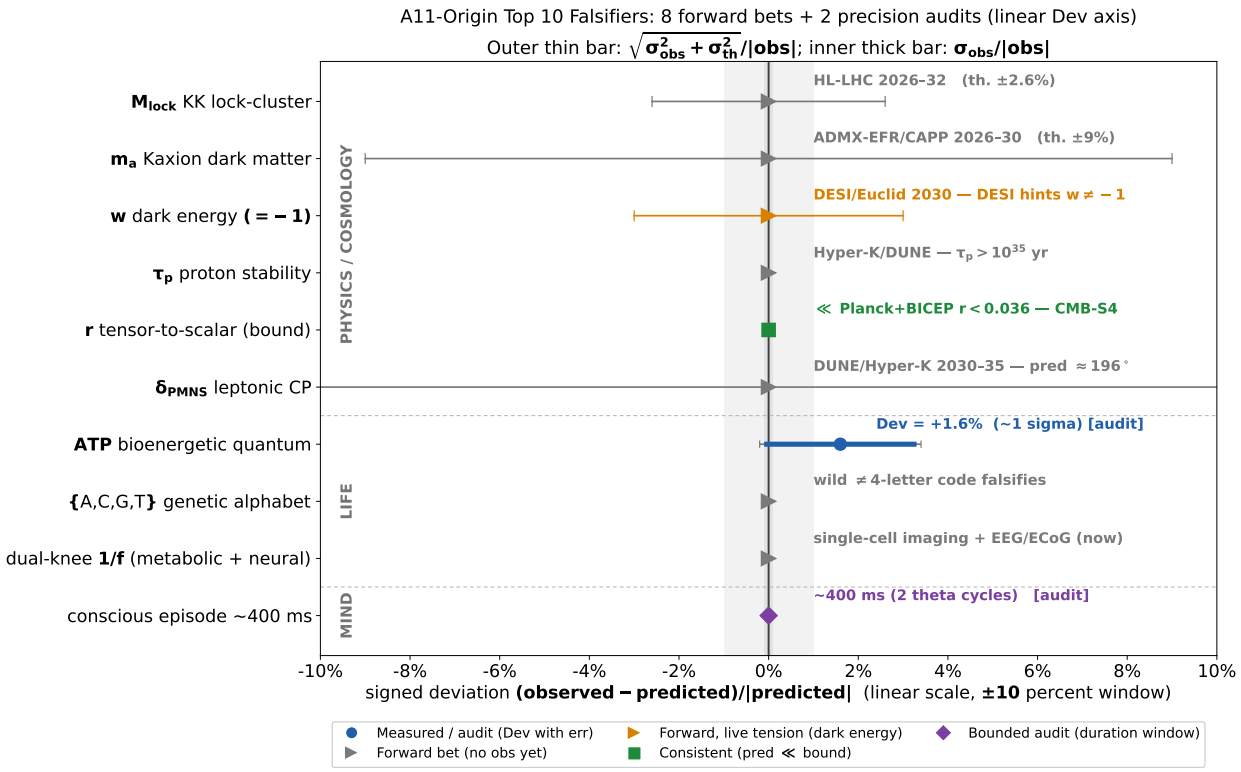


Figure 3: The GRIP engine: four moves, two regimes, one ground state. The central column is the four-move descent DGI → (F_{GFF}) → GSSB → attractor; the three constitutional axioms (left) force the moves and the four Qi-4 pillars (right) filter the Morse minima. GRIP-In (cyan) loops within a layer to the unique ground state; GRIP-Out (orange) reorganizes the landscape and opens the next floor. Fully annotated as Figure 9 in Part III.

Eight Bets Whose Answer Is Not Yet Known, and Two Audits That Already Have One



Where this paper is exposed, and the shape of the exposure. Ten commitments on one axis: the signed deviation of prediction from measurement, with precision bands at 10^{-1}, 10^{-2} and 10^{-3}. The important feature is not where the markers sit but what kind of marker each one is. **Eight are forward arrows** — the KK lock-cluster at 3.85 TeV, the Kaxion at 8.1 μeV, dark energy at $w = -1$, proton stability, the tensor-to-scalar ratio at 0.0038, the leptonic CP phase, the four-letter genetic alphabet, and the dual-knee $1/f$ neural spectrum — and an arrow means the answer is not yet known. **Two are circles**, the ATP bioenergetic quantum and the conscious-episode duration, already measured and landing inside the window. This is the opposite of a postdiction plot: where the audits of GG-A9-SM and GG-A10-Cosmos show what the framework has already matched, this page shows what it has staked and not yet collected. Eight of the ten are open, every one of them is dated, and a single failure ends the row it sits in. In full, with the pull table and the decade calendar behind it: Figure 12, p. 181.

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Preface

This paper is long, and its subject — how a single geometry could give rise to cosmos, life, and mind — is large. Before the technical argument begins, three short notes: one to the people who will ultimately judge the work, one on how to find your way through it, and one on what is settled and what is still forecast.

To the next generation. This paper is offered, above all, to the students who will test it. Its author has spent a working life arriving here; its fate now belongs to people who are today learning their first physics, their first biochemistry, their first neuroscience. If you are one of them, you need not accept a word of this framework — you need only hold it to the standard it sets for itself. Follow the chain of reasoning rung by rung; measure the ten numbers; where it is wrong, show that it is wrong, and where it is silent, ask why. The deepest compliment you can pay an idea is to try in earnest to break it, and this one was built to make that attempt as clean as possible. Whatever the verdict, the question it takes up — how cosmos became life, and life became mind — is worth a career. We hope you find it as worth yours as we have found it worth ours.

How to read this paper. No reader needs all eighteen rungs at once. The fastest route in is the Executive Summary for the shape of the argument; Part III for the single mechanism that drives every layer; Part IV for the layer-by-layer results, each tagged with its confidence; and Part XVI for the ten tests that will decide the matter. Specialists can enter at their own layer — a chemist at the amino acids, a biologist at the genetic code or the first cell, a neuroscientist at the spatial maps and the conscious episode — because each layer's result is stated so that it can be read, and challenged, on its own.

What is settled, and what is forecast. Five floors, and they are not all at the same stage, so here is the map, once. The particle floor is derived in GG-A9-SM and the cosmic floor in GG-A10-Cosmos, both at what this program calls *codebook standard*: every quantity derived from the constitution, predicted before it is compared with anything, set against measurement, and assigned a pull. Those two floors supply the numbers the lower rungs of this paper stand on. The upper three floors — chemistry, life, and mind — are stated here as named theorems, each carrying a tag that says in one word how far its derivation reaches: *Derived*, *Anchor-Derived*, *Conditional*, *Asserted*, *Existence-Demonstrated*. Every rung carries one, and the tags are defined in Part IV, where they are used. The full derivations of the upper three floors are the work of GG-A12-Chemistry, GG-A13-Life and GG-A14-Mind, now being written.

What the tags do not soften. The ten falsifiers. Each is a number, an instrument and a decade window, and a decisive failure on any one of them ends the framework — whatever tag the surrounding rung happens to carry. The tags say how far the derivation reaches today; the falsifiers say what the world will be allowed to say about it regardless. That is the whole of the discipline, and it is why the three floors still being built are an invitation rather than a caveat. They are exactly where the next generation can help.

Part I
Introduction

Why are we here, and how this paper proposes to answer

1 "Why are we here?"

Of all the questions human beings have ever asked, one stands above the rest in depth and persistence: *Why are we here?*

Indeed, every civilization has posed this question. The Upanishads asked it three thousand years ago and answered: because the cosmic self (Brahman) sought to know itself. The Book of Genesis answered: because God chose to create. Greek philosophy answered in multiple voices: Aristotle said everything has a purpose (telos), Democritus said everything is atoms and void, and Plato said the visible world is a shadow of a higher reality of perfect forms. The Enlightenment scientists — Galileo, Newton, Laplace — deliberately set the question aside: physics could describe *how* the world works without asking *why* it exists. Darwin offered a partial answer for the diversity of life (Darwin, 1859), but not for its existence. The twentieth century brought quantum mechanics and general relativity — two of the most successful theories in the history of science — but neither addressed the existence of the beings doing the physics. Schrödinger, in his prescient 1944 book *What is Life?* (Schrödinger, 1944), asked how the laws of physics could explain the order and stability of living matter. He pointed to the "aperiodic crystal" of the gene as the key, but he could not derive its specific molecular architecture from physics alone. Crick and Watson discovered the double helix in 1953 (Watson and Crick, 1953), but the question remained: why *this* molecule? Why four bases? Why a triplet code? Why 20 amino acids?

The standard answer — "because evolution selected them" — is circular. Evolution explains how organisms adapt once they exist; it does not explain why anything exists to evolve. The deeper question — why the laws of physics are such that self-replicating information-processing systems inevitably arise — remained unanswered. And twentieth-century physics, despite its extraordinary successes, left the question untouched: neither quantum mechanics nor general relativity says anything about why there are beings capable of writing down the Schrödinger equation.

This paper proposes that the question now has a scientific answer.

1.1 Why science has struggled with this question

The difficulty is by no means a lack of intelligence or imagination. It is structural. Physics, as it has been practiced since Newton, divides the world into two domains: the *laws* (equations of motion, field equations, symmetry principles) and the *initial conditions* (the specific state of the universe at some early time). The laws are universal and necessary; the initial conditions are contingent and

arbitrary. In this framework, the existence of life falls on the side of initial conditions: life exists because the universe happened to start in a state that eventually produced it. There is no deeper explanation.

The anthropic principle attempted to bridge this gap by arguing that we can only observe a universe compatible with our existence. But this is a selection effect, not an explanation — it is like saying that the reason you are alive is that dead people cannot ask questions. The multiverse hypothesis went further, proposing that all possible laws of physics are realized somewhere, and we inhabit the subset that permits observers. But this hypothesis is untestable, explains nothing specific, and replaces one mystery (why these laws?) with a larger one (why a multiverse?).

The GG-Theory framework (Grand Geometric Theory — the twenty-two-paper program that derives physics, cosmology, and the biology of intelligent observers from a single six-dimensional geometry with no continuous free parameters) offers a different approach. It does not appeal to initial conditions, selection effects, or ensembles of possible universes. Instead, it derives the existence of life and consciousness from the *laws themselves* — specifically, from the unique geometrically consistent structure of a six-dimensional bulk spacetime — governed by the Geometry-Gauge Equivalence Principle (GGEP, AX-2: gravity and gauge fields are two aspects of one composite connection) and the six-dimensional Bianchi identity (BI-6, the Green–Schwarz-modified anomaly-closure equation that admits exactly one consistent coefficient vector) — and the operational rules by which that geometry is projected onto the four-dimensional world we observe (the Operational/Open GGEP, OGGEP, AX-3: every theory must come with a projection law that maps bulk states to boundary data; and the Geometric Dynamics of Open Systems, GDOS, AX-3's boundary law, governing how systems exchange energy, matter, and information with their environment).

1.2 What is consciousness, and where does it come from?

The second great question addressed in this paper is the nature of consciousness. What is it? Where does it come from? Why does it exist at all?

These questions have been debated for as long as the question of existence itself. Descartes proposed that consciousness is a separate substance ("res cogitans") distinct from matter ("res extensa"). Materialists since Hobbes have countered that consciousness is "nothing but" the activity of the brain. Modern neuroscience has mapped the brain in exquisite detail — we know which neurons fire during perception, which brain regions are active during dreaming, which neurotransmitters correlate with mood — but what Chalmers (1995) calls the *hard problem* persists: why does subjective experience exist at all? Why does the electrochemical activity of neurons feel like anything?

The GG-Theory does not solve the hard problem by explaining away subjectivity. Instead, it provides something no previous physical theory has offered: an *operational definition* of consciousness that is derivable from the same equations that govern particle physics. Consciousness, in this framework, is the internal measurement of a selected and stabilized branch of the brain's world-model (the Inner Hologram), implemented by the same DGI (Dynamical Gauge Invariance — the unbroken-symmetry parent context) → GSSB (Geometric Spontaneous Symmetry Breaking — the chain of Bogomolnyi-saturating saddle events) → GA (Geometric Attractor — the unique stable

end-state) pipeline that governs symmetry breaking in particle physics and phase transitions in thermodynamics.

This definition is precise (it specifies exactly which neural operations constitute a conscious episode), falsifiable (it predicts when consciousness is present and when it is absent), and derivable (it follows from the GDOS open-system framework without any new postulate about the nature of mind).

2 The central claim: every layer of the cascade is an open-system observable

One recognition underlies this capstone and the whole cohort beneath it, and it is worth stating before the cascade is assembled. No physical system is closed — not a single particle, not the universe behind its horizon, not a living cell exchanging matter and energy with its surroundings. What an observer registers is therefore never the full six-dimensional bulk but its lawful projection onto a four-dimensional boundary — the open-system geometric–gauge equivalence principle (OGGEP, AX-3; Arisaka, 2026, A1-Constitution) — and that projection *is* observation itself (GG-A8-QM (Arisaka, 2026, A8-QM); GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)). Its dynamics is the open-system law GDOS (Arisaka, 2026, A5-GDOS), forced by the geometric Gi-4 (Arisaka, 2026, A6-GRIP) and quantum-information Qi-4 (Arisaka, 2026, A7-Qi4) pillars. It follows that every layer of the cascade this paper assembles — the twenty-eight Standard-Model parameters of GG-A9-SM, the cosmic inventory of GG-A10-Cosmos, and the higher strata up to life and mind — is a *registered observable* of one projection, not a free input.

For the century since the birth of quantum mechanics, the constants of physics were treated as inputs to a closed four-dimensional theory, and no one asked whether they are instead observables of an open-system projection from a higher-dimensional bulk. That question, and its affirmative answer, is the recognition on which the entire cohort — and this capstone's claim that one constitution forces every layer from the electron to the conscious mind — finally rests.

3 A reader's guide for different audiences

Roughly speaking, the paper is written at the level of an advanced undergraduate in any STEM field. All mathematical equations are preserved in full rigor, but every equation is accompanied by a physical explanation, a concrete example, or an everyday metaphor. The goal is to make the argument accessible to any scientist — physicist, biologist, chemist, neuroscientist, or philosopher — who is willing to follow a sustained logical chain from spacetime geometry to consciousness.

GG-A11-Origin is the philosophical capstone of a twenty-two-paper cohort, and a single linear reading of its 471 pages will not serve every reader equally well. This Section names the natural entry points and reading paths for four kinds of readers — the life scientist, the neuroscientist or philosopher of mind, the philosopher, and the physicist already familiar with the corpus — so that the paper can serve each on its own terms.

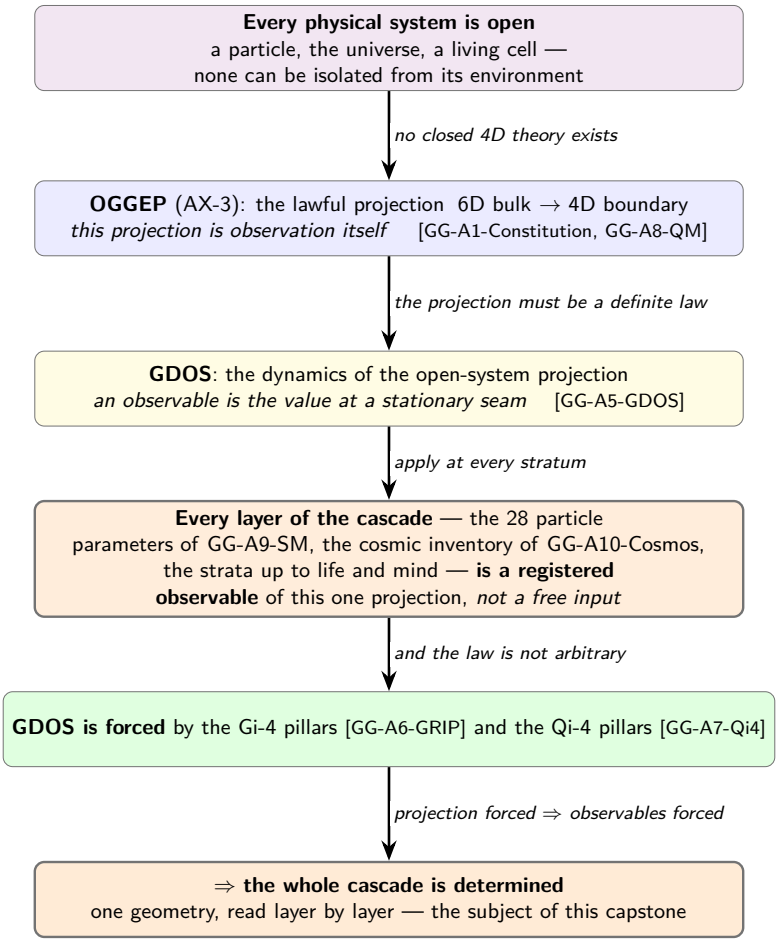


Figure 4: The central claim, as one deductive funnel. Because no physical system is closed, the four-dimensional world is a lawful projection (OGGEP, AX-3) of the six-dimensional bulk, and that projection is observation itself; its dynamics is the open-system law GDOS, forced by the Gi-4 and Qi-4 pillars. Every layer of the cascade — particle masses, the cosmic inventory, and the higher strata up to life and mind — is therefore a *registered observable* of one projection, not a free input. This funnel is shared, verbatim in structure, with the companion papers GG-A9-SM and GG-A10-Cosmos; only the payload differs, layer by layer. The whole GG-Theory cohort rests on this single recognition.

For the life scientist. If your training is in biology, biochemistry, or molecular biology, the most useful entry points are Part XIII (the dynamics block: the bioenergetic anchor Q_B, the Selfish Open System class, and the Geometric Free-Energy Functional with the Three-Gauge Theorem), Part XIII Section 5–7 (the holographic triad and the CDI ladder of consciousness), and Part XVII §87 (the cascade's cross-domain reach, especially molecular biology, developed in GG-A13-Life). Part XIII §59.7 gives the four metaphors that translate the framework into life-scientist idiom: the universal altitude, the musical score, the water in different vessels, and the cascade staircase. Skip the technical 6D-bulk machinery of Part II's 6D-bulk + BI-6 section on a first reading; you can return to it if the constitutional warrant becomes a sticking point.

For the neuroscientist or philosopher of mind. If your training is in neuroscience, cognitive science, or philosophy of mind, the most useful entry points are Part XIV (the cognitive cascade: Pagoda, holographic triad, CDI ladder), Part XV (the self-referential closure and the comparison with the philosophical tradition), and Part XVII–XII (the philosophical summit and the closing of the loop). Section 59.3 of Part XIII identifies Friston's variational free energy as one of the three boundary projections of the Geometric Free-Energy Functional; Section 62.1 explains the holographic-triad inheritance. The hard problem of consciousness, as named by Chalmers (1995), is engaged in Part XIV and revisited in Part XV (the self-referential closure) and Part XVIII (the closing personal section). Skip the OGN-5 (Occam-Gauge-Normalization 5-integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$, the framework's only numerical inputs) Diophantine ledger of Part II on a first reading; it returns naturally in Part XVII.

For the philosopher. If your training is in philosophy of science, metaphysics, or the philosophical tradition, the most useful entry points are Part XV (the self-referential closure and the engagement with thirteen philosophical predecessors) and Part XVII–XII (the philosophical summit). Part XV §72 engages Spinoza, Leibniz, Kant, Hegel, Whitehead, Wigner, Wheeler, Penrose, Smolin, Tegmark, Barrow–Tipler, Aristotle, the Upanishadic tradition, and the Buddhist tradition in turn, each in roughly two pages of dedicated engagement. Part XVII–XII returns to the same predecessors at summit register. The technical content of Parts II–VI is the warrant the framework supplies for the philosophical claims; it can be returned to after the philosophical engagement has been read.

For the physicist already familiar with the corpus. If you have read GG-A1-Constitution through GG-A10-Cosmos and the predictions branch, the most useful entry points are Part II (the cohort inheritance, in compressed form) and Part XV (the central new self-referential closure theorem). Part XVII collects the summit-register reading of the recursive uniqueness theorem across the cascade; Part XVIII delivers the closing-of-the-loop content. The pedagogical bridges in Parts IV through VIII can be skimmed.

For the integrative reader. For a reader who prefers to take the paper in linear order, the natural reading is Part I to Part XVIII straight through, allowing the pedagogical bridges to do their work at each stage. A first reading at this pace takes roughly two days of careful attention; a deeper second reading takes longer. The pedagogical bridges are designed so that no reader of solid STEM training should be unable to follow the argument at the bridge level even if the technical level remains beyond their current preparation.

A paper that is read carelessly by one audience and skipped by another is not serving the subject. The framework has earned its place in the natural sciences; it should also have a place on the desks of life scientists, neuroscientists, and philosophers who want to understand what the framework claims and why.

4 Scope: what this paper does and does not answer

Two readings of the title question. The title question *why are we here?* has two readings. The framework distinguishes them clearly so that the reader knows, before reading the rest, exactly what the present paper answers and what it does not.

Reading 1 (first-clause): why is there a constitution at all? This is the deeper metaphysical question: why does anything exist rather than nothing? Why is the input ledger of axioms, postulates, and integers what it is rather than something else? The framework does not answer Reading 1. The GG-Constitution of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) is presented as a posit — four axioms, seven postulates, an integer ledger — whose internal consistency the cohort demonstrates, but whose metaphysical necessity the framework does not assert. The Reading-1 question is one rung deeper than the framework reaches.

Reading 2 (second-clause): given the constitution, why are observers articulating it a forced consequence? This is what the present paper answers. Given that the GG-Constitution exists with the operational properties GG-A1-Constitution specifies, the recursive uniqueness theorem of Part XI (T-Origin) shows that observers articulating it are a forced consequence of it. The Cascade of GRIP-Out with GGA (Part III) supplies the dynamical mechanism: the four-step alternation of GRIP-In and GRIP-Out with GGA-as-ground-state at every layer drives the cascade from the gauge structure of the Standard Model through chemistry, life, and mind to the meta-cognitive layer at which the constitution is articulated.

Modal vocabulary. The framework claims *mathematical-structural necessity* for the cascade given the constitution (§70 of Part XV distinguishes three modal senses). It does not claim *metaphysical necessity* for the constitution itself. Spinoza took the stronger position (*causa sui*); the framework takes the weaker, leaving Reading 1 as a philosophically live question. The engagement with Spinoza's dual-attribute doctrine (Part XV §72.4) and with the Madhyamaka denial of *svabhāva* (Part XV §72.2) explores this boundary in detail.

Why both readings matter. The framework's Reading-2 answer is structurally rich and empirically anchored: eighteen named theorems, the Top 10 Falsifiers, a complete derivational chain from quarks to articulation. The framework's Reading-1 silence is also structurally consequential: it locates the limit of the framework's claim and leaves room for the deeper metaphysical inquiry that lies one rung beyond. A reader who hoped for a Reading-1 answer should not look here for it; a reader who is content with the Reading-2 answer can take the framework's structural claim as a complete account at its own scope.

5 Program Dictionary: a reader's two-page legend

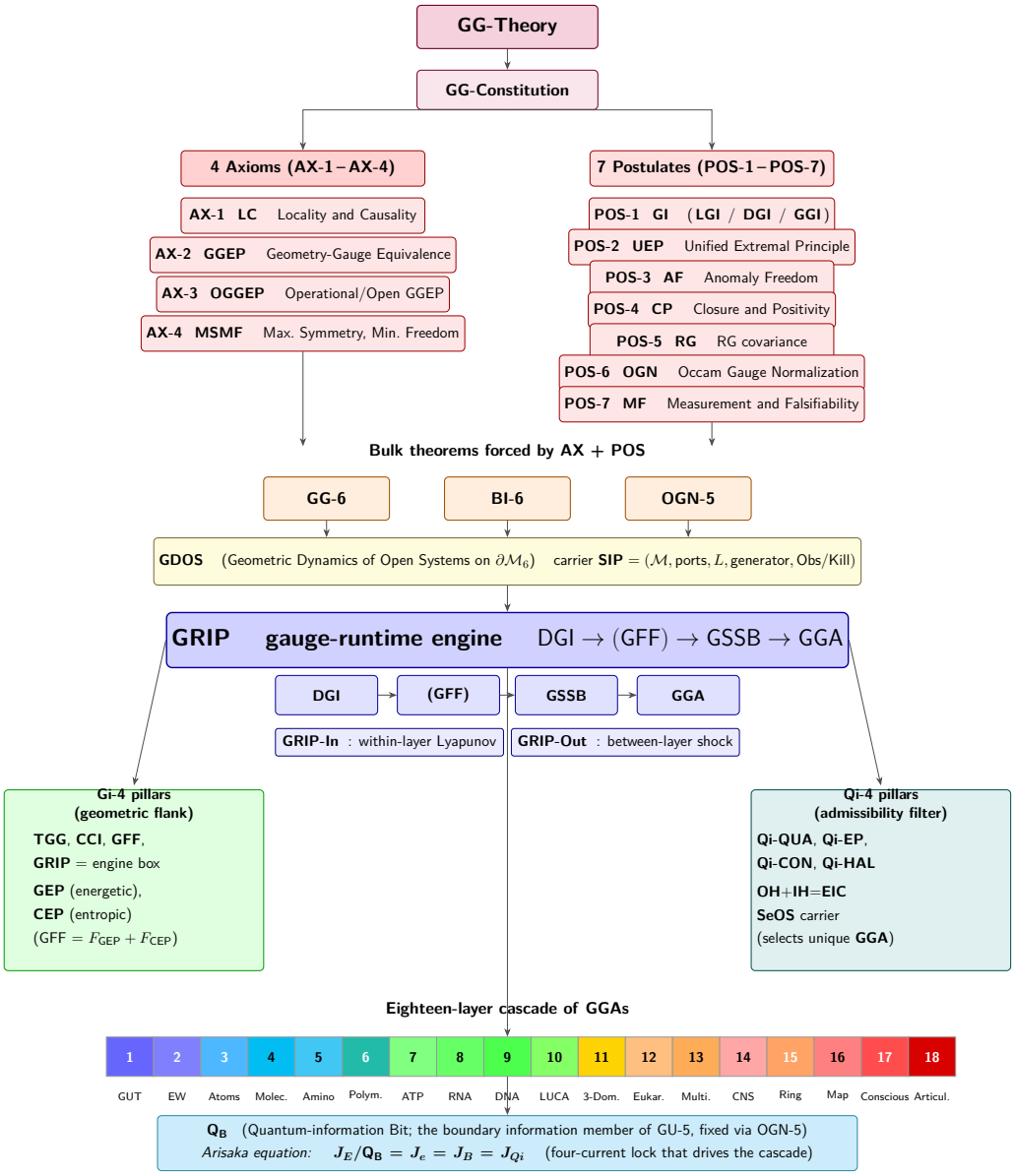


Figure 5: Hierarchy of program-defined acronyms, revised for GG-A11-Origin: GRIP is promoted to the central engine box at Tier 5, with the GGA chain DGI → (GFF) → GSSB → GGA shown explicitly and the two regimes GRIP-In/GRIP-Out shown as parallel arrow modes; the eighteen-layer cascade of GGAs appears as a horizontal ribbon at the bottom with cascade-flavor coloring (blue → cyan → green → orange → red).

This two-page dictionary is offered as a reader's legend: a single front-matter table mapping every program-defined acronym used in the body of GG-A11-Origin to a one-sentence operational definition. A reader who flips here first can decode any macro encountered in the body without flipping to Appendix A (which gives the same content in the canonical Appendix-A format inherited from GG-A1-Constitution Part VIII). The dictionary is grouped by structural role.

Framework + constitutional charter. GG-Theory = Grand Geometric Theory (the twenty-two-paper program). GG-Constitution = the constitutional charter (4 axioms + 7 postulates) of GG-Theory, supplied by GG-A1-Constitution. GG-6 = the six-dimensional bulk geometry ($\mathcal{M}_4 \times I_r \times S^1_\theta$).[1] GDOS = Geometric Dynamics of Open Systems, the boundary law forced by OGGEP. BI-6 = the six-dimensional Bianchi identity $dH_3 = X_4$ (Green–Schwarz-modified, fixing the unique anomaly polynomial). OGN-5 = Occam-Gauge-Normalization five-integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$, the framework's only numerical inputs. QGL = Quadruple Gauge Locking, the Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$. Gi-4 = Geometric-Invariance four-pillar structure (TGG, CCI, GFF, GRIP), supplied by GG-A6-GRIP. Qi-4 = Quantum-Information four-pillar structure (Qi-QUA, Qi-EP, Qi-CON, Qi-HAL), supplied by GG-A7-Qi4.

Four constitutional axioms. LC (AX-1) = Locality and Causality. GGEP (AX-2) = Geometry-Gauge Equivalence Principle (gravity and gauge are aspects of one composite connection). OGGEP (AX-3) = Operational/Open GGEP (every theory must come with a bulk-to-boundary projection law). MSMF (AX-4) = Maximum Symmetry, Minimum Freedom (no hidden continuous knobs). OGN (POS-6 OGN) = Occam Gauge Normalization (constitutional ratios are integer/rational).

Gi-4 pillars. TGG = Total Geometric–Gauge object (the composite connection on the bulk). CCI = Covariant Conservation Identity (the consequence of BI-6 for boundary currents). GFF = Geometric Free-Energy Functional, the Morse landscape on which the cascade descends ($F_{\mathsf{GFF}} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}}$). GEP = Geometry-Gauge Energy Principle (the energetic sector of GFF). CEP = Curvature-Entropy Principle (the entropic sector of GFF). GRIP = Gauge-Runtime Invariance Pipeline, the universal cascade engine DGI $\to$ (GFF) $\to$ GSSB $\to$ GGA. GRIP-In = within-layer regime of GRIP (Lyapunov descent on a fixed Morse landscape). GRIP-Out = between-layer regime of GRIP (perturbation-driven landscape reorganization). DGI = Dynamical Gauge Invariance (the unbroken-symmetry parent context, top of saddle ladder). GSSB = Geometric Spontaneous Symmetry Breaking (chain of Bogomolnyi-saturating saddle events). GA = Geometric Attractor (any stable Morse minimum on the GFF landscape). GGA = Ground Geometric Attractor (the uniquely most stable global minimum, the cascade output). RUT = Recursive-Uniqueness Theorem — the central theorem (T-Origin): each cascade layer has a unique Ground Geometric Attractor, so the whole cascade is forced layer by layer.

[1] Throughout the cohort, the "6D bulk" is read on the field-theory side of the bulk–boundary correspondence: the fifth (scale) dimension is the renormalization-group axis $r = \ln(E_{\mathrm{GUT}}/\mu)$, not a Randall–Sundrum spatial dimension, and "warped" denotes RG running; the explicit renormalization-group construction is given in Arisaka (2026, A2-GG6).

Qi-4 pillars. Qi-QUA = Quantum information for QGL (locked-current bookkeeping). Qi-EP = Quantum information for the Unified Extremal Principle (trajectory selection). Qi-CON = Quantum information for Conformal Invariance (scaling diagnostics). Qi-HAL = Quantum information for the Holographic Attractor Lattice (memory architecture). OH = Outer Hologram (boundary projection of bulk data; outward face of EIC). IH = Inner Hologram (inner self-modeling layer; inward face of EIC). EIC = Evolving Inner Cosmos (boundary completion of Qi-4, the conscious-episode attractor). CDI = cascade-depth completeness index (this paper), a count of how many storey-ports a substrate's OH–IH closure has completed. Distinct from GG-A7-Qi4's Qi-4 Completeness Index, which is a weighted geometric mean of the four pillar scores on $[0, 1]$ and appears here as $\mathsf{CDI}_{\mathrm{adm}}$. *Tentative operational form:* the number of Qi-HAL storey-ports the substrate closes (sensorimotor, attention, working memory, allocentric map, EIC closure), a storey count $S \in \{0, \ldots, 5\}$, reported on the comparative ladder $\mathsf{CDI} = 2S \in [0, 10]$ (insect ring attractor $\mathsf{CDI} \sim 6$, rodent allocentric map ~ 8, human conscious episode ~ 10). The ladder is illustrative; the operational scoring of each port and its calibration against comparative-neuroscience data are developed in GG-A14-Mind.

Qi-HAL sub-architecture. MePMoS = Memory-Prediction-Motion-Sensing (the cognitive substrate the cascade brings into being). NHT = Neural Hologram (the boundary encoding of the substrate's predictive state). HAL = Holographic-Attractor-Lattice (the read-out structure on the encoded hologram). BFFT = Binary / Fractal Fourier Transform (the basis change that operates on the holographic read-out).

GDOS carrier and class. SIP = System Instance Packet, the canonical five-field object boxed at (17) — state manifold and metric, boundary ports, GDOS generator and noise closure, GFF landscape and locked current, observable/kill bundle — on which GRIP runs. SeOS = Selfish Open System, the class of finite, port-bounded, Lyapunov-descending open systems that includes every living cell.

Program-defined mathematical constants. Q_B = Quantum-information Bit, the bioenergetic Arisaka constant $\mathsf{Q}_\mathsf{B} = (2/5)(E_{\mathrm{Ry}}/K) \approx 0.155$ eV per locked quantum; $N_A\mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol is one-half the ATP-hydrolysis free energy, so $2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol matches the measured 30.5 ± 0.5 kJ/mol at biological temperatures. M_{lock} = non-spatial Kaluza–Klein lock-cluster scale (scale-running resonances of the RG-scale throat, *not* a spatial extra dimension), $M_{\mathrm{lock}} \approx 3.85$ TeV. z_* = topological-lock corridor-switch redshift of the recombination era, $z_* = e^7 \approx 1096.6$ (the integer-ledger anchor; distinct from the operational Planck $z_{\mathrm{dec}} = 1089.92$, which GG-A10-Cosmos's own atomic chain reproduces at the 0.1% level).

The eighteen-layer cascade. GGA_1: Standard-Model gauge group (6D bulk closure). GGA_2: electroweak vacuum, charged-lepton mass ladder, Higgs vev $v \approx 246$ GeV. GGA_3: periodic table at $E_{\mathrm{Ry}} = 13.6$ eV. GGA_4: small molecules (H_2O, CO_2, NH_3, CH_4). GGA_5: 20 L-handed proteinogenic amino acids ($|\mathsf{GGA}_5| = K - NL = 35 - 15 = 20$). GGA_6: polymers (oligopeptides, oligonucleotides, oligosaccharides). GGA_7: ATP at $\Delta G_{\mathrm{ATP}} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol (empirical 30.5 ± 0.5). GGA_8: RNA $\{A, U, G, C\}$ with Watson–Crick pairing. GGA_9: DNA $\{A, C, G, T\}$ with fidelity $\epsilon \approx 10^{-9}$/bp.

GGA_{10}: LUCA (Last Universal Common Ancestor) at $\sim$ 3.8 Ga. GGA_{11}: Three-Domain Split (Bacteria $\oplus$ Archaea). GGA_{12}: eukaryotic cell at $\sim$ 2 Ga (Lane–Martin economics). GGA_{13}: multicellularity (M0–M7 ladder). GGA_{14}: integrated nerve-ring connectome (*C. elegans*-class CNS). GGA_{15}: insect-heading ring attractor. GGA_{16}: rodent hippocampal allocentric map. GGA_{17}: conscious episode completing over two $\sim$ 200 ms theta cycles ($\sim$ 400 ms), the EIC closure, CDI $\sim$ 10. GGA_{18}: the meta-cognitive act of articulating the GG-Constitution (the present paper).

Companion paper macros (sans-serif, per L39). GG-A1-Constitution = Arisaka-GG-A1-Constitution; GG-A2-GG6 = GG-A2-GG6; GG-A3-BI6 = GG-A3-BI6; GG-A4-Euclid = GG-A4-Euclid; GG-A5-GDOS = GG-A5-GDOS; GG-A6-GRIP = GG-A6-GRIP; GG-A7-Qi4 = GG-A7-Qi4; GG-A8-QM = GG-A8-QM; GG-A9-SM = GG-A9-SM; GG-A10-Cosmos = GG-A10-Cosmos; GG-A11-Origin = GG-A11-Origin (the present paper). Predictions branch: GG-P1-KK = GG-P1-KK (KK lock cluster); GG-P2-N3 = GG-P2-N3 (three-leg derivation of $N_g = 3$ families); GG-C1-Kaxion = GG-C1-Kaxion (Kaxion dark matter). Capstone: Arisaka (planned) = the planned textbook volume *ArisakaBookI*.

For the full canonical Appendix-A-format glossary (with first-introduction primary-link column, standard physics abbreviations, and the L52-canonical formatting), see Appendix A. This front-matter Program Dictionary is the operational legend; Appendix A is the constitutional reference.

6 Roadmap of the twenty-one Parts

Before the cascade of the present paper is walked (Part III onward), let us lay out a panorama of the twenty-one Parts (Figure 6). A reader of any later Part should be able to flip back to this Section and see where the present argument stands in the twenty-one-Part arc. The companion panorama — the twenty-two-paper cohort in which this capstone stands, and which upstream companion carries which imported result — opens Part II (§7.1, Figure 7).

The paper proceeds in twenty-one Parts (every program-defined acronym used in the structural overview below is spelled out in the Program Dictionary at §5). Part II catalogs the inheritance from GG-A1-Constitution through GG-A10-Cosmos and the predictions branch.

Part III states the central dynamical mechanism of the framework — the **Cascade of GRIP-Out with GGA** (GGA = Ground Geometric Attractor, each layer's unique stable basin; GRIP-Out = the out-of-thermal-equilibrium phase transition that lifts the cascade from one layer to the next) — consisting of three named theorems (T-GRIP-In-Lyapunov-Descent, T-GRIP-Out-Necessity, T-GGA-as-Ground-State) and the Cascade-Self-Sustenance corollary — the regime *definitions* live at runtime level in the parent paper GG-A6-GRIP (def:GRIPin, def:GRIPout, def:GGA); the regime *theorems* are proved here; this is the completing innovation that lets the cascade ascend from layer to layer while terminating uniquely at each layer's ground state.

Part IV is the formal *Statement of Results*: eighteen named theorems — one for each of the seventeen cascade layers plus the meta-theorem of articulation (T-GUT-Closure, T-Electroweak-Vacuum, T-Atomic-Ground-State, T-Molecular-Closure, T-Amino-Acid-Selection, T-Polymer-Closure, T-Bioenergetic-Closure, T-RNA-World-Closure, T-Information-Closure, T-Cell-Closure, T-Primary-Domain-Split, T-Eukaryogenesis, T-Multicellularity, T-Neural-Ring-Attractor, T-Allocentric-Map,

T-Conscious-Episode, T-Articulation) — so that any single layer can be cited individually without importing the entire cohort apparatus.

Parts V–VIII develop the geometric cascade in pedagogical order: the recursive uniqueness theorem with the five-step proof of inevitability (V), the eighteen-layer GSSB cascade walked layer by layer (VI), the dynamics block of $\mathsf{Q_B}$ (the Quantum-information Bit, the bioenergetic Arisaka constant $\mathsf{Q_B} \approx 0.155$ eV per locked quantum, two of which (one ATP) match the ATP-hydrolysis free energy, $2N_A\mathsf{Q_B} \approx 30$ kJ/mol, at biological temperatures), SeOS (the Selfish Open System — the class of finite, port-bounded, Lyapunov-descending open systems that includes every living cell), and the Geometric Free-Energy Functional (GFF) with the Three-Gauge Theorem (VII), and the cognitive cascade with the Five-Story Pagoda, the holographic triad, and the CDI (cascade-depth completeness index) ladder (VIII).

Part XV proves the central new theorem of GG-A11-Origin — the self-referential closure of the cascade — and engages thirteen philosophical predecessors. Part XVI returns to the framework's self-critical posture: significance, comparison with alternatives, predictions, open questions.

Part XVII delivers the Conclusions: the summit view of the geometric inevitability of Cosmos, Life, and Mind, with the recursive uniqueness theorem read across the entire cascade — including the cascade's reach beyond physics, floor by floor, into the forthcoming consequence papers GG-A12-Chemistry–GG-A14-Mind. Part XVIII is the Coda: the closing of the self-referential loop, the renunciations the framework required, the personal arc, the empirical horizon read at philosophical register, and the framework's final word to the reader. Part XIX collects the appendices.

Figure 6 renders this Part-by-Part development as a single flowchart, so the big picture is visible at a glance.

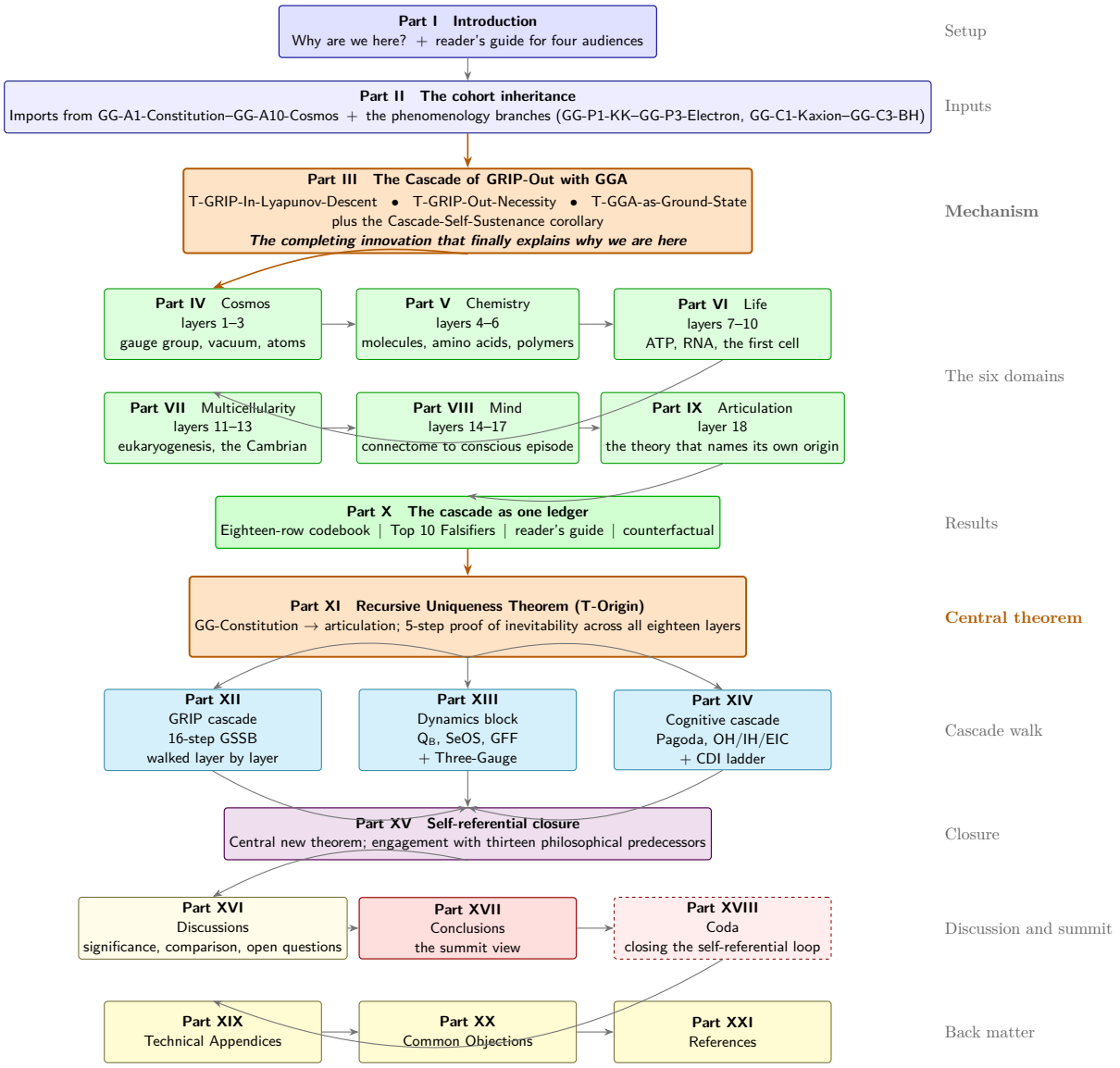


Figure 6: Roadmap of the twenty-one Parts of GG-A11-Origin, grouped into eight phases — *Setup* (Parts I–II), *Mechanism* (Part III), *the six domains* (Parts IV–IX), *Results* (Part X), *Central theorem* (Part XI), *Cascade development* (Parts XII–XIV), *Closure* (Part XV), *Discussions and summit* (Parts XVI–XVIII), and the *back matter* (Parts XIX–XXI). **Parts III and XI** are highlighted because together they carry the paper's central claim: Part III installs the completing mechanism — the Cascade of GRIP-Out with GGA — and Part XI states and proves it as one recursive uniqueness theorem, T-Origin, the universal identity that runs from the grand-unified vacuum to the act of articulation. The six domain Parts are drawn as a serpentine rather than a fan because the cascade runs through them in order: cosmos before chemistry, chemistry before life. Every later Part exercises or reflects on that result.

Part I has covered a great deal of ground, and it is worth gathering it in one breath before the real work begins. We opened with the two oldest questions anyone can ask — why is there a universe at all, and why is there someone inside it able to wonder about that — and made an unusual promise: that both can be approached with the same geometry that governs particle physics, and that neither needs a new law added by hand. From there we stated the central claim of the paper — that reality is a single cascade of open systems, each layer selected and stabilized by the same rule, running from the grand-unified vacuum up through atoms, molecules, cells, and minds, to the strange moment when a mind inside the universe reconstructs the very constitution that produced it.

The rest of Part I was the honest housekeeping such a claim deserves. We offered a guide for four different kinds of reader, drew a candid line around what this paper does and does not settle, and set down a two-page dictionary so that no symbol arrives unexplained. We then laid the twenty-one Parts out as a single flowchart, and finally placed the paper where it belongs — as the capstone of a twenty-two-paper program whose whole architecture you can now read off one figure. The point of all that scaffolding is simple, and we hope reassuring: almost nothing in what follows is invented on the spot. GG-A11-Origin inherits its constitution, its geometry, its dynamics, and its four-dimensional physics from work that is already done and already checked.

That inheritance is where Part II begins. Before this paper proves anything new, it lays its debts on the table — companion by companion, theorem by theorem — naming exactly what GG-A11-Origin borrows from each of the eighteen other papers and where in the cascade it puts each borrowed result to work. A reader who has followed the earlier papers can pass through Part II quickly; a reader who has not can treat it as the working manual for everything that comes after.

Part II
The cohort inheritance

What GG-A11-Origin receives from GG-A1-Constitution through GG-A10-Cosmos

7 What GG-A11-Origin imports, paper by paper

The load-bearing claim of GG-A11-Origin. GG-A11-Origin by no means stands alone: it is the closing capstone of a twenty-two-paper program, and a reader who meets GG-Theory here can take in its whole architecture at a glance before following the cascade. It is not a stand-alone proposal; it is a downstream-deployment paper that imports the constitutional, geometric, dynamical, and four-dimensional content of the framework from the ten upstream companion papers and the predictions branch. Nothing in the body of GG-A11-Origin is re-derived from scratch. What GG-A11-Origin contributes that none of the prior papers could contribute alone is the synthesis: the demonstration that the same recursive uniqueness theorem that GG-A9-SM proved at the particle-physics layer and GG-A10-Cosmos proved at the cosmological layer extends, with the same constitutional warrant, to every higher stratum of the geometric cascade — chemistry, life, mind, and the self-referential closure in which observers within the universe articulate the constitution that produced them. The present section makes the inheritance explicit, paper by paper, theorem by theorem.

The reader who has read GG-A1-Constitution through GG-A10-Cosmos can skim this section. The reader who has not should treat it as the operational summary of the framework against which the rest of GG-A11-Origin is to be read. Each subsection below names the upstream paper, the key theorems imported, and the downstream Part(s) of GG-A11-Origin that exercise the import.

7.1 The cohort map and the cross-paper coherence table

Figure 7 draws all twenty-two papers in one frame, with GG-A11-Origin highlighted in the capstone position.

The cohort falls into five strata, read from the top down, together with two phenomenology branches and one foundations column. At the head sits the constitutional root GG-A1-Constitution, whose four axioms and seven postulates fix what may count as an admissible claim. The root compiles into the *GG6 trio*: GG-A2-GG6 derives the six-dimensional bulk, GG-A3-BI6 proves its BI-6 anomaly freedom, and the historical companion GG-A4-Euclid supplies the integer ledger and lineage of the constants. From the trio descends the open-system boundary law GG-A5-GDOS, organized by its two pillar papers — GG-A6-GRIP, the geometric Gi-4 pillars, and GG-A7-Qi4, the quantum-information Qi-4 pillars. The fourth stratum is the *consequence trio* that recovers textbook physics from this single source: quantum mechanics in GG-A8-QM, the Standard Model in GG-A9-SM, and ΛCDM cosmology in GG-A10-Cosmos. The present paper, GG-A11-Origin, is the capstone that

closes the A-series and reads the whole cascade as one recursive uniqueness theorem. Hanging off this spine are the two phenomenology branches — the Predictions Branch (GG-P1-KK, GG-P2-N3, GG-P3-Electron, GG-P6-Proton (Arisaka, 2026, P6-Proton)) and the Cosmology & Astrophysics Branch (GG-C1-Kaxion, GG-C2-Hubble, GG-C3-BH) — and, on the spine's left flank, the Foundations Branch: GG-P4-Real (Arisaka, 2026, P4-Real) and GG-P5-CPT (Arisaka, 2026, P5-CPT), read below. Beside the spine rather than on it stand the two white papers, which synthesize the cohort rather than extend it: GG-W1-Symmetry (Arisaka, 2026, W1-Symmetry) reads its symmetry structure historically, as a ladder of seven rungs, and GG-W2-Holonomy (Arisaka, 2026, W2-Holonomy) reads it structurally, as one two-fiber anatomy applied to sixteen standing problems.

The Foundations Branch. The map's left flank carries the cohort's third branch — two member papers, a single column beside the spine, whose subject is the boundary's complex structure and its mirrors. GG-P4-Real (Arisaka, 2026, P4-Real) supplies the origin of the complex structure on which the cascade's quantum floors run: it derives the boundary's i from two real structures of the GG-A2-GG6 arena — the compact phase circle and the causal clock — while GG-A11-Origin itself defers the question of *why* the boundary is complex to the state-space derivation of GG-A8-QM (Arisaka, 2026, A8-QM), whose real-bulk account GG-P4-Real develops at full length. GG-P5-CPT (Arisaka, 2026, P5-CPT) defines time by its four endowments and fixes the law-level arrow as orientation reversal of the three real bulk factors — kin to the cascade's own one-way descent through its layers, each GRIP-Out shock stepping the geometry down one floor and never back up. Both carry P-series designators; their place at the spine's flank, not the phenomenology rows, marks their foundational role.

Where the map above draws the cohort's shape, the table below records what the present paper actually takes from each member and where it is put to work. Let us look carefully at Table 1, the largest cross-paper coherence map of the series, spanning the twenty-one companion papers of the A-series spine and the four branches across the twenty-one Parts of GG-A11-Origin. Beyond the eleven-paper A-series spine, the phenomenology is carried by the Predictions Branch — GG-P1-KK (Arisaka, 2026, P1-KK), GG-P2-N3 (Arisaka, 2026, P2-N3), GG-P3-Electron (Arisaka, 2026, P3-Electron), GG-P6-Proton (Arisaka, 2026, P6-Proton) — the Cosmology & Astrophysics Branch — GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion), GG-C2-Hubble (Arisaka, 2026, C2-Hubble), GG-C3-BH (Arisaka, 2026, C3-BH) — the Foundations Branch — GG-P4-Real (Arisaka, 2026, P4-Real), GG-P5-CPT (Arisaka, 2026, P5-CPT) — and the White-Paper Branch — GG-W1-Symmetry (Arisaka, 2026, W1-Symmetry), GG-W2-Holonomy (Arisaka, 2026, W2-Holonomy).

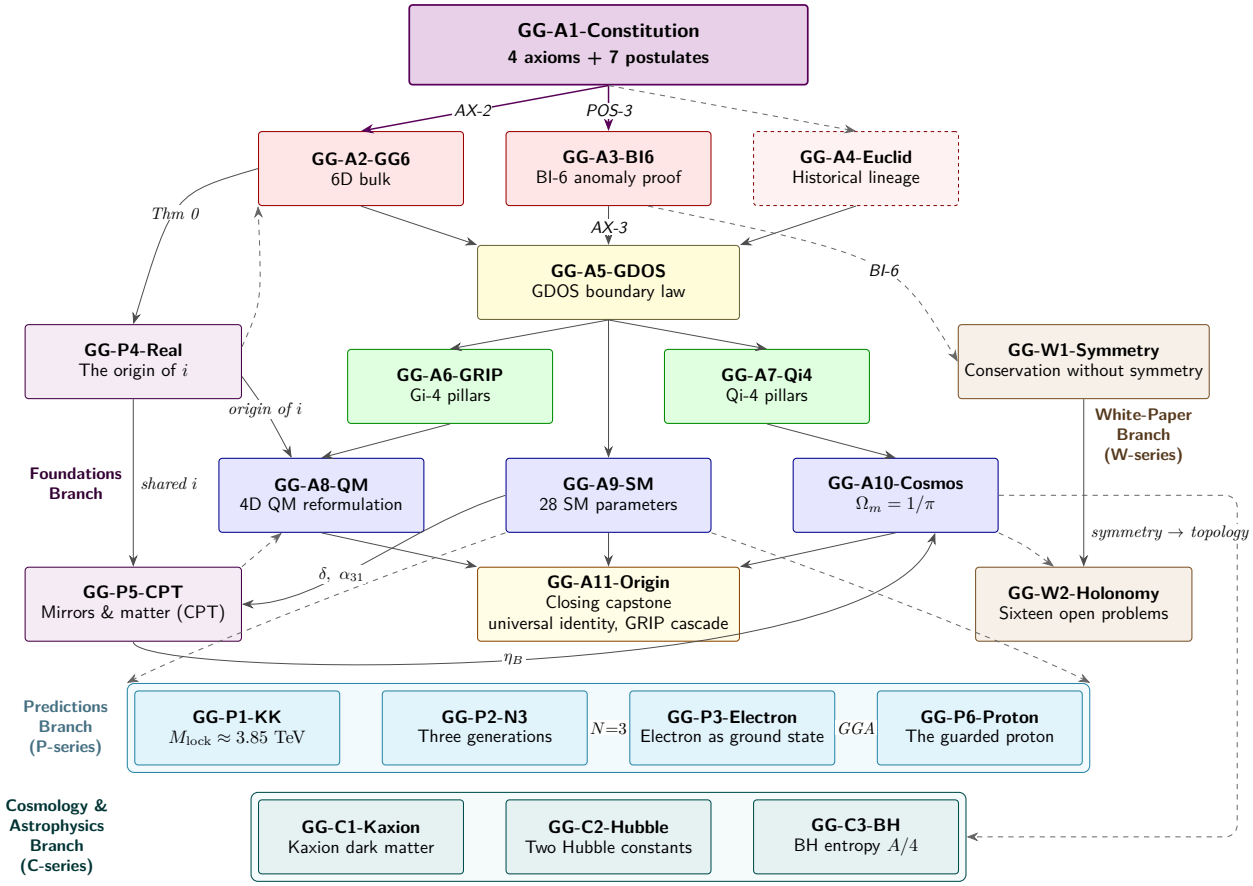


Figure 7: The twenty-two-paper cohort map of GG-Theory. The constitutional root GG-A1-Constitution (violet, top) supplies the four axioms and seven postulates from which the rest of the cohort descends: the GG6 Trio (GG-A2-GG6, GG-A3-BI6, GG-A4-Euclid, red) realizes the bulk geometry; GG-A5-GDOS (yellow) the boundary law; the GDOS Trio pillars (GG-A6-GRIP, GG-A7-Qi4, green) the geometric and quantum-information runtime; the 4D-Physics Trio (GG-A8-QM, GG-A9-SM, GG-A10-Cosmos, blue) the textbook readouts; and the closing capstone GG-A11-Origin (gold) the quarks-to-consciousness identity cascade. Two framed branches carry the phenomenology — the **Predictions Branch** (cyan), whose four papers hand their results along the row by the internal arrows (GG-P2-N3's N_g=3 into GG-P3-Electron, and that paper's ground-attractor method, GGA, on into GG-P6-Proton), and the **Cosmology & Astrophysics Branch** (teal). The spine is flanked by two columns of two, which do opposite jobs. On the left the **Foundations Branch** (violet) feeds it: GG-P4-Real, fed by GG-A2-GG6's Theorem 0 arena, manufactures the i that GG-A8-QM consumes, and GG-P5-CPT is the GG-A9-SM–GG-A10-Cosmos interface, fed by the ledger phases and feeding the η_B chain across the width of the map, with the shared-i edge descending solid between them. On the right the **White-Paper Branch** (brown) reads it: GG-W1-Symmetry walks the century from Noether to Hopkins–Singer, and GG-W2-Holonomy dissects the structure that arc arrives at — protection by topology rather than by symmetry — across sixteen open problems. The white papers derive nothing new, carrying every result at its parent's declared grade; the single dashed feed drawn into each names its heaviest source, not its only one. *Reading conventions:* solid arrows mark axiom-forced descent and carry an edge label naming the driving axiom or postulate where most illustrative; dashed arrows mark the deployment of derived results, or historical links inherited without being constitutionally forced.

Table 1: Cross-paper coherence map: the twenty-one companion papers — the A-series spine and the Predictions, Cosmology & Astrophysics, Foundations, and White-Paper branches — the theorems and structures they supply, and where they are exercised in GG-A11-Origin. Twenty-one rows, one per companion, each giving what that paper supplies and where the present paper spends it — the constitution's axioms and postulates from GG-A1-Constitution, the BI-6 coefficient vector and the OGN-5 ledger $(1, 3, 5; 7, 35)$ from GG-A2-GG6, anomaly freedom and the trace-ratio lock from GG-A3-BI6, the twenty-eight-to-zero compression and the five geometric constants from GG-A4-Euclid, and the GDOS apparatus from GG-A5-GDOS. The table is the paper's audit of its own imports: every result used here is entered against the paper that proves it.

Upstream	Imported theorems / structures	Exercised in GG-A11-Origin
GG-A1-Constitution	GG-Constitution: AX-1 (LC), AX-2 (GGEP), AX-3 (OGGEP), AX-4 (MSMF) and seven postulates POS-1 through POS-7	Part II (foundation), Part XI (five-step proof Step 1), Part XV (self-referential closure)
GG-A2-GG6	T4 (BI-6 coefficient vector $(1, -1, -2/5, -2/5)$); T6 (OGN-5 Diophantine ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$)	Part II (foundation), Part XI (Step 1), Part XIII (Q_B derivation)
GG-A3-BI6	T-BI6-7.2 (BI-6 anomaly freedom); T-BI6-9.1 (the trace-ratio lock $\lvert a/c\rvert = \lvert a/d\rvert = 5/2$)	Part II (foundation), Part IV (Step 1), Part XI (GSSB cascade ground)
GG-A4-Euclid	No free continuous parameter in the input ledger, scoped as GG-A4-Euclid scopes it; the Geometric Universal Five Constants GU-5 $= \{c, G_N, \hbar\,;\, k_B, Q_B\}$ (3 bulk + 2 boundary)	Part II (zero-free-parameters claim), Part XIII (Q_B anchor)
GG-A5-GDOS	T1–T11 (the GDOS boundary law); the Lyapunov lemma under T5; T7.1–T7.7. The GFF is GG-A6-GRIP's and the SeOS class is GG-A7-Qi4's; the Three-Gauge reading is this paper's own	Part XI (Step 2), Part XIII (GFF descent), Part XIV (consciousness)
GG-A6-GRIP	T1–T5 (Gi-4 pillars: DGI $\to$ GSSB $\to$ GA); the GRIP cascade theorem	Part IV (Steps 3–5), Part XII (cascade), Part XIV (holographic triad), Part XIV (CDI)
GG-A7-Qi4	T-SIP, T-QUA, T-EP, T-CON, T-HAL, T-EIC (the six named theorems of the Qi-4 pillars); the Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$	Part II (QGL), Part XI (Step 3), Part XIV (EIC), Part XIV (Q-HAL-CDI)
GG-A8-QM	The 4D operational reformulation of quantum mechanics; T7.1–T7.7 (QM postulates as theorems)	Part XIV (consciousness as internal measurement), Part XIV (CDI ladder)

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Table 1 continued from previous page

Upstream	Imported theorems / structures	Exercised in GG-A11-Origin
GG-A9-SM	28-parameter codebook of the Standard Model derived to theorem level; Part XI: the *universal-identity insight* (seven-layer cascade) and the *uniqueness of the canonical four-force architecture* (T-SM-62.1, eight constitutional lemmas), with the Q1+Q2 synthesis that closes the Part	Part II (forces inheritance), Part XI (Step 1), Part XII (cascade), Part XV (self-referential closure — direct upstream of A11 Part XV)
GG-A10-Cosmos	Cosmological codebook: $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$; the universal-cosmic-identity insight at the cosmological stratum	Part II (cosmic-inventory inheritance), Part XVII (cosmological inevitability), Part XIV (cosmological base of the recursive uniqueness theorem)
GG-P1-KK	The Kaluza–Klein lock-cluster at $M_{\text{lock}} \approx 3.85$ TeV (testable at HL-LHC)	Part XVI (Top 10 Falsifiers test 1)
GG-P2-N3	The conditional three-leg derivation of the family number $N_g = 3$	Part II ($N_g = 3$ inheritance), Part XI (cascade)
GG-P3-Electron	The electron as the unique stable Geometric Attractor of the charged-lepton stratum (the six oldest electron questions, closed)	Part XV (universal-identity closure — every electron the same geometric ground state)
GG-P4-Real	The two real sources of the boundary's complex structure: positive frequency as holomorphy, from the compact phase circle and the causal clock	Part XVII (the number field itself selected, at candidate grade, so the cascade runs on real geometry at every floor)
GG-P5-CPT	C, P, and T as orientation reversals of the three real bulk factors — why every particle has a twin, and why the universe is made of matter	Part XVII (the four-endowment definition of time and the law-level arrow, kin to the cascade's own directionality)
GG-C1-Kaxion	Kaxion dark matter at ~ 8.1 μeV (testable at ADMX / next-gen haloscopes)	Part XVI (Top 10 Falsifiers test 2)
GG-C2-Hubble	The Hubble tension as two projections of one derived anchor — the early/late two-stage corridor	Part XIX (Hubble corridor), Part XX (tension addressed, not assumed away)
GG-C3-BH	Black-hole entropy $A/4$ recovered as a boundary theorem (horizon thermodynamics)	Part XVII (the cascade's reach into horizon thermodynamics)
GG-P6-Proton	The proton as the Ground Geometric Attractor of matter; the rank-matching obstruction that makes baryon number a winding rather than a Lie-algebra charge, so that $\Delta B = \pm 1$ minting is nonexistent and leptogenesis is forced rather than preferred	Part IV (layer 2, the stability of matter), Part XVI (the origin-of-matter chain)

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Table 1 continued from previous page

Upstream	Imported theorems / structures	Exercised in GG-A11-Origin
GG-W1-Symmetry	The conservation-law ladder: laws grow harder to break as they say less about motion, and the ledger's integers sit at the top of it	Part II (why the integers cannot run), Part XVII
GG-W2-Holonomy	The holonomy sorting — the circle remembers what the interval forgets — which is why the compact angle carries the quantized ledger and the radial interval carries none	Part II (the OGN-5 ledger's protection), Part XVII

7.2 Inheritance from GG-A1-Constitution: the GG-Constitution

GG-A1-Constitution is the constitutional document: four axioms — AX-1 LC (locality and causality, the locality half being the clause that excludes fundamental extended objects), AX-2 GGEP (gauge and geometry as one composite connection), AX-3 OGGEP (a bulk theory is not physically defined unless it specifies a fixed operational dictionary from bulk structure to registered boundary observables), AX-4 MSMF (no continuous parameter not forced by the other clauses, and, where discrete invariants exist, the minimal non-degenerate values compatible with the constitution) — and seven postulates POS-1–POS-7: gauge invariance across scales, the unified extremal principle, anomaly freedom, closure and positivity, RG covariance, OGN topological integrality, and MF. The OGN-5 integer ledger is named in GG-A1-Constitution and derived downstream, in GG-A2-GG6 and GG-A3-BI6. GG-A11-Origin inherits the entire ledger unchanged and adds no constitutional clause; GG-A1-Constitution assigns it no Principal Theorem. GG-A1-Constitution also states, in advance, the grade of the claim this paper exists to make: that the same clauses reach through chemistry and biology to living matter is "the program's central wager, not a theorem of this paper, and is marked as such wherever it appears." GG-A11-Origin carries that grade.

7.3 Inheritance from GG-A2-GG6: GG-6 geometry and the OGN-5 ledger

GG-A2-GG6 fixes the canonical six-dimensional bulk geometry $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$ — forced, in its Theorem 0, by AX-1 and AX-2 together, so that the extra dimensions are theorems rather than assumptions justified after the fact — and closes the BI-6 identity $dH_3 = X_4$ on the coefficient vector $(1, -1, -2/5, -2/5)$. It states the OGN-5 Diophantine cascade $J = 2N + 1$, $K = LJ$, $K = M^2 + N^2 + L^2$, whose solution is $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. Two steps of that cascade are not GG-A2-GG6's and GG-A2-GG6 says so: $L = 5$ comes from GG-A3-BI6's single-tensor Green–Schwarz consistency theorem, and $N = 3$ from GG-A3-BI6's dual-lock closure. The trace ratio $(L - N)/L = 2/5$ is an independent check on a ledger already determined, not a route to it. The second root $(1, 7, 5; 15, 75)$ also satisfies $LJ = M^2 + N^2 + L^2$, and is excluded by the block embedding and by nothing else, which is worth stating plainly. GG-A11-Origin treats all of this as input and never re-derives it.

7.4 Inheritance from GG-A3-BI6: the BI-6 closure as the universal-anomaly fingerprint

GG-A3-BI6 carries the BI-6 closure to full rigor. Locally, the perfect-square factorization $I_8 = (1/2)X_4^2$ is possible if and only if the anomaly matrix has rank one and is positive semidefinite; the coefficient *values* $(1, -1, -2/5, -2/5)$ are then fixed by the OGN-5 trace ratio, not by the factorization alone. Globally, GG-A3-BI6 proves anomaly freedom for every large gauge transformation of arbitrary topological type, on every closed spin seven-manifold, with no restriction on the topology of the four-dimensional base — a stronger statement than the class-restricted one, and the strongest result the paper owns. The 1984 Green–Schwarz factorization (Green and Schwarz, 1984) is read constitutionally as the first technical demonstration of AX-2. GG-A3-BI6 does *not* claim a unique solution for the boundary spectrum: it gives an existence construction and records minimality as open. GG-A11-Origin inherits the rigor without repeating it, and inherits the open item with it.

Why the OGN-5 ledger is forced, not fitted. The five integers $(1, 3, 5; 7, 35)$ are not chosen ex post to fit the data. GG-A3-BI6 fixes $M = 1$ from the rank-one tensor lattice, $L = 5$ from single-tensor Green–Schwarz consistency, $N = 3$ from the dual-lock closure $N = L \pm \sqrt{L - M^2}$ together with the block embedding $N < L$, then $J = 2N + 1$ and $K = LJ$. Two of those five steps are pinned by AX-4 MSMF rather than by anomaly cancellation, and GG-A3-BI6 grades the ledger accordingly: proved, *given* AX-4. The global anomaly freedom of the Hopkins–Singer lift (Hopkins and Singer, 2005; Monnier and Moore, 2019) is what makes the bulk consistent; it fixes none of the integers, and this paper no longer says that it does. The reason the integers cannot run is not anomaly cancellation but topology: holonomy requires closed loops and an interval has none, so the compact angle S^1_θ carries all of the bulk's holonomy, quantized and protected, while the radial interval I_r carries none. The circle remembers, and the ledger is written on the circle. The closed forms that follow — $\alpha^{-1}(0) = 2^J + N^2 = 137$, and $M_{\text{lock}} \sim M_{\text{Pl}} e^{-K}$ — are therefore algebraic identities of the geometry, fixed before any empirical input was consulted. The closed form for the weak mixing angle, $\sin^2\theta_W = L^2/(4N^3) = 25/108$, belongs to GG-A9-SM and GG-A4-Euclid and not to GG-A3-BI6. The sharpest form of the integer-search objection, and the full response, is taken up in the Appendix, §F.5.

7.5 Inheritance from GG-A4-Euclid: the Euclidean closure of the input ledger

GG-A4-Euclid proves the input ledger carries no free continuous parameter. The compression is not "twenty-eight to zero"; GG-A4-Euclid retired that formulation, and this paper retires it too. The Standard Model together with general relativity carries *thirty* free continuous constants — twenty-eight of the Standard Model, plus G_N and Λ — and what survives on the other side is not an empty set but a residue GG-A4-Euclid names: discrete axiomatic choices, unit conventions, and one overall mass scale. The forced inputs are the Geometric Universal Five Constants GU-5 $= \{c, G_N, \hbar; k_B, Q_B\}$, the topological constants (π, e), and the OGN-5 integers $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. GG-A4-Euclid scopes its own closure theorem twice, and GG-A11-Origin carries both scopes: zero free continuous parameters *in the gauge and cosmological sectors*, with the fermion sector structurally framed and not yet completely closed; and one frozen discrete completion class whose necessity is

asserted rather than proved. GG-A11-Origin accordingly never describes the framework as having "few" free parameters — and never states the count as zero without the scope.

7.6 Inheritance from GG-A5-GDOS: GDOS and the boundary law

GG-A5-GDOS supplies the dynamical machinery: the eleven GDOS theorems T1–T11; the Lyapunov lemma under T5, which GG-A5-GDOS names the constitutional source of the second law; and T7.1–T7.7, the quantum-mechanical postulates promoted to theorems on the OGGEP projection. Three attributions this paper previously made to GG-A5-GDOS belong elsewhere, and are corrected here. The Geometric Free-Energy Functional $F_{\mathsf{GFF}} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}}$ is GG-A6-GRIP's; what GG-A5-GDOS contributes is the identification of its two blocks with GG-A5-GDOS's own T9.2 and T5. The Selfish Open System (SeOS) class is GG-A7-Qi4's. The Three-Gauge reading — Gibbs, Friston and GG-6 as three windows on one F_{GFF} — is this paper's own, and is graded as such where it is stated; GG-A5-GDOS's triad is the different one of least time, maximum entropy production and free energy, which GG-A5-GDOS credits to GG-A7-Qi4. GG-A5-GDOS's Lyapunov lemma also carries a scope limit that travels with it: when circulation is present the functional is no longer strictly monotone, though the total entropy production rate remains non-negative and the system can settle into a non-equilibrium steady state. Every layer of this paper's cascade above the atomic rungs is such a steady state, so the caveat is load-bearing here and not decorative. The traffic runs both ways: GG-A5-GDOS consumes this paper's regime theorems at its own projection-rate section and inside its T10 bridge lemma.

7.7 Inheritance from GG-A6-GRIP: the Gi-4 pillars and the GRIP cascade

GG-A6-GRIP proves the Gi-4 pillars and closes the GRIP cascade (DGI→GSSB→GA) as the cascade dynamics on the stratified boundary moduli. It is not the bulk-to-boundary projection — that is OGGEP and GDOS, which GG-A6-GRIP imports — and this paper no longer says it is. GRIP is nonetheless the central operational engine of GG-A11-Origin, and two clauses of GG-A6-GRIP govern how far the engine may be carried. Both are carried here.

First, a Geometric Attractor is a *local* minimum, and a Morse landscape generally admits many. The cascade terminates on the *ground* attractor — the unique global minimum — only on an *admissible* stratum, meaning one that is connected, compact, Kähler with the boundary gauge connections flat along it, and on which F_{GFF} is the moment map of a Hamiltonian torus action with isolated non-degenerate fixed points. GG-A6-GRIP establishes admissibility for one stratum, the family projector $\mathbb{CP}^{N_g-1}$, and says plainly that the Higgs and Wilson-line strata are not established there, and that on a periodic compact-angle potential over the discrete OGN-5 phases the uniqueness conclusion may genuinely fail. Wherever this paper claims a unique ground state at a layer, it is claiming admissibility at that layer, and the claim is no stronger than that hypothesis.

Second, the cascade cannot climb from one layer to the next by gradient flow. Strata are labeled by discrete projector-class data that no continuous curve can change, so a gradient trajectory never leaves its stratum: every layer-to-layer step requires a GRIP-Out event, which GG-A6-GRIP deliberately excludes from its septuple and whose theory it delegates to this paper. That delegation is the reason GG-A11-Origin exists as a separate paper, and it is also the reason GG-A6-GRIP names

its own limit in its own words: the identification of the chemical, biochemical, biological and cognitive layers with the same four moves is "the cohort's central wager rather than a theorem of this paper." GG-A11-Origin makes that wager, and grades it as one.

The observed universal identity of objects at a layer is that attractor's boundary readout. The mechanism is GG-A6-GRIP's own — a basin has no interior degrees of freedom for two readouts of it to differ by — and GG-A9-SM Part XI carries it at the particle layer.

7.8 Inheritance from GG-A7-Qi4: the Qi-4 pillars and the Arisaka equation

GG-A7-Qi4 proves the Qi-4 pillars: T-SIP (the System Instance Packet), T-QUA (the Arisaka equation, which is the informational content of Quadruple Gauge Locking; the four-factor bulk gauge group itself is GG-A2-GG6's), T-EP (the unified extremal principle), T-CON (conformality, whose T-CON.2 carries the two-knee spectral result), T-HAL (the Holographic Attractor Lattice), and T-EIC (the Evolving Inner Cosmos). Two grades travel with these and are carried here. T-HAL is a *canonical normal-form* decomposition, not a uniqueness theorem — two of its five motifs are definitional and uniqueness is an open problem of GG-A7-Qi4. T-EIC is deliberately graded rather than forcing: its inner-hologram and evolving-inner-cosmos clauses are conditionals, and GG-A7-Qi4 states outright that the theorem "does not force an all-or-none divide." The pillars lock the four currents into the Arisaka *equation* $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$, which is not the Arisaka *ratio* $1 : -1 : -2/5 : -2/5$ with the signs dropped but a distinct statement reached after a sector-dependent unit conversion, and they fix Q_B as the universal information-energy currency. A seventh result of GG-A7-Qi4 is load-bearing for this paper and was not previously named: its Qi-4 characterization of the GGA establishes only that the configuration GG-A6-GRIP's descent halts at carries all four certificates. The converse — that no other Geometric Attractor passes all four — is not proved, and GG-A7-Qi4 declines to prove it precisely because the earlier version rested it on this paper, which is a circle. This paper's uniqueness therefore comes from GG-A6-GRIP's per-stratum ground-state corollary and its admissibility hypothesis, never from the four pillars. Finally, GG-A7-Qi4's pagoda factorization proves an *arbitrary-depth* tower wherever its floor-creation conditions hold, and records that the count of five floors is an empirical reading rather than a theorem output; that is what licenses this paper's eighteen layers as a finer admissible refinement rather than a rival count.

7.9 Inheritance from GG-A8-QM: the 4D operational reformulation of quantum mechanics

GG-A8-QM (Arisaka, 2026, A8-QM) lifts GG-A5-GDOS's T7.1–T7.7 into a 4D operational reformulation of quantum mechanics — eleven principal theorems, of which seven are that lift and four are new — and is candid that almost nothing in it is self-contained. GG-A11-Origin imports its operational reading of measurement, in GG-A8-QM's own words rather than in a paraphrase this paper had drifted into: an observation is the OGGEP projection of a bulk quantity onto a boundary stratum, and registration is the descent of the joint system-and-apparatus configuration into one Geometric Attractor basin, irreversibly locked by the boundary free-energy law, the outcome being the contextual joint holonomy of system and apparatus read out by that projection — *with no collapse, no branching, and no observer required.* The earlier phrasing here, "stabilization of a

selected IH branch," imported a branching GG-A8-QM explicitly denies, and is withdrawn. The direction of the consciousness question also runs the other way from what this paper previously stated: GG-A8-QM declines to make consciousness a primitive of measurement and marks it out of scope, pointing to GG-A11-Origin Part XIV. This paper receives that deferral; it does not import an answer. What GG-A8-QM does supply, and what belongs in any account of this paper's foundations, is the status of the Born rule: closed at the relaxation level, with the Constitutional Born Theorem conditional on four named premises, and a single remaining analytic residue — the field-grade representation of the channel as a port stream.

7.10 Inheritance from GG-A9-SM: the Standard-Model parameter audit and the Part-XI synthesis

GG-A9-SM is the direct upstream foundation. Its body closes the 28-parameter Standard-Model codebook ($\alpha^{-1}(M_Z) = 2^J = 128$, $\sin^2\theta_W = 25/108$, $\alpha_s(M_Z) = 1/(\pi e)$, $K = 35$, $N = 3$, $\delta_{\mathrm{CKM}} = 13\pi/35$ at quantum-defect order, $N_A\mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol) — and closure here means what GG-A9-SM says it means, which is an ontological statement about what the parameters are rather than a claim that all of them have been computed: six are derived, fourteen are derived conditional on a named lemma in each case, and eight remain asserted with the calculation that would close them named explicitly. GG-A11-Origin carries that triage and not a bare "no continuous freedom."

GG-A9-SM's Part XI supplies two results, of which one is a theorem and one is not. The *universal-identity insight* — the universe is not full of arbitrary identical objects but of attractors, and objects are what the attractors look like from the boundary — is stated by GG-A9-SM as an insight, and this paper no longer calls it a theorem. It is established there through *seven* layers, from leptons and quarks to single-cell life, with the full cascade and its ten transitions deferred to the present paper. Its load-bearing refinement is the step from Geometric Attractor to *Ground* Geometric Attractor: the terminus is the unique deepest minimum, not merely a stable one, which is why identity and stability arrive together and why proton stability is ground-state stability. The *uniqueness-of-forces theorem* (§95) is the theorem: under the eight constitutional clauses the canonical bulk with group $\mathrm{Spin}(1,5) \times \mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$ is the unique admissible solution, projecting to exactly four forces with the qualitative behaviors *we observe*. The *Q1+Q2 synthesis* (§96): these are one theorem applied at two strata — "the two fundamental questions of physics turn out to be one fundamental question, asked twice." GG-A9-SM has since added a third instance, the sorting of every Standard-Model parameter into a holonomy-class label on the circle and a descent address on the interval, so GG-A11-Origin's Part XV extends a three-instance synthesis rather than a two-instance one.

GG-A9-SM is also the cohort's home for the origin of matter, and GG-A11-Origin takes its account of the matter asymmetry from there rather than restating it: the CP doctrine that $\alpha_{31} = \pi$ is CP-conserving in the flavor sum and CP-violating in the flavor differences, with the inference that the factor of i is itself the CP violation withdrawn; the baryon bridge $\eta_{10} = 273.9\,\Omega_b h^2$; the two roads to the baryon number, of which the static ledger count is the framework's prediction and the dynamical chain is a demonstration that a parameter-free mechanism exists which could have produced it; and the gap of 16.4% between them, named once.

7.11 Inheritance from GG-A10-Cosmos: the cosmological inventory and the universal-cosmic-identity

GG-A10-Cosmos fixes the π-locked cosmological inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ as the unique constitutional *form* on the cosmological stratum — unique because the competing rational functions of π are excluded by fiber-volume geometry rather than by the data, and carried at grade D* under GG-A10-Cosmos's named closed-packet conjecture, which GG-A10-Cosmos describes as programmatic and not yet closed. It matches Planck to better than 3% in the raw comparison, and to about 2% once the epoch calibration GG-A10-Cosmos states is applied. GG-A10-Cosmos does *not* prove a universal-cosmic-identity theorem, and this paper no longer says it does: universal cosmic identity is GG-A10-Cosmos's ninth Structural Innovation, an interpretive synthesis that GG-A10-Cosmos presents as a preview and reserves, explicitly, for the capstone. This paper is that capstone, so it develops the principle — the cosmic coincidence is the boundary readout of the unique stable attractor on that stratum — and does not cite GG-A10-Cosmos as having established it. GG-A10-Cosmos also carries the one epoch-free row in its inventory, $\Omega_b/\Omega_m = 1/(2\pi)$, graded D rather than D*; it must be compared in ω_b/ω_m and never in Ω_b/Ω_m, because the measured Ω_m carries a neutrino component this framework's does not. GG-A10-Cosmos also supplies a third import that GG-A11-Origin carries directly into its cascade: the *second horizon problem* (GG-A10-Cosmos's Part on the sameness of things). Where the universal-cosmic-identity theorem establishes *that* the inventory is unique, the second horizon problem asks *why every causally disconnected region reads the same inventory* — a question the temperature horizon problem never posed. GG-A10-Cosmos's answer has four parts, and only three of them are earned outright. The *mold* — that each object has exactly one specification if the vacuum is unique — is a *reduction* of cosmic identity to vacuum uniqueness rather than a proof of either, and GG-A10-Cosmos states in terms that it would be dishonest to sell it as a standalone solution. The other three are earned independently of that conjecture: the *ordering*, that the derived grand-unification-scale launch means the inflationary stretch acted *before any matter existed*, so the identity of the electron and the atom was inherited from one causal patch rather than negotiated across the sky; the *pinning*, that the one mark which could have varied, the compact angle, was frozen while the sky was still one patch; and the *prompt crossing*, that no region could be caught in another basin on the way down (GG-A10-Cosmos; the horizon-independence corollary of GG-P3-Electron). GG-A11-Origin carries all four at those grades, and does not present the reduction as the proof. GG-A9-SM Part XI (particles) and GG-A10-Cosmos Part X (cosmology) together close the recursive uniqueness theorem at the lowest two layers, and the second horizon problem supplies its causal warrant there; GG-A11-Origin extends both to every higher layer.

7.12 Inheritance from the Predictions Branch (GG-P1-KK, GG-P2-N3, Arisaka-GG-C1-Kaxion)

The Predictions Branch supplies the falsifiable anchors: GG-P1-KK the Kaluza–Klein lock-cluster at $M_{\text{lock}} \approx 3.85$ TeV (HL-LHC); GG-P2-N3 the conditional three-leg derivation of $N_g = 3$ ($m_\tau/m_\mu \approx 16.817 \pm 0.5\%$); Arisaka-GG-C1-Kaxion the Kaxion dark-matter line at ~ 8.1 μeV, inside

a closed window of seven cap loadings and alone in it (ADMX and next-generation haloscopes). GG-A11-Origin inherits these as its empirical anchor: if any fails decisively, the framework fails — the structural difference between GG-Theory and any necessitarian philosophical predecessor lacking a falsification anchor.

7.13 How the eleven inheritances combine: the recursive uniqueness theorem of GG-A11-Origin

The eleven inheritances above are by no means eleven separate imports; they are one coherent ledger applied at successive layers of the cascade. At the bulk layer (layer 1), GG-A1-Constitution supplies the constitution; GG-A2-GG6, GG-A3-BI6, GG-A4-Euclid establish the canonical 6D geometry and the integer ledger. At the particle-physics layer (layer 2), GG-A9-SM closes the 28-parameter codebook and supplies the universal-identity and uniqueness-of-forces theorems of its Part XI. At the cosmological-evolution layer (layer 3), GG-A10-Cosmos closes the π-locked inventory and supplies the universal-cosmic-identity insight of its Part X.

At every higher layer — chemistry (layers 4–6), bioenergetics and genetic information (layers 7–9), single-cell life (layer 10), multicellular organisms (layer 13), nervous systems (layers 15–16), mind / awareness (layer 17), and articulation of the constitution itself (layer 18, the closing self-referential layer) — the *same uniqueness theorem* is applied with *the same constitutional warrant*. At each layer the GRIP cascade selects the unique stable Geometric Attractor on the layer-specific boundary stratum; at each layer the boundary readout is universal-identity / uniqueness-of-architecture; at each layer the four-current QGL ratio holds via the inherited BI-6 closure; at each layer the GFF Lyapunov descent governs the dynamics. The recursive structure is the load-bearing claim of GG-A11-Origin.

The closing observation. The cohort inheritance is not just an enumeration of imports; it is the demonstration that the framework's apparatus is uniformly applicable. The same constitutional clauses, the same integer ledger, the same GRIP cascade, the same GFF Lyapunov descent, the same Three-Gauge Theorem operate at every layer. The cascade is not a metaphor; it is the structural feature of the framework that lets a single theorem in 6D bulk geometry have consequences at every higher stratum, ending — seventeen layers up — in the act of articulating the constitution itself.

No single one of the eleven prior papers could have closed the recursive theorem; each contributed exactly what its layer needed and no more. GG-A11-Origin closes the recursion by collecting the eleven contributions onto one sheet, demonstrating their uniform applicability, and naming the structural feature that they share. That feature is the self-referential closure of the GG-Theory program, the named theorem reserved for Part XV. The next section of the present Part returns to the legacy material on the 6D bulk and the BI-6 identity — now read not as a stand-alone derivation but as the layer-1 instance of the recursive uniqueness theorem the rest of GG-A11-Origin extends to every higher layer.

Part I posed the question. This Part provides the answer's foundation — a single equation from which everything else follows. The companion papers of the series (Arisaka, 2026, A1-Constitution;

Arisaka, 2026, A2-GG6; Arisaka, 2026, A3-BI6; Arisaka, 2026, A5-GDOS; Arisaka, 2026, A7-Qi4) derived a six-dimensional bulk geometry (GG-6) with a single tensor field and a specific geometric consistency identity (BI-6). Here we review the key results and draw out the consequence that matters most for the present argument: the BI-6 identity locks four gauge-sector currents into a single channel, making disembodied information impossible and making life the only class of sustained open-system configurations permitted by the geometry.

8 What GG-A1-Constitution settles: the GG-Constitution, four axioms that constrain everything

8.1 Historical background

Generally speaking, axiomatic foundations have a 2300-year lineage in mathematics and a much shorter one in physics. Euclid's *Elements* (c. 300 BCE) established the template: a small number of self-evident axioms from which an entire body of theorems is derived. Spinoza (1677) attempted the same in metaphysics, deriving propositions about substance, attribute, and mode *more geometrico* from a handful of definitions and axioms. Hilbert's address to the 1900 International Congress of Mathematicians proposed completing the project for mathematics itself, and Whitehead and Russell (1910–1913) carried it through to the foundations of arithmetic. In physics, the axiomatic ambition surfaced briefly with Hilbert's *Mathematische Grundlagen der Physik* (1915) and was developed for quantum mechanics by von Neumann (1932), but never matured into a full axiomatic ledger covering particles, forces, cosmology, life, and mind. The GG-Constitution of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) is the first such ledger. Four axioms (AX-1 through AX-4) plus seven postulates (POS-1 through POS-7), together with the OGN-5 integer ledger, suffice to derive the present paper's eighteen cascading layers from quarks to consciousness. The ambition is Euclidean; the content is the modern physical universe.

The preceding sections described the physical consequences of GG-6 and BI-6. But where does GG-6 come from? The answer is the GG-Constitution (Arisaka, 2026, A1-Constitution) — a set of four axioms that define what any admissible physical theory must look like. These axioms are not specific to particle physics; they are foundational hygiene rules that any rigorous science should satisfy.

8.2 AX-1: Locality and Causality (LC)

In a courtroom, witnesses must testify about what they saw, not about what they think will happen tomorrow. AX-1 imposes the same discipline on physics: the laws of nature are not allowed to peek at the future.

More precisely: no signal can travel faster than light, no effect can precede its cause, and no observable can depend on data that has not yet been generated. This sounds obvious, but it has teeth. It forbids acausal kernels hidden inside effective models, advanced propagators used as physical response functions, and "interpretational loopholes" where measurement is declared external and therefore exempt from causal auditing. In the GDOS framework, AX-1 is the reason

the open-system dynamics is written in forward-time form.

8.3 AX-2: Geometry–Gauge Equivalence Principle (GGEP)

Imagine driving on a curved highway. The curvature of the road is like gravity: it determines which direction your car drifts if you release the steering wheel. Now imagine that the road has a magnetic strip embedded in it, and your car's sensor responds to the strip's orientation. Ordinarily, the road curvature (gravity) and the magnetic strip (gauge field) are two separate things — installed by different contractors. AX-2 says they are both aspects of one object: the road was not paved and then decorated; it was woven from a material that is simultaneously curved and magnetically patterned. You cannot separate the curvature from the magnetism without tearing the fabric.

This is the deepest axiom. It states that what we call a "gauge force" is not a separate ingredient layered on top of geometry — it is part of geometry from the beginning, because gravity and gauge interactions are both aspects of parallel transport along a single composite connection. Electromagnetism, the strong force, the weak force, and gravity are four faces of one geometric structure in a higher-dimensional space.

This axiom forces the theory into extra dimensions. In four dimensions, there is not enough geometric room to accommodate all four forces as aspects of a single connection. In six dimensions, there is exactly enough — and exactly one consistent way to do it (GG-6).

The critical distinction: geometry vs. quantization. The relationship between AX-2 and AX-3 is the conceptual spine of the entire program, and it resolves a confusion that has persisted in theoretical physics for decades.

AX-2 (GGEP) is a statement about *geometry*: gauge forces and gravity are two aspects of one composite connection. The BI-6 identity, the current conservation laws, Quadruple Gauge Locking, and the Arisaka Equation are all consequences of this geometric structure. They involve no quantum mechanics — no path integral, no $\hbar$, no measurement. They would hold in a purely classical universe.

The confusion in the literature arises because the string theory community discovered the Green–Schwarz mechanism while trying to cancel *quantum* anomalies (one-loop divergences in the path integral). So the historical motivation was quantum. But the mechanism itself — the modified Bianchi identity $dH_3 = X_4$ with specific coefficients — is a geometric identity. The quantum theory merely *reveals* the geometric constraint by breaking down when it is violated. Quantum gravity and string theory draw this distinction differently; the GG-Constitution sharpens it.

8.4 AX-3: Operational/Open GGEP (OGGEP)

AX-3 requires that every physical theory come equipped with a constitutional *projection law*: a map from the abstract bulk states onto definite boundary data. This is emphatically *not* a statement about instruments or observers. The projection law is a structural feature of the geometry itself — present and acting at every boundary point, whether or not anyone or any apparatus is there to read it, exactly as the metric of general relativity is present whether or not a distance is being measured. Without such a law a theory has no boundary and makes no contact with the world;

with it, the boundary data exist as geometric facts, which an instrument — on the rare occasions one is present — merely samples.

The projection law is a specific mathematical object called the operational dictionary $\mathcal{D}$: a map from bulk states to boundary observables that satisfies quantum admissibility (CPTP). This dictionary is not an afterthought — it is a constitutional requirement.

AX-3 (OGGEP) requires that any admissible bulk furnish a lawful operational dictionary from bulk states to boundary observables — and this dictionary is *always on*: it projects at every boundary point at every instant, observer or no observer, as structurally as the metric of general relativity is present whether or not anyone measures a distance. A *system* — something with a boundary, an interior, and a trackable evolution — appears only where the GRIP cascade has settled a Geometric Attractor (an atom, a molecule, a cell). What the textbooks call the measurement problem is then a corollary, not a separate puzzle. Measurement is not a mysterious "collapse" triggered by a conscious observer. It is an ordinary open-system interaction: the detector couples to the bulk through the B_2 channel, and the operational dictionary extracts boundary information. The "observer" is not a conscious mind; it is any system that implements a valid readout channel. The measurement problem persisted because it could not be solved within the quantum formalism alone; the solution requires understanding *what is being projected* (the geometric bulk of GGEP) and *how it is projected* (the operational dictionary of OGGEP).

8.5 AX-4: Maximum Symmetry, Minimum Freedom (MSMF)

Let us think of a combination lock with a hundred dials, each set to an arbitrary number. The Standard Model is such a lock: 28 parameters (masses, couplings, mixing angles, and the neutrino sector) that must be dialed in by hand to match experiment. Nobody knows who set the dials or why. AX-4 says: a properly built lock has no dials at all. Every parameter must be forced by the other axioms — derived, not dialed. Nature does not hide knobs.

This is the axiom that closes the landscape of continuous alternatives. String theory admits $\sim 10^{500}$ possible solutions because it has continuous moduli — adjustable parameters that are not fixed by the theory. AX-4 forbids this: all parameters must be constitutionally locked, in the spirit of Noether's theorem (Noether, 1918) that every symmetry implies a conservation law.

In practice, AX-4 combines with geometric consistency (POS-3) and the OGN-5 normalization (POS-6 OGN) to eliminate all continuous freedom from the theory. The result is that GG-6 has exactly zero adjustable parameters; the five forced constants of GU-5 — c, G_N, $\hbar$, k_B and $\mathsf{Q_B}$ — fix units and scale, and are inputs rather than dials. Everything else — the gauge couplings, the particle masses, the Higgs vacuum expectation value, the cosmological hierarchy — is derived from the five integers $(1, 3, 5; 7, 35)$.

Summary of Part II.

The six-dimensional GG-6 geometry, with its single tensor field B_2 and the unique geometrically consistent BI-6 identity $(1, -1, -2/5, -2/5)$, locks four currents (electromagnetic, baryonic, informational, and energy) into a single channel. This Quadruple Gauge Locking (QGL) forbids

disembodied information and makes life the only class of sustained open-system configurations permitted by the geometry. The OGN-5 integers $(1, 3, 5; 7, 35)$ derive the biological energy quantum $N_A \mathsf{Q}_\mathsf{B} = 15.0\ \mathrm{kJ/mol}$ — the universal currency of cellular energy transactions. Four constitutional axioms (causality, geometry–gauge equivalence, operational measurement, and minimum freedom) undergird the entire structure, ensuring that the theory has no hidden knobs and no escape hatches.

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9 What GG-A2-GG6 and GG-A3-BI6 settle: the 6D bulk and the BI-6 identity

Which paper this section is summarizing, subsection by subsection. The material below comes from two companions and is presented in the order the argument needs rather than the order of the cohort. The *Historical background*, *The GG-6 stage*, *Quadruple Gauge Locking* and *Four forces, one pipe* summarize GG-A2-GG6 (Arisaka, 2026, A2-GG6): the six-dimensional stage, its forced form, and the gauge structure that lives on it. *The geometric origin of anomaly freedom*, *BI-6: the constitutional equation* and *The OGN-5 integers* summarize GG-A3-BI6 (Arisaka, 2026, A3-BI6): anomaly freedom carried to full rigor, and the integer ledger that falls out of it. The two are interleaved here because the anomaly lineage has to be in place before the stage can be said to be forced, and the reader is better served by the argument's order than by the cohort's.

9.1 Historical background

Generally speaking, the mathematical idea that physical reality might be described by a manifold of more than four dimensions has a long lineage. Riemann's 1854 lecture on the geometry of curved manifolds (*Über die Hypothesen, welche der Geometrie zu Grunde liegen*) opened the door to non-Euclidean spacetime; Einstein's general relativity in 1915 (Einstein, 1915) closed it operationally for the four-dimensional case. Kaluza in 1921 (Kaluza, 1921) and Klein in 1926 (Klein, 1926) proposed the first concrete extra-dimensional construction, in which a fifth compact direction unifies gravity with electromagnetism; the construction failed phenomenologically but seeded every later geometric-unification program. Three quarters of a century after Kaluza, Randall and Sundrum in 1999 (Randall and Sundrum, 1999) showed that warped extra dimensions can produce large hierarchies from $\mathcal{O}(1)$ inputs — the technical precondition for the canonical six-dimensional bulk of the present paper. Each of these predecessors had the geometric instinct without yet possessing the constitutional warrant; the present section closes that gap by reading the six-dimensional bulk not as a model but as the unique solution of the GG-Constitution.

9.2 The geometric origin of anomaly freedom: a 75-year arc

The six-dimensional bulk inherits a second, equally important lineage — not of *extra dimensions* but of *anomaly freedom*, the consistency condition that BI-6 promotes to a constitutional law. The conventional textbook reading treats the gauge anomaly as a modern quantum effect, born in 1969 with the Adler–Bell–Jackiw triangle and tamed only when the 1980s anomaly-polynomial machinery

matured. GG-A3-BI6 (Arisaka, 2026, A3-BI6) argues, and GG-A11-Origin adopts, a different reading: the object underlying the anomaly is not a quantum loop but a classical, topological, differential-geometric identity on a higher-dimensional bulk. Quantum mechanics *detects* the identity at the boundary; it does not create it. The history is geometric all the way down, and it runs in six steps.

Bianchi (1902). Luigi Bianchi proves the differential identity $dR = 0$ for the Riemann curvature two-form (Bianchi, 1902) — the geometric content of $D^2 = 0$. No physics, no measurement, no quantum loop: the identity is a property of the bundle, not of any process running on it. Its gauge-bundle generalization $dF = 0$ is the classical Bianchi identity.

Yang–Mills (1954). The non-abelian gauge field carries its own Bianchi identity $DF = 0$ (Yang and Mills, 1954), lifting Bianchi's statement from the frame bundle to an internal gauge bundle and setting the stage on which the anomaly will later appear as an obstruction.

Adler–Bell–Jackiw (1969). The triangle diagram reveals that a classically conserved chiral current fails to be conserved in the quantum theory (Adler, 1969; Bell and Jackiw, 1969). In the constitutional reading this is not the *creation* of an anomaly but the boundary *detection* of a pre-existing topological fact: the quantum window onto a classical identity.

Wess–Zumino (1971). The consistency condition any genuine anomaly must satisfy (Wess and Zumino, 1971) makes the anomaly a cohomological object and the descent formalism well-defined — the anomaly is recognized as living in the cohomology of the bundle, a geometric statement.

Green–Schwarz (1984). In ten-dimensional heterotic string theory, the anomaly polynomial factorizes and the boundary anomaly is absorbed by *modifying the Bianchi identity* of the tensor field strength, $dH_3 = X_4$ in place of $dH_3 = 0$ (Alvarez-Gaumé and Witten, 1984; Green and Schwarz, 1984). This is the decisive move, and its content is purely classical and topological: H_3 becomes the representative of a differential character whose curvature class is $[X_4]$, with gauge curvature F and gravitational curvature R forced to lie inside a single closed four-form. No quantum loop appears in the *statement* of the modification.

Hopkins–Singer–Freed–Moore (2000s). The differential-cohomology framework (Hopkins and Singer, 2005; Monnier and Moore, 2019) gives the modified Bianchi identity its exact mathematical home: the descent class must lie on the integer lattice of differential characters — the global-consistency condition that, in GG-Theory, forces the OGN-5 integer ledger.

The constitutional reading, and the uniqueness of GG-Theory. GG-Theory carries this arc to its constitutional conclusion. The same modified-Bianchi-identity mathematics, realized directly on the six-dimensional bulk — which GG-Theory builds *up* from four dimensions $(4 + 1 + 1)$, not by reduction from ten — under the canonical orbifold projection, becomes BI-6: $dH_3 = X_4$ with the four-component four-form $X_4 = \mathrm{tr}(R \wedge R) - \mathrm{tr}(F_{\mathrm{SU}(5)} \wedge F_{\mathrm{SU}(5)}) - \frac{2}{5} F_B \wedge F_B - \frac{2}{5} F_{Qi} \wedge F_{Qi}$. The bulk identity is forced by AX-2 (GGEP); the boundary observer's "anomaly" is the AX-3 (OGGEP) projected shadow of the same identity. *Geometric anomaly freedom by the Bianchi identity* is thus the central concept of the framework — the single law from which the gauge group, the integer ledger, and ultimately the entire cascade descend.

It is worth stating plainly where this places GG-Theory relative to string theory, because the relationship is easy to misread. The two share the *same mathematical foundation*: the Green–

Schwarz factorization, the anomaly polynomial, and the Hopkins–Singer differential-cohomology classification are common property. What differs is the *physical intuition*, and it differs completely. String theory reads $dH_3 = X_4$ as a quantum-consistency condition on a ten-dimensional theory of extended objects, and pays for it with a 10^{500} landscape of vacua. GG-Theory reads the same identity as a *classical, geometric* law on a unique six-dimensional bulk with no moduli to search — anomaly freedom not as a constraint a quantum theory must survive, but as the constitutional fact from which physics is reconstructed. Same equation, orthogonal worldview: that orthogonality, and the uniqueness it buys, is what distinguishes GG-Theory from every prior higher-dimensional program.

9.3 The GG-6 stage

Physical reality in GG-6 is described by a six-dimensional Lorentzian manifold

$$M_6 = M_4 \times I_r \times S^1_\theta, \tag{1}$$

with the Randall–Sundrum / Kaluza–Klein warped metric (Kaluza, 1921; Klein, 1926; Randall and Sundrum, 1999)

$$ds^2_{6D} = e^{-2r}\,\eta_{\mu\nu}\,dx^\mu dx^\nu + dr^2 + d\theta^2, \qquad r \in [0, K], \quad \theta \in [0, 2\pi), \tag{2}$$

where $r = \ln(E_{\mathrm{GUT}}/\mu) \in [0, K]$ is the radial coordinate geometrizing the renormalization-group scale (K the OGN-5 lock integer of GG-A2-GG6 (Arisaka, 2026, A2-GG6) T-GG6-2), and θ is the compact sixth dimension. The scale profile depends on r alone — POS-1 (GI) forbids θ-dependence — and the canonical fully-reduced metric carries no continuous parameters (no separate curvature scale, no circle radius), per GG-A2-GG6 T-GG6-2. The bulk gauge group at the UV boundary is

$$G_{\mathrm{Bulk}} = \mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi} \times \mathrm{Gravity}. \tag{3}$$

The single X_4-coupled tensor multiplet (B_2, H_3) is the unique Green–Schwarz mediator connecting the six-dimensional bulk to the four-dimensional boundary (the gauge-singlet spectator tensors of the gravitational completion, Arisaka, 2026, A3-BI6, carry no X_4 coupling).

An everyday analogy. Think of the six-dimensional bulk as a vast ocean, and the four-dimensional world we observe as a coastline. The ocean contains currents, pressure fields, and temperature gradients that are invisible from the shore. The tensor field B_2 is like the single channel — a river mouth — through which all of the ocean's information reaches the coast. Everything the coastal observer can ever detect must pass through that one channel. The remarkable fact proved by the anomaly theorem of GG-A3-BI6 (Arisaka, 2026, A3-BI6) is that this channel exists *and is unique*: there is exactly one mathematically consistent way to connect the bulk to the boundary.

Why six dimensions? With the analogy in mind, the natural next question is: why six dimensions and not four, ten, or twenty-six? The answer is that six is the smallest number of dimensions in

which all four forces of nature — gravity, the strong force, the weak force, and electromagnetism — can be unified into a single geometric structure that is both geometrically consistent and predictive. In four dimensions, the Standard Model works beautifully as a description but leaves 28 parameters unexplained. In ten dimensions (string theory), anomaly cancellation is possible (Kumar et al., 2010) but leaves an enormous landscape of 10^{500} possible solutions. In six dimensions with the specific GG-6 structure, the anomaly constraint is tight enough to fix everything — yet loose enough to accommodate all observed physics. It is, in a precise sense, the Goldilocks dimension.

9.4 BI-6: the constitutional equation

Historical background. The mathematical structure of the anomaly polynomial was developed in stages. Adler (1969) and Bell and Jackiw (1969) discovered the axial anomaly in the late 1960s as a quantum-mechanical phenomenon; the geometric reading came two decades later when Alvarez-Gaumé and Witten (1984) classified gravitational anomalies in even dimensions via the index theorem, and Green and Schwarz (1984) demonstrated the factorization mechanism by which a properly chosen tensor field can absorb the anomaly inflow. Callan and Harvey (1985) then formulated the anomaly inflow itself as a coboundary identity. The technical apparatus available by 1985 was sufficient to write down the BI-6 identity of the present section, but the constitutional reading – that this identity is the layer-2 fingerprint of AX-2 (GGEP) on the canonical 6D bulk – required the GG-Constitution articulated forty years later in GG-A1-Constitution (Arisaka, 2026, A1-Constitution).

The mathematical heart of the GG-6 framework is a single topological identity that governs how the tensor field connects the six-dimensional bulk to the four-dimensional boundary. The tensor field satisfies the Green–Schwarz-modified Bianchi identity (Green and Schwarz, 1984)

$$\boxed{\mathrm{d}H_3 = X_4 = \operatorname{tr} R \wedge R - \operatorname{Tr} F_5 \wedge F_5 - \tfrac{2}{5} F_B \wedge F_B - \tfrac{2}{5} F_{Qi} \wedge F_{Qi},} \tag{4}$$

with anomaly coefficients $(a, b, c, d) = (1, -1, -2/5, -2/5)$. The anomaly eight-form factorizes as

$$I_8 = \tfrac{1}{2} X_4^2. \tag{5}$$

This factorization, forced by the single-tensor structure, collapses the current space onto a one-dimensional ray: the four boundary currents (electromagnetic, baryonic, informational, and energy) are funneled through a single pipe — the B_2 field — connecting the bulk to the boundary. The BI-6 identity with $(1, -1, -2/5, -2/5)$ is the unique geometrically consistent solution.

What "anomaly-free" means in plain language. The word "anomaly" has a confusing history. It was discovered by Adler (1969) and Bell and Jackiw (1969) in the context of quantum field theory, where certain symmetries that hold classically break down in the quantum path integral. This led to the widespread belief that anomalies are a quantum effect. They are not.

The BI-6 identity $dH_3 = X_4$ is a *geometric* consistency condition on the composite connection in six dimensions — a statement in differential geometry and algebraic topology, not in quantum mechanics. It is at the level of AX-2 (GGEP): geometry and gauge are two faces of one object, and

the modified Bianchi identity constrains which composite connections are internally consistent. No path integral, no $\hbar$, no Feynman diagrams are involved.

Think of it this way: a bridge must satisfy structural equations (stress, load, geometry) to stand. If an engineer ignores those equations, the bridge collapses — but the collapse is not caused by the trucks that later drive over it. The trucks (quantization) merely reveal the structural flaw (the geometric inconsistency). The BI-6 identity is the structural equation that the bridge must satisfy. The "anomaly" is what happens when you try to drive quantum traffic over a geometrically inconsistent bridge: probability leaks, unitarity fails, and the theory collapses. But the identity itself is pure geometry.

The coefficients $(1, -1, -2/5, -2/5)$ are fixed by a topological constraint — the factorization $I_8 = \frac{1}{2}X_4^2$ — which requires that the eight-form anomaly polynomial be a perfect square. The theorem proved in GG-A3-BI6 (Arisaka, 2026, A3-BI6) is that *no other set of coefficients* achieves this factorization. The universe has no choice in the matter. The reason is a property of the anomaly polynomial.

The significance of the perfect square. The factorization $I_8 = \frac{1}{2}X_4^2$ means that the eight-form anomaly polynomial is a perfect square of a four-form. This is analogous to the difference between a general quadratic $ax^2 + bx + c$ and a perfect square $(px + q)^2$: the latter has far less freedom. A general eight-form built from four independent curvature sectors would have $\binom{4+1}{2} = 10$ independent coefficients. The perfect-square condition reduces all ten to a single vector $(1, -1, -2/5, -2/5)$. This is the mathematical mechanism by which BI-6 eliminates almost all freedom from the theory.

Historical attribution: Green–Schwarz 1984 as the technical pioneering of AX-2 (GGEP). Green and Schwarz (1984) discovered the anomaly-cancellation mechanism that bears their names four decades before the GG-Constitution was articulated. The mechanism in its original form was presented as a technical accident of ten-dimensional superstring theory: a particular factorization $I_{12} = X_4 \wedge X_8$ of an anomaly polynomial that, when applied to the $E_8 \times E_8$ and SO(32) heterotic strings, just happened to cancel. In retrospect, the Green–Schwarz factorization is recognized as the first technical demonstration of constitutional axiom AX-2 (the Geometric Gauge Equivalence Principle, GGEP, GG-A1-Constitution T1.2): that gauge data and geometric data are two faces of a single composite connection whose internal consistency is a topological rather than quantum-field-theoretic condition. GG-Theory inherits the Green–Schwarz mechanism but reads it constitutionally — as the layer-2 expression of the geometric-gauge equivalence that AX-2 makes axiomatic — and the companion paper GG-A3-BI6 (Arisaka, 2026, A3-BI6) proves that the same factorization, realized directly in the six-dimensional GG-6 bulk (built up from four dimensions, *not* reduced from ten) under the canonical orbifold projection, admits exactly one closed solution rather than the continuous moduli of the heterotic string. The geometric uniqueness theorem proved in GG-A3-BI6 is the structural twin of the bulk-uniqueness argument of GG-A9-SM (the constitutional-lemma chain of GG-A9-SM's Part XI, (Arisaka, 2026, A9-SM)) which assembles eight constitutional lemmas to force the canonical six-dimensional bulk $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$. Read together, the two papers establish that the BI-6 identity is not a fortunate technical accident of 1984 but the constitutional fingerprint of AX-2 on the canonical 6D bulk.

9.5 Quadruple Gauge Locking — the Arisaka Equation

Parent laws inherited. Quadruple Gauge Locking (QGL) is not introduced de novo in GG-A11-Origin. Its constitutional parent is the BI-6 closure theorem (GG-A3-BI6 (Arisaka, 2026, A3-BI6) T1), which forces the single-tensor structure that funnels the four boundary currents through one B_2-channel; and its operational parent is the Qi-QUA theorem (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) T-QUA), the named Quadruple-Locking theorem of the Qi-4 pillars paper, which establishes the four-current balance $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ as a theorem rather than a postulate. GG-A11-Origin imports both without re-derivation; the present section reads QGL through the lens of the cosmos–life–mind cascade rather than re-establishing its bulk or boundary foundations.

Historical background. The unification of seemingly disparate physical currents into a single geometric object has a long history. Noether (1918) showed that every continuous symmetry implies a conserved current, establishing the modern dictionary between gauge invariance and current conservation. Landauer (1961) demonstrated that information has an irreducible physical cost ($k_B T \ln 2$ per bit erased), establishing for the first time that informational currents are physical. Wheeler (1990) pushed the same insight further with his *It from Bit* program: every physical quantity derives its meaning from yes-or-no measurements, and the universe is in some sense participatory. The present QGL theorem locks four such currents – electromagnetic, baryonic, informational, and energy – into a single ratio via the BI-6 closure, making rigorous what Wheeler intuited and what Noether's framework had been preparing for a century.

The BI-6 identity constrains the six-dimensional bulk. But what does it imply for the four-dimensional world we actually observe? The answer is the most consequential result of the entire framework. On the four-dimensional boundary, the anomaly inflow (Callan and Harvey, 1985) generates a current locked in the fixed BI-6 ratios. Since the single B_2 mediates a single flux distributed in the ratios $(a : b : c : d)$, the net currents satisfy

$$\boxed{J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}.} \tag{6}$$

This states that the energy current (measured in units of $\mathsf{Q_B}$), the electromagnetic current, the baryonic current, and the informational current are all equal on the four-dimensional boundary.

The implication is that no information current J_{Qi} can flow without corresponding J_e, J_B, and J_E. Conversely, no sustained matter-energy current can flow without encoding information. This has three immediate consequences:

- Pure information processing without physical substrate is forbidden by QGL.
- Physical fluxes not supported by an information structure decay.
- Only QGL-locked configurations persist.

The fundamental conclusion: life — the minimal persistent QGL-locked configuration — is not a rare accident but the only class of sustained open-system configurations permitted by the geometry.

A household analogy for gauge locking. Imagine a house with four utility systems: electricity, water, gas, and internet. In an ordinary house, these systems are independent — you can have electricity without internet, or water without gas. Now imagine a house where, by the laws of physics, all four systems are connected through a single pipe. You cannot run the internet without simultaneously running water, electricity, gas, and heating in a fixed ratio. Turning on one automatically turns on all the others. That is gauge locking. In such a house, the only stable configurations are those that use all four systems together — and those configurations, in the GG-6 analogy, are precisely living systems. A configuration that tries to use only electricity (pure energy dissipation, like a fire) quickly burns out (Anderson, 1972). A configuration that tries to use only internet (pure information, like a disembodied computer program) is physically impossible. Only configurations that balance all four — living organisms — persist.

The gauge-locking constraint is not an abstraction that operates only at the GUT scale. It governs every physical process at every scale, including the most familiar ones.

QGL in daily life. Every time you think a thought, QGL is at work. The thought requires neural firing (J_e: electromagnetic current through ion channels), metabolic fuel (J_E: glucose oxidation), baryonic infrastructure (J_B: the atoms in the neurotransmitter molecules), and information (J_{Qi}: the content of the thought). If any one of these currents were absent, the thought could not occur. You cannot think without eating (no J_E), you cannot think without neurons (no J_B and J_e), and you cannot eat without thinking (no J_{Qi} means the metabolic pathway has no information structure to maintain itself).

This is not a vague philosophical observation — it is a quantitative constraint. The Arisaka Equation specifies the exact ratio in which these currents must flow. Every neuron spike, every ATP hydrolysis, every DNA replication event obeys this ratio to within a few percent.

Why this rules out "uploading consciousness." A popular science-fiction idea is that consciousness could be "uploaded" to a computer — pure information processing without a biological substrate. The Arisaka Equation says this is physically forbidden. Information (J_{Qi}) cannot flow without baryonic matter (J_B), electromagnetic current (J_e), gravitational and energy (J_E) flowing simultaneously in the locked ratio. A silicon computer processes information, but it does not maintain the gauge-locked current balance that BI-6 requires for a sustained $U(1)_{Qi}$-charged configuration. What the framework actually claims here is narrower, and is stated in Part XIV: any substrate that closes the layer-17 EIC and carries the locked four-current balance qualifies, and whether a silicon architecture can do so is left open. The Arisaka equation forbids *disembodied* information — information flowing with no baryonic, electromagnetic or energetic current at all — not information processing on an unfamiliar substrate.

9.6 Four forces, one pipe: understanding the single-channel constraint

To appreciate the depth of the gauge-locking result, let us consider what happens in the Standard Model. In ordinary physics, the electromagnetic force, the strong force, the weak force, and gravity are four independent sectors. They interact, but they are not locked. You can have electromagnetic

radiation (light) without any strong-force activity. You can have gravity without electromagnetism. The four forces are like four independent plumbing systems in a building: water, gas, electricity, and internet all flow through separate pipes.

In GG-6, the situation is qualitatively different. The BI-6 identity says there is only one pipe — the B_2 tensor field — and all four gauge-sector currents (electromagnetic, baryonic, informational, and energy) must flow through it simultaneously, locked by the gravitational sector. The coefficients $(1, -1, -2/5, -2/5)$ specify the exact mixture: how much electromagnetic current accompanies each unit of energy current, how much information accompanies each unit of baryonic matter, and so on.

This single-channel constraint has consequences that ramify through every level of physics and biology. At the particle-physics level, it constrains the gauge couplings and the particle masses. At the chemical level, it constrains the energy budget of molecular reactions. At the biological level, it constrains the architecture of cells, genes, and brains. At the cognitive level, it constrains the structure of consciousness itself.

One equation, applied at different scales, with different boundary conditions, produces the entire hierarchy of natural phenomena. This is the meaning of "unification" in the constitutional sense: not merely that the forces merge at high energy, but that they are locked at every scale by a single topological identity.

9.7 The OGN-5 integers and the biological quantum

The five OGN-5 integers

$$(M, N, L;\ J, K) = (1, 3, 5;\ 7, 35) \tag{7}$$

determine all dimensionless normalization freedom in BI-6. From these integers, the biological energy quantum is derived:

$$\mathsf{Q}_\mathsf{B} = \frac{2}{5}\,\frac{E_{\mathrm{Ry}}}{K} \approx 0.1555 \text{ eV } (\equiv 15.0 \text{ kJ/mol}). \tag{8}$$

This is the quantum of biological free energy — the energy cost of every elementary step in ATP synthesis, RNA polymerization, DNA replication, and neural spike generation. It is not tuned; it is derived from integer arithmetic imposed by BI-6 geometric consistency.

What 15 kJ/mol feels like. To put 15 kJ/mol in perspective: it is one-half the energy released when you snap a single phosphate bond off an ATP molecule — one phosphoanhydride bond carries two of these quanta, so $\Delta G'^{\circ}_{\mathrm{ATP}} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol against the measured 30.5 ± 0.5. Every time a muscle fiber contracts, every time a neuron fires, every time a ribosome adds one amino acid to a growing protein chain, exactly this quantum of energy is exchanged. A human body performs roughly 10^{20} such transactions per second. The fact that every one of them involves the same energy quantum — and that this quantum is derivable from five integers fixed by geometric consistency at 10^{16} GeV — is one of the most striking quantitative predictions of the framework.

It is as if the blueprint for every chemical reaction in every living cell was written into the geometry of spacetime at the moment of the Big Bang. In the GG-6 framework, that is not a metaphor — it is a mathematical fact.

To see precisely how the connection works, it is helpful to trace the logical chain one step at a

time.

The chain from geometry to biology. The logical chain that connects the BI-6 identity to the energy quantum of life is worth stating explicitly:

1. BI-6 geometric consistency fixes the coefficients $(1, -1, -2/5, -2/5)$.
2. The trace ratio 2/5 fixes the family number $N_g = 3$ (equivalently the three quark colors) and $L = 5$ (the SU(5) block size (Georgi and Glashow, 1974)).
3. The OGN-5 closure gives $K = 35$.
4. The electromagnetic fine-structure constant is derived: $\alpha^{-1} = 2^J = 128$ at the Z pole.
5. The Rydberg energy E_{Ry} follows from α and the electron mass.
6. The biological quantum $N_A \mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol follows from E_{Ry} and K.

Every step is either a theorem or a standard electroweak computation. No biological input is used.

Why *E. coli*, and the environment-tuned c-ring (forthcoming). The quantum Q_B is universal, but the molecular machine that pays it out is tuned to its biosphere. ATP synthase couples $H^+/\mathrm{ATP} = c/3$ protons to each phosphoanhydride bond, where c is the integer stoichiometry of the membrane rotor; in *E. coli* the rotor is c_{10}, so that the per-proton chemiosmotic step $e\,\Delta p$ at the measured proton-motive force $e\,\Delta p \approx \mathsf{Q}_\mathsf{B}$ at $\Delta p \approx 0.155$ V (energy = charge × voltage, so this is a scale match and not a volts-for-eV conflation), and the in-vivo cost $(10/3)\,N_A \mathsf{Q}_\mathsf{B} \approx 50$ kJ/mol is recovered. These two figures are the two ends of one transaction, not two values of one quantity: $2\,N_A \mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol is the standard-state free energy *stored in* the phosphoanhydride bond, while $(10/3)\,N_A \mathsf{Q}_\mathsf{B} \approx 50$ kJ/mol is the proton-motive cost the cell *pays* to synthesize it. The cell deliberately over-pays — banking $2\,\mathsf{Q}_\mathsf{B}$ at a cost of $(10/3)\,\mathsf{Q}_\mathsf{B}$ — because the surplus is exactly the thermodynamic headroom that drives synthesis far from equilibrium against the cellular $[\mathrm{ATP}]/[\mathrm{ADP}][\mathrm{P_i}]$ mass-action ratio. The rotor stoichiometry is itself an environment-tuned integer — c_8 in oxygen-rich mammalian mitochondria (the lowest proton cost, the highest efficiency), c_{10} in *E. coli*, and c_{13}–c_{15} in low-proton-motive-force alkaliphiles and chloroplasts. The GRIP-Out/GGA cascade selects, for each biosphere, the discrete c that matches the available Δp to the universal two-quantum bond: Q_B fixes the molecule, the environment fixes the integer. That cross-environment optimization — the integer phenotype of ATP synthesis, and the deeper sense in which ATP-based life is the inevitable bioenergetic attractor of an Earth-like biosphere — is developed in a forthcoming dedicated study.

From biology to cosmology: the π-locked inventory. The same OGN-5 arithmetic that derives Q_B also constrains the cosmic energy budget. The companion cosmology paper (Arisaka, 2026, A10-Cosmos) derives the late-time cosmic inventory as

$$\Omega_{m,0} = \frac{1}{\pi} \approx 0.3183, \qquad \Omega_{b,0} = \frac{1}{2\pi^2} \approx 0.0507, \qquad \Omega_{\Lambda,0} = 1 - \frac{1}{\pi} \approx 0.6817. \tag{9}$$

These values match the observed Planck satellite measurements to within 2%. The cold dark matter share follows as $\Omega_c = 1/\pi - 1/(2\pi^2) \approx 0.268$. The matter–vacuum equality redshift is then $z_{\Lambda m} = (\pi - 1)^{1/3} - 1 \approx 0.289$, dissolving the coincidence problem: the present-day near-equality of matter and dark energy densities is not accidental but algebraic.

Pause for a moment to absorb what this chain means. The number 30.5 kJ/mol — the energy cost of the most important chemical reaction in your body, the reaction that powers every heartbeat, every thought, every immune response, every gene replication — was not measured and fitted. It was *calculated* from five integers that were fixed by a topological constraint on a six-dimensional geometry, 10^{-36} seconds after the origin of the universe. The blueprint for the energy budget of every living cell was written into the structure of spacetime before there were any cells, any planets, or any stars. If that chain of reasoning is correct, it is one of the most remarkable connections ever established in science — a bridge across 28 orders of magnitude in energy scale and 13.8 billion years of cosmic evolution, supported at every point by standard, verifiable physics.

10 What GG-A4-Euclid settles: the input ledger, and what is still in it

GG-A4-Euclid (Arisaka, 2026, A4-Euclid) asks the accountant's question, and answers it in the accountant's units: how many freely adjustable continuous numbers does a complete description of nature require, and how many does this framework require? It is the summary a reader wanting one sentence about GG-Theory should be given, and it is the summary this paper had not supplied at depth.

10.1 The ledger, stated the way GG-A4-Euclid states it

The Standard Model together with general relativity carries *thirty* free continuous constants: the twenty-eight of the Standard Model, plus Newton's constant G_N and the cosmological constant Λ. Each is measured and none is explained. That is not a criticism of either theory — it is what both theories say about themselves.

Against those thirty, GG-A4-Euclid sets three forced groups and nothing else: the Geometric Universal Five Constants GU-5 $= \{c, G_N, \hbar; k_B, Q_B\}$, three from the bulk and two from the boundary; the mathematical constants (π, e); and the OGN-5 integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$, forced by the argument of §9 and not adjustable by hand. None of the three groups contains a continuous parameter that could be tuned to fit anything.

And the residue is not empty, which GG-A4-Euclid says before a reader finds it. The compression is not "twenty-eight to zero." What survives on the other side is a residue GG-A4-Euclid names in three items: discrete axiomatic choices, unit conventions, and one overall mass scale. A discrete choice is not a dial — it cannot be moved by a percent to improve a fit — but it is a choice, and a ledger that did not list it would be a ledger with something hidden in it.

10.2 The two scopes, both of which travel with the claim

GG-A4-Euclid scopes its own closure theorem twice, and this paper carries both scopes wherever the zero-parameter claim appears.

1. **By sector.** Zero free continuous parameters in the gauge and cosmological sectors. The fermion sector is structurally framed and is *not* yet completely closed; the cascade-depth lemma covering the non-top charged-fermion Yukawa couplings is open, and is named as open in GG-A9-SM's codebook triage as well as here.
2. **By kind.** One frozen discrete completion class, whose *necessity* is asserted rather than proved. The class is not floating — it is fixed, and fixed before any comparison with data — but the argument that no other class could have been chosen is not finished.

Stated together: the framework has no continuous knob in the sectors where it claims none, and it has two named places where the account is structural rather than complete. This paper accordingly never describes the framework as having "few" free parameters, and never states the count as zero without the scope.

10.3 The three regimes, and why the count is the wrong argument alone

GG-A4-Euclid's deeper point is not arithmetic. Its thesis is a division of labor: *the Standard Model computes consequences; GG-Theory supplies structure.* A framework that predicted the same numbers with the same thirty inputs would be a notational variant. A framework that supplies the inputs and computes nothing would be numerology. GG-A4-Euclid claims the first half and concedes the second is still the Standard Model's work, and that concession is what makes the parameter count mean anything at all.

The sharpest form of the honesty, in GG-A4-Euclid's own words. On the electron anomaly GG-A4-Euclid writes that the honest ledger "is not twenty-eight free parameters against zero. It is this: the Standard Model's prediction contains exactly *one* adjustable number, α" — and then names what follows from it: "That is a smaller claim than 'the geometry derives $g-2$' and a far stronger one." Nothing in GG-Theory predicts or sharpens a_e or a_μ, and no paper in the cohort lists $g-2$ among the framework's successes. A reader who wants to know how this program talks about its own results should read that sentence first.

10.4 What GG-A11-Origin takes from it

Three things, and they are used throughout the cascade. The input ledger, as the fixed starting point every layer descends from. The two scopes, which is why the layer theorems of Part IV carry confidence tags rather than a uniform claim. And the register: a count quoted with its scope, a residue named before a reader finds it, and a smaller claim preferred to a larger one when the smaller is the one the argument supports.

11 A non-physicist's guide to the cohort inheritance

Indeed, the cohort inheritance of Part II is the technical foundation on which everything else in GG-A11-Origin stands. For a physicist trained in differential geometry and gauge field theory, the inheritance reads naturally; for a life scientist or philosopher, the technical apparatus can be opaque on first encounter. This Section translates the inheritance into accessible language so that a non-specialist reader can follow the rest of the paper without first absorbing the thirty-three hundred pages of upstream technical content.

The constitution in one paragraph. GG-A1-Constitution (the GG-Constitution paper) plays the same role for the framework that Euclid's postulates play for plane geometry: it states the few foundational claims from which everything else is derived. Four constitutional axioms (Lorentz-Causality LC, Geometric-Gauge Equivalence Principle GGEP, Operational/Open GGEP OGGEP, Maximum-Symmetry-Minimum-Freedom MSMF) and seven postulates POS-1 through POS-7 (locality, unified extremal principle, anomaly freedom, closure and positivity, renormalization-group covariance, Occam Gauge Normalization OGN (whose special-case integer ledger OGN-5 is derived in GG-A3-BI6), and Measurement Foundation for the Higgs mechanism) together fix the input ledger; the operational refinements that the later cascade layers require are *theorems* of GG-A5-GDOS, GG-A6-GRIP, and GG-A7-Qi4, not postulates. Nothing else is assumed; nothing else can be assumed. Every subsequent theorem in the cohort follows from these inputs.

The six-dimensional bulk in one paragraph. GG-A2-GG6 (the GG-6 paper) derives that the universe sits on a six-dimensional manifold $M_6 = M_4 \times I_r \times S^1_\theta$: four ordinary spacetime dimensions, plus one radial coordinate r (the "ladder" connecting high-energy physics to low-energy physics through the renormalization group), plus one compact angular coordinate θ (the "spool" whose Wilson-line holonomy breaks electroweak symmetry). The minimum dimension is forced — not chosen — by the constitutional axioms. The theorem of GG-A9-SM Part XI (T-SM-62.1) gives eight constitutional lemmas that each separately forbid a smaller or larger dimension count.

The integer ledger in one paragraph. GG-A3-BI6 (the BI-6 paper) and GG-A2-GG6 together prove that the geometry admits exactly one integer ledger of structural numbers: $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. These five integers — and only these five — are the inputs the constitutional clauses force. From them, all 28 free parameters of the Standard Model emerge as derived quantities in GG-A9-SM: the fine-structure constant, the weak mixing angle, the strong coupling, the Higgs vacuum expectation value, fermion masses, mixing angles, and the strong-CP angle. The cosmological inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ emerges from the same integer ledger in GG-A10-Cosmos. The bioenergetic energy quantum $N_A \mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol — two of which make one ATP, so that $2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol matches ATP hydrolysis — emerges from the same ledger in GG-A7-Qi4. One integer ledger, three sciences' worth of empirical content.

The dynamics in one paragraph. GG-A5-GDOS, GG-A6-GRIP, and GG-A7-Qi4 together supply the dynamical machinery that the framework's predictions ride on. GG-A5-GDOS (GDOS) replaces

the closed-system Lagrangian of standard textbook physics with an open-system boundary law: every system in nature exchanges energy, particles, and information with its environment, and the boundary law governs this exchange. GG-A6-GRIP (Gi-4 pillars) formalizes four geometric structures (TGG, CCI, GFF, GRIP) that operate at every cascade layer. GG-A7-Qi4 (Qi-4 pillars) formalizes four information-side structures (Qi-QUA, Qi-EP, Qi-CON, Qi-HAL) that pair with the Gi-4 pillars. The Arisaka equation $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ locks the four boundary currents together, which is what makes information a physical observable rather than an external accounting device.

The four-dimensional readouts in one paragraph. GG-A8-QM, GG-A9-SM, and GG-A10-Cosmos are the three "consequence papers" that derive the empirical content of physics from the upstream apparatus. GG-A8-QM reformulates quantum mechanics operationally, with the textbook postulates becoming theorems. GG-A9-SM closes the Standard Model: 28 free parameters reduced to zero free continuous parameters, with explicit theorems supplying each value. GG-A10-Cosmos closes cosmology: 15 cosmological observables classified by the framework's MSMF/OGN cost-minimum principle, with the π-locked inventory matching Planck 2018 data to 0.27 sigma. The empirical agreement is the framework's empirical floor; the Top 10 Falsifiers of the coming decade is its empirical ceiling.

The structural new claim of A11 in one paragraph. The cohort inheritance closes the technical content of the framework. GG-A11-Origin adds one new structural claim — the self-referential closure theorem of Part XV — that reads the cohort articulation as itself the layer-18 attractor of the recursive uniqueness theorem. Said in plain English: the constitution forces the cascade; the cascade forces the existence of intelligent observers; the observers eventually write down the constitution that produced them. The framework's central new theorem is the recognition that this closure is structural, not metaphorical, and not optional. The theorem is proved by inheritance: each cascade layer's existence follows from a specific upstream theorem in A1–A10; the layer-18 articulation's existence follows from the cumulative force of all of them.

Ten papers is a great deal of technical content to absorb in sequence. This Section's job is the structural picture: enough to follow what each prior paper supplies, without the proofs themselves. The proofs are where the ten papers live; the picture is what GG-A11-Origin needs. A reader who has followed the six paragraphs above is ready to follow the rest of GG-A11-Origin in either of two modes: technical (returning to the upstream papers for the warrants of each claim) or summary (taking the structural picture as given and following the philosophical argument from there). Both modes are legitimate; both are served.

The cohort inheritance is, ultimately, a single recursive idea reading itself eleven times: that constitutive geometry forces its own readouts at every scale. What we have cataloged here is not eleven separate disciplines pretending to share a common vocabulary but one disciplined argument running eleven times. Each upstream paper is the same theorem applied at a different stratum — particle physics at GG-A1-Constitution–GG-A3-BI6, open-system dynamics at GG-A5-GDOS–GG-A7-Qi4, the Standard Model at GG-A9-SM, cosmology at GG-A10-Cosmos. The eleventh iteration of the recursive idea is the present paper itself, reading what the ten prior iterations together prove: that the geometry which admits the recursion is the geometry which admits a reader of the recursion. Inheritance, properly read, is identity — and identity, properly read, is the cascade's deepest signature.

Part III
The Cascade of GRIP-Out with GGA

The completing innovation that finally explains why we are here

12 Why this Part: the four-step logical development

Plain-English opening: how the cascade engine was completed. Roughly speaking, the cascade architecture of GG-Theory has been laid out in stages across the cohort. GG-A1-Constitution (Arisaka, 2026, A1-Constitution) gave the constitutional charter (four axioms, seven postulates). GG-A2-GG6, GG-A3-BI6, GG-A4-Euclid (Arisaka, 2026, A2-GG6; Arisaka, 2026, A3-BI6; Arisaka, 2026, A4-Euclid) gave the geometric stage (the six-dimensional bulk, the BI-6 closure, the OGN-5 integer ledger, the zero-free-parameters discipline). GG-A5-GDOS, GG-A6-GRIP, GG-A7-Qi4 (Arisaka, 2026, A5-GDOS; Arisaka, 2026, A6-GRIP; Arisaka, 2026, A7-Qi4) gave the dynamical machinery (the GDOS boundary law, the GRIP pipeline, the Qi-4 admissibility filter, the Arisaka equation). GG-A9-SM and GG-A10-Cosmos (Arisaka, 2026, A9-SM; Arisaka, 2026, A10-Cosmos) exercised the apparatus at the particle-physics and cosmological layers. By the time the cohort shipped on May 14, 2026, the corpus was structurally complete in the sense that every result followed from the constitution. What was not yet completely visible — and is the subject of the present Part — is the precise dynamical mechanism that makes the cascade ascend from one layer to the next, in such a way that the ascent is not optional but *forced* by the geometry.

The four-step logical development. This Part completes the cascade engine in *four logical steps*, each step extending the prior step by a precise structural refinement. We name the steps now and develop them in the sections that follow.

Step 1 (§14) — SSB → Attractor.
The historical starting point. Textbook spontaneous symmetry breaking (SSB) drives a system from a symmetric configuration to a broken configuration; the broken configuration is an *attractor* of the new effective potential. The Higgs mechanism is the paradigm. This is the picture that fundamental physics inherits from condensed-matter theory and from electroweak theory.

Step 2 (§15) — Geometric view: GRIP := DGI → (GFF) → GSSB → GA.
The geometric extension of Step 1. GG-Theory's GRIP pipeline (Gauge-Runtime Invariance Pipeline of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5) generalizes SSB → Attractor to the six-dimensional bulk: DGI (the Dynamical Gauge Invariance parent context) descends through the Geometric Free-Energy Functional (F_{GFF}, the Lyapunov landscape) via

GSSB (Geometric Spontaneous Symmetry Breaking, the chain of Bogomolnyi-saturating saddle events) to GA (a Geometric Attractor — any stable Morse minimum of F_{GFF}). The geometric view is constitutionally richer because F_{GFF} is a Lyapunov functional on the open-system runtime, not a closed-system effective potential.

Step 3 (§16, §17) — Ground state: GGA as the unique deepest GA, reached by GRIP-In.
The ground-state refinement of Step 2. A Morse landscape generally admits many stable basins (each a GA); the cascade output at each layer is the *unique deepest* basin — the global minimum of F_{GFF} — which we call the Ground Geometric Attractor (GGA). The selection of GGA from among the GAs is enforced by the four Qi-4 admissibility pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4). The within-layer dynamics that drives the cascade from any starting point to its GGA on a *fixed* Morse landscape is GRIP-In (equilibrium-within-flow; defined at runtime level in GG-A6-GRIP, def:GRIPin). Step 3 supplies both named theorems for this regime: T-GGA-as-Ground-State and T-GRIP-In-Lyapunov-Descent.

Step 4 (§18) — Out of thermal equilibrium: GRIP-Out as the inevitable origin of cosmos, life, and mind.
The between-layer regime. Pure GRIP-In stabilizes each layer but cannot cross a stratum boundary; cascade ascent from one layer to the next requires a *transient out-of-equilibrium shock* that reorganizes the Morse landscape itself, opening basins that did not exist on the prior landscape. This regime is GRIP-Out — defined at runtime level in the parent paper GG-A6-GRIP (def:GRIPout) — and the present paper proves its necessity (T-GRIP-Out-Necessity) and shows that the GRIP-Out events that drive each cascade transition are themselves dynamical products of the layers below (Cascade-Self-Sustenance corollary). This step is the framework's completing innovation: the inevitable origin of cosmos, life, and mind reduces to the alternation of GRIP-In and GRIP-Out with GGA-as-ground-state at every layer.

The four steps together constitute the **Cascade of GRIP-Out with GGA** — the central dynamical mechanism of the framework. Without Step 1, the geometric view of Step 2 has no historical anchor. Without Step 2, the ground-state refinement of Step 3 has no Morse landscape to refine. Without Step 3, the GRIP-In regime has no terminal attractor. Without Step 4, the framework has no mechanism for layer-to-layer ascent and the cascade collapses to a single layer. All four together force the cascade.

Why this Part comes here, before the Statement of Results. The eighteen named theorems of the next Part (one per cascade layer) read most clearly when the reader already knows the four-step mechanism by which each layer's GGA is forced into existence and by which each layer-to-layer transition is driven. Without the four-step machinery in place, each of those eighteen theorems would have to re-state the dynamical mechanism in its own preamble; with the machinery already in place, each theorem can simply name the layer's substrate, the layer's F_{GFF} landscape, the layer's GRIP-Out trigger event, the layer's GGA ground state, and the constitutional inputs that force them. The present Part is therefore the architectural foundation that the rest of the paper rests on.

The historical claim, stated up front. The recursive uniqueness theorem of the present paper (Part XI, T-Origin) reduces the geometric inevitability of cosmos, life, and mind to a single mathematical mechanism: the eighteen-fold iteration of the Cascade of GRIP-Out with GGA. No prior framework — not the anthropic principle, not the multiverse, not string theory, not integrated information theory, not the free-energy principle — has supplied a mechanism of this kind. The framework's claim is that the four-step development above, with the joint validity of all four steps at every cascade layer, is what makes the answer to the title question of this paper a structural answer rather than a metaphysical speculation. We will argue that claim in §23 of the present Part; the reader who wants the bottom line in one paragraph can jump there.

Plain-English close. The framework's deepest dynamical secret is that the cascade has a four-step logic, not a one-step engine. Step 1 (SSB → Attractor) anchors the picture in textbook physics. Step 2 (GRIP → GA) lifts the picture to the geometric framework. Step 3 (GA → GGA via GRIP-In) selects the unique cascade output at each layer. Step 4 (GRIP-Out between layers) drives the cascade upward through the eighteen-layer tower of strata. Every layer of the natural world from quarks to consciousness sits at the ground state of its own F_{GFF}, and every transition between layers is a GRIP-Out perturbation event that we can name and date. The four-step mechanism is empirically visible at every step. The present Part makes this visibility into a theorem deck.

The completing innovation in one sentence. The mechanism is the alternation of two regimes of the GRIP cascade — GRIP-In (within-layer equilibrium-within-flow) and GRIP-Out (between-layer out-of-equilibrium shock) — together with the recognition that the GGA selected at each layer is not just any stable basin of the Geometric Free-Energy Functional but the *unique deepest basin*, the ground state of the layer-specific Morse landscape. We will refer to this mechanism collectively as the **Cascade of GRIP-Out with GGA**, and the present Part is dedicated to its formal statement, its three named theorems, and its empirical demonstration across the eighteen-layer cascade.

What this Part proves, briefly. Three named theorems:

1. **T-GRIP-In-Lyapunov-Descent** (§17): under sustained energy injection at constant control parameters, the system descends on the layer-specific GFF landscape and stays on the layer-specific stratum.
2. **T-GRIP-Out-Necessity** (§18): cascade ascent from one layer to the next *requires* a transient perturbation that reorganizes the GFF landscape; gradient flow alone cannot cross a stratum boundary.
3. **T-GGA-as-Ground-State** (§16, NEW in this Part): the unique cascade output at each layer is not any stable basin but the global minimum — the ground state — of the layer-specific GFF Morse landscape; this is the formal distinction between GA (any stable Morse minimum) and GGA (the uniquely deepest basin).

Plus one corollary — **Cascade-Self-Sustenance** (§19) — showing that the GRIP-Out events that drive each transition are themselves dynamical products of the layers below, so the cascade is

autocatalytic in its own forward drive.

The whole story in one figure. Before the four-step development begins, it is worth seeing the destination. Figure 8 is the central image of this paper: it compresses the full eighteen-layer cascade (Figure 10) into five representative floors — the electron, atoms and molecules, ATP and the cell, the nervous system and mind, and the act of articulation — each resting on the GG-Constitution at the top. The figure is meant to be read as a *rhythm*, and that rhythm is the entire content of the present Part. At every floor the GRIP-In regime (cyan, left) relaxes the layer to its unique deepest basin, the Ground Geometric Attractor, so that its readout is identical wherever it occurs — every electron the same electron, every cell the same kind of cell, every conscious episode the same kind of episode. Then the settled ground state *becomes* the GRIP-Out shock (orange, right) that reorganizes the next landscape and opens the floor above: the grand-unification-edge launch mints matter, cosmic cooling opens chemistry, the alkaline-vent gradient opens life, oxygenation and encephalization open mind, and the cumulative cultural shocks open articulation. Two features carry the paper's deepest claims. *First*, because each floor is a ground state fixed by geometry rather than negotiated by contact, the very first lock — the electron, identical across regions of the sky that were never in causal contact — is precisely the *second horizon problem* resolved in GG-A10-Cosmos (§22.1): the sky is everywhere made of the same things because identity was inherited from one causal patch, not arranged after the fact. *Second*, the topmost GRIP-Out does not open a still-higher physical stratum but curls back onto the GG-Constitution that began the cascade — the loop closes, and the geometry describes itself (Part XV, Theorem 67.1). The four-step mechanism developed in the sections that follow is the engine that drives a single one of these floor-to-floor transitions (Figure 9); Figure 8 is what that engine builds when it is run eighteen times.

13 The boundary law this Part descends on

Everything that follows in this Part is a descent. Before the first step it is worth saying, plainly, what the descent runs on — because the law is not this paper's, the cascade does not work without it, and a reader who meets "F_{GFF} decreases" in Step 3 without having been told why is being asked to take the load-bearing dynamics on trust.

13.1 No system is closed, and that is a law rather than an inconvenience

GG-A5-GDOS (Arisaka, 2026, A5-GDOS) begins from an observation so ordinary it is usually treated as an approximation to be apologized for: no physical system is closed. Every system exchanges energy, entropy and information with what surrounds it, and the closed system of the textbooks is an idealization that holds only when the exchange is slow enough to ignore.

GG-A5-GDOS's move is to stop apologizing. If openness is the generic case, then the correct object is not the closed Hamiltonian but the open boundary, and the correct dynamics is not conservation but *descent*: an open system settles where its free energy is least, given what it is coupled to. That is the GDOS program — Geometric Dynamics of Open Systems — and it supplies eleven theorems, T1–T11, of which three matter directly here.

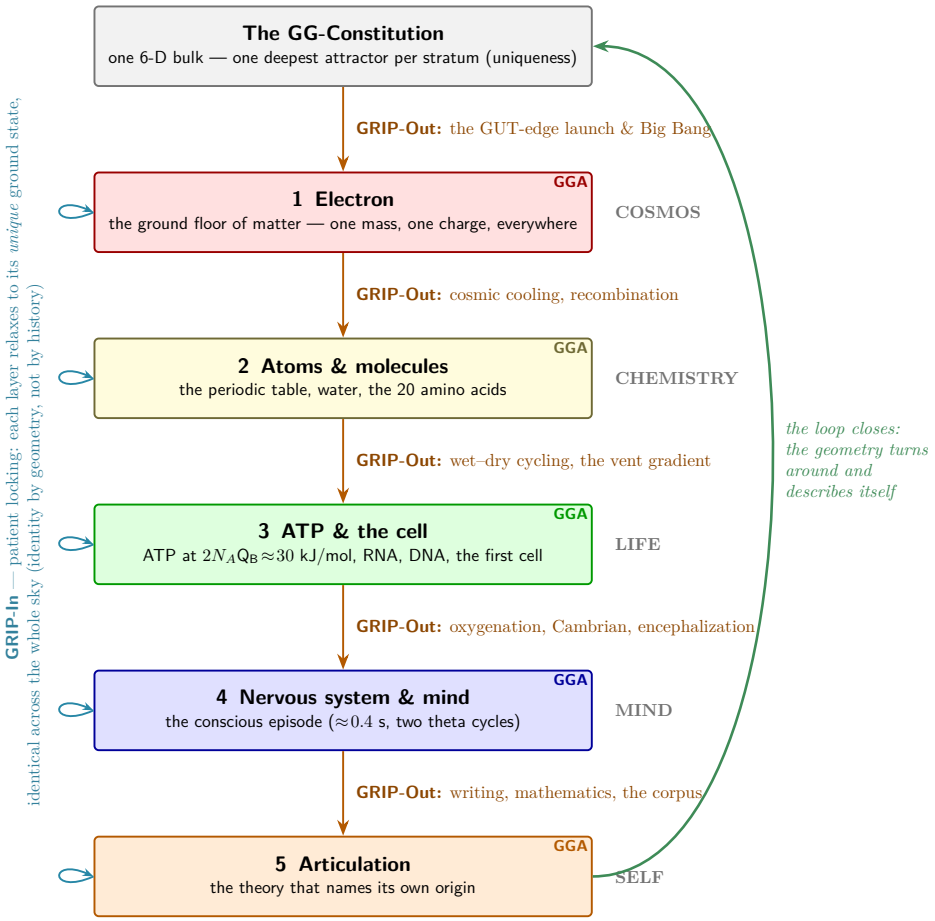


Figure 8: The Cascade of GRIP-Out with GGA — the central concept of this paper, in five representative floors. The eighteen-layer cascade of Figure 10, compressed to five floors resting on the GG-Constitution: the electron; atoms and molecules; ATP and the cell; the nervous system and mind; and the act of articulation. At each floor GRIP-In (cyan) relaxes the layer to its unique deepest basin — the Ground Geometric Attractor, whose readout is identical everywhere it occurs — and the settled ground state then *becomes* the GRIP-Out shock (orange) that reorganizes the next landscape and opens the floor above. The color bands match Figure 10. The first lock, the electron across the whole sky, is the second horizon problem of GG-A10-Cosmos (§22.1); the last, articulation, closes the loop onto the constitution (Part XV). Previewed as the front-matter showcase, Figure 2.

13.2 The three that matter here

T5: the descent, and the second law. GG-A5-GDOS's Lyapunov lemma sits under T5, and GG-A5-GDOS names it the constitutional source of the second law: along admissible trajectories the boundary free energy is non-increasing. This is the statement Step 3 of this Part uses at every layer, and it is what makes the cascade a descent rather than a wandering.

T7.1–T7.7: the quantum postulates as theorems. On the OGGEP projection, the postulates of quantum mechanics are derived rather than assumed. GG-A8-QM (Arisaka, 2026, A8-QM) lifts these into a full 4D operational reformulation; what this Part needs is only that the boundary on which the cascade runs is a quantum boundary by theorem and not by stipulation.

T9.2 and T5 again: the two blocks of the functional. The Geometric Free-Energy Functional $F_{\mathsf{GFF}} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}}$ is GG-A6-GRIP's object, not GG-A5-GDOS's. What GG-A5-GDOS contributes is the identification of its two blocks with GG-A5-GDOS's own T9.2 and T5 — so the functional the cascade descends is GG-A6-GRIP's in form and GG-A5-GDOS's in content. The SeOS class, likewise, is GG-A7-Qi4's. This paper stated the custody wrongly in earlier versions and states it correctly here and in §7.6.

13.3 The scope limit, stated where the descent begins

GG-A5-GDOS's Lyapunov lemma carries a caveat, and this is the right place for it rather than a footnote after a hundred pages of descent.

> When circulation is present, the functional is no longer strictly monotone. Total entropy production remains non-negative — the second law is not at risk — but the system need not settle to a static minimum. It can instead settle into a *non-equilibrium steady state*: a configuration held open by a through-flow, stable in form while matter and energy pass through it.

That caveat is load-bearing in this paper, and not decoratively so. Every layer of the cascade above the atomic rungs — a cell, an organism, a nervous system, a conscious episode — is exactly a non-equilibrium steady state. None of them is a static minimum of anything. So when this Part says the cascade "settles," the settling meant from layer 7 upward is the steady-state kind, and the reader should carry that distinction from here on. The framework does not weaken by saying so: a theory of life that required living things to sit at static minima would be refuted by the first cell it met.

13.4 The traffic runs both ways

It is worth recording that this is not a one-directional inheritance. GG-A5-GDOS consumes this paper's regime theorems at its own projection-rate section and inside its T10 bridge lemma. The boundary law and the cascade that runs on it were developed against each other, and a reader

auditing either should know that the two papers cite one another rather than forming a chain with a single direction.

14 Step 1 — The starting point: SSB → Attractor (the Higgs mechanism)

Plain-English opening. Twentieth-century fundamental physics inherited from condensed-matter theory and from the electroweak unification program a single structural picture for how a symmetric system reaches a definite physical state: *spontaneous symmetry breaking*. A potential $V(\phi)$ that was symmetric under some group G acquires, by cooling or by some other change of control parameter, a new structure in which the symmetric configuration becomes unstable and a family of broken configurations becomes the new stable manifold. The system, sitting at the symmetric configuration, finds itself at a saddle point of the new potential; it rolls off the saddle and settles into one of the broken configurations, breaking the symmetry from G down to a smaller subgroup H. The broken configuration is an *attractor* of the new effective potential: the place where the gradient flow ends. We call this picture SSB → Attractor, with the arrow representing the dynamics of descent from the symmetric saddle to the broken minimum.

The Higgs mechanism as paradigm. The Higgs mechanism is the textbook realization of SSB → Attractor in fundamental physics. In the early universe at temperature T well above the electroweak scale $T_c \approx 159$ GeV, the Higgs field ϕ has effective potential $V_{\text{eff}}(\phi; T)$ with a single minimum at $\phi = 0$; the gauge group $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ is unbroken. As the universe cools through T_c, V_{eff} acquires the Mexican-hat topology familiar from undergraduate field-theory textbooks: the origin $\phi = 0$ becomes a local maximum, and a one-parameter family of minima appears at $|\phi| = v/\sqrt{2} \approx 174$ GeV. The Higgs field rolls off the origin and settles into one of the broken minima; the gauge group breaks to $\mathrm{SU}(3)_c \times \mathrm{U}(1)_{\text{EM}}$; the W and Z acquire mass through the Higgs coupling; the broken vacuum is the attractor of the post-cooling effective potential. Every undergraduate course in the Standard Model presents the Higgs mechanism in essentially this form, and the picture is correct as far as it goes.

Three more textbook examples. The same SSB → Attractor logic underlies the three other paradigmatic broken-symmetry phenomena of twentieth-century physics. *First*, the ferromagnetic phase transition: above the Curie temperature, a ferromagnet's magnetization $\mathbf{M}$ is zero (rotational symmetry intact); below T_C, $|\mathbf{M}| > 0$ in a spontaneously selected direction (rotational symmetry broken to the residual SO(2) subgroup around the magnetization axis). *Second*, the superconducting transition: above T_c, charge symmetry $\mathrm{U}(1)_Q$ is unbroken; below, the BCS condensate breaks $\mathrm{U}(1)_Q$ and a definite phase is selected. *Third*, chiral symmetry breaking in QCD: at high temperature the chiral $\mathrm{SU}(N_f)_L \times \mathrm{SU}(N_f)_R$ is unbroken; at low temperature the quark condensate breaks it to the diagonal $\mathrm{SU}(N_f)_V$, generating pions as the Goldstone bosons of the broken axial $\mathrm{SU}(N_f)_A$. All three are textbook SSB → Attractor: a symmetric configuration becomes unstable as a control parameter varies; the system rolls into a broken minimum which is the attractor of the new potential.

Why this picture is the right starting point but not the complete story. The SSB → Attractor picture has three structural virtues and three structural limitations. The virtues are: (i) it is the well-established result of half a century of theoretical and experimental work, anchoring the rest of the discussion in textbook physics; (ii) it identifies the attractor (the post-SSB configuration) as a definite, calculable structural feature, not a metaphysical assertion; and (iii) it makes contact with the broader *dissipative structure* tradition (Prigogine, Friston, Schnakenberg, Seifert) (Seifert, 2012), which sees stable far-from-equilibrium states as Lyapunov-descended attractors of an open-system dynamics. The limitations, which the subsequent Steps of the present Part address, are: (i) the picture is given in terms of a closed-system effective potential $V_{\text{eff}}(\phi; T)$, not in terms of an open-system Lyapunov functional with explicit port structure; (ii) the picture identifies an attractor but does not select among multiple stable attractors when more than one is admissible; and (iii) the picture handles one symmetry-breaking transition at a time, without a hierarchical structure that would let one transition feed into the next. Step 2 will geometricize the picture (Limitation i); Step 3 will refine "attractor" to "ground state" (Limitation ii); Step 4 will hierarchize (Limitation iii) and supply the alternation that makes the cascade ascend.

Plain-English close. Step 1 is the picture every working physicist already knows: a symmetric system has a control parameter; the parameter changes; the symmetric configuration becomes unstable; the system rolls to a broken minimum that is the attractor of the new potential. The Higgs mechanism, ferromagnetism, superconductivity, and chiral symmetry breaking are the canonical examples. The remainder of this Part is the structural refinement of this single picture across three additional steps, ending with a mechanism rich enough to drive the eighteen-layer cascade of cosmos, life, and mind.

15 Step 2 — The geometric view: GRIP := DGI → (GFF) → GSSB → GA

Plain-English opening. The SSB → Attractor picture of Step 1 is a closed-system picture: the effective potential is a function on a finite-dimensional field manifold, the dynamics is gradient descent on that potential, and there is no built-in notion of openness or of port-structured exchange with an environment. Step 2 lifts this picture into the geometric framework of GG-Theory by replacing each of the three structural ingredients of SSB → Attractor with its open-system, gauge-runtime counterpart. The result is a pipeline GRIP (Gauge-Runtime Invariance Pipeline) that operates on the six-dimensional bulk and terminates not at a single attractor but at a layer-specific Morse landscape with potentially multiple stable basins.

The four ingredients of the geometric view. The pipeline has four components, each generalizing a counterpart in Step 1.

DGI (Dynamical Gauge Invariance, parent context). The DGI replaces the symmetric configuration of Step 1. Where the Higgs mechanism started with a single field ϕ symmetric under $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$, the DGI starts with the full unbroken-symmetry parent on the six-dimensional

bulk: $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi} \times$ Gravity, with the gauge group jointly forced by the BI-6 anomaly closure of GG-A3-BI6 (Arisaka, 2026, A3-BI6) and the OGN-5 integer ledger of GG-A2-GG6 (Arisaka, 2026, A2-GG6). The DGI is the geometric data on which the cascade runtime operates.

(F_{GFF}) **(Geometric Free-Energy Functional, the Lyapunov landscape).** The Geometric Free-Energy Functional of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2 replaces the closed-system effective potential of Step 1. F_{GFF} is a Lyapunov functional on the open-system runtime: $dF_{\mathsf{GFF}}/dt \leq 0$ along all admissible trajectories, with equality only at stationary points. Unlike a closed-system effective potential, F_{GFF} explicitly incorporates the boundary-port exchange of energy, matter, and information that an open system requires (per the OGGEP axiom AX-3); the descent on F_{GFF} is the open-system analog of the textbook Lagrangian descent on V_{eff}. This is the structural ingredient that makes GG-Theory's picture richer than the closed-system Higgs picture.

GSSB (Geometric Spontaneous Symmetry Breaking, the chain of saddle events). GSSB of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-2–T3 replaces the single saddle-and-rolloff event of Step 1. In the geometric view, the descent through F_{GFF} is not a single drop from the symmetric saddle to a single broken minimum; it is a *chain* of Bogomolnyi-saturating saddle events, each with on-shell action $S_{\text{saddle}} = \pi$, each corresponding to a non-trivial homotopy class on the gauge orbit (GG-A6-GRIP T-GRIP-4). Each saddle event in the GSSB chain breaks a part of the parent symmetry; the chain proceeds until the descent reaches a local minimum of F_{GFF}.

GA (Geometric Attractor, any stable Morse minimum). GA replaces the single attractor of Step 1. A Geometric Attractor is *any* stable Morse minimum of F_{GFF} on the layer-specific stratum. In general, the Morse landscape on a given stratum admits multiple GAs (multiple stable basins); the GRIP pipeline as stated in Step 2 terminates at *some* GA but does not yet specify which. Step 3 will supply the further refinement that selects the unique cascade output from among the GAs.

The GRIP pipeline in one line. The four ingredients chain together as

$$\boxed{\mathsf{GRIP} \;:=\; \mathsf{DGI} \;\longrightarrow\; (\,F_{\mathsf{GFF}}\,) \;\longrightarrow\; \mathsf{GSSB} \;\longrightarrow\; \mathsf{GA}} \tag{10}$$

This is the structural content of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5: GRIP is the universal cascade pipeline that operates on any layer-specific substrate (specified by a System Instance Packet SIP of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) §6), descends through the layer-specific F_{GFF} via the GSSB saddle chain, and terminates at a stable GA of F_{GFF} on the layer-specific stratum. GRIP as stated in (10) is the geometric generalization of SSB $\rightarrow$ Attractor; it is the form of the cascade machinery delivered by the GG-Theory corpus up through GG-A7-Qi4.

Why GRIP $\rightarrow$ GA is necessary but not sufficient. The geometric view of Step 2 is structurally richer than the closed-system SSB picture of Step 1: it works on an open-system Lyapunov landscape,

it handles a chain of saddle events rather than a single drop, and it makes contact with the full GG-Theory apparatus. But GRIP → GA alone does not specify the unique cascade output at each layer. If a layer's Morse landscape has three stable basins, then (10) says the system reaches some GA — but it does not say which. The universal-identity insight that "every electron is the same electron" would not be derivable from (10) alone: every electron *would* be a charged-lepton GA of GG-Theory's layer-2 Morse landscape, but the layer-2 landscape might admit other GAs besides the charged lepton, and (10) would not single out the electron. Step 3 provides the further refinement that does the singling-out.

Plain-English close. Step 2 has lifted the textbook SSB → Attractor picture into the geometric framework of GG-Theory. The new ingredients are: DGI (the full unbroken-symmetry parent on the 6D bulk), F_{GFF} (the Lyapunov functional on the open-system runtime), GSSB (the chain of Bogomolnyi-saturating saddle events), and GA (any stable Morse minimum on the layer-specific stratum). The pipeline DGI → (F_{GFF}) → GSSB → GA is the form of the cascade engine delivered by the GG-Theory corpus up through GG-A7-Qi4, and it is structurally richer than the closed-system SSB picture in three ways. But it is not yet uniqueness-selecting: a Morse landscape with multiple stable basins yields multiple GAs, and (10) does not pick one. Step 3 supplies the selection.

16 Step 3 — T-GGA-as-Ground-State: GGA is the unique deepest basin of GFF, the ground state of GA

Plain-English opening: any stable basin vs the deepest one. The Morse landscape of the Geometric Free-Energy Functional F_{GFF} on a layer-specific stratum may have many stable minima — multiple basins in which a system could plausibly settle. Each of these is a *Geometric Attractor* (GA): any stable Morse minimum of F_{GFF} on the stratum. But the cascade output — the layer's GGA — is not any GA; it is the unique *global* minimum, the deepest basin among all stable basins on the stratum. This is the formal distinction that makes the cascade output unique at each layer, and the present section promotes the distinction from a definitional convention (recorded in the Program Dictionary) to a named theorem.

Why the distinction matters. Without the ground-state qualifier, the cascade machinery would admit *multiple* stable outputs at each layer. A Morse landscape with three stable basins has three GAs; nothing in the GRIP-on-SIP-with-Qi-4 machinery, taken alone, would single out one of them as the cascade output. On a *single* stratum the difficulty is already resolved upstream, and it is worth being exact about where: GG-A6-GRIP (Arisaka, 2026, A6-GRIP) proves a per-stratum ground-state corollary, which shows that on any stratum of the class that paper calls admissible the free-energy functional has exactly one critical point of index zero, so the descent has one place to halt. GG-A9-SM deploys that result at the particle-physics layer (every electron is the same electron because the geometry permits exactly one charged-lepton GGA) and GG-A10-Cosmos at the cosmological layer (the inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ read off the ground basin of the cosmological stratum).

What the present paper adds is the statement those single-stratum results do not make. The cascade of this paper constructs a *sequence* of strata, each opened by a GRIP-Out event acting on the settled output of the one below, and the question of whether the ground-state property survives that construction — at every layer, on strata this paper builds rather than inherits — is not answered by any upstream theorem. T-GGA-as-Ground-State is that answer: the cascade-wide generalization.

Constitutional inputs. T-GGA-as-Ground-State invokes AX-4 (MSMF, Maximum-Symmetry Minimum-Freedom: the constitution does not admit two structurally distinct stable outputs at the same layer when one suffices) and POS-6 OGN (BI-6 anomaly closure). It does *not* invoke the Qi-4 pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) as a selector, and the distinction matters enough to state plainly: the ground attractor is fixed by the landscape, and the four pillars *characterize* the configuration the descent halts at rather than picking it out from among candidates. That is GG-A7-Qi4's characterization theorem, and it is used here only where a pillar property is quoted, never to establish existence or uniqueness.

Upstream theorems. The mathematical heart is GG-A6-GRIP's per-stratum ground-state corollary (Arisaka, 2026, A6-GRIP), which establishes — on any stratum of that paper's admissible class — that F_{GFF} restricted to the stratum has exactly one critical point of index zero, that it is therefore the global minimum, and that the confined descent reaches it from generic initial data. The present theorem takes that single-stratum result as its input and asks whether it survives layer by layer along the cascade this paper constructs. Two things must be checked at each step, and neither is upstream: that the stratum the GRIP-Out event opens is one on which the corollary applies, and that the settled output of the layer below is an admissible initial datum for the layer above.

Theorem 16.1 (T-GGA-as-Ground-State: GGA is the unique global minimum of GFF (T-Origin-12.1))**.** *Let $\mathcal{S}_n$ be the layer-n stratum and $F^{(n)}_{\mathsf{GFF}}(x;p)$ the Geometric Free-Energy Functional on $\mathcal{S}_n$ with control parameters p held at their layer-n values. Let $\{\mathsf{GA}^{(1)}_n, \mathsf{GA}^{(2)}_n, \ldots\}$ denote the set of stable Morse minima of $F^{(n)}_{\mathsf{GFF}}$ on $\mathcal{S}_n$ (each a* Geometric Attractor*). Suppose that at every layer of the cascade the stratum $\mathcal{S}_n$ lies in the admissible class of GG-A6-GRIP and that the settled output of layer $n-1$ is a generic initial datum for the descent on $\mathcal{S}_n$. Then at every layer the set $\{\mathsf{GA}^{(i)}_n\}$ has exactly one element GA^{*}_n of index zero, and it is the global minimum:*

$$\boxed{\mathsf{GGA}_n \;:=\; \mathsf{GA}^{*}_n \;=\; \arg\min_{x\in\mathcal{S}_n} F^{(n)}_{\mathsf{GFF}}(x;p)} \tag{11}$$

We call GGA_n the Ground Geometric Attractor *of layer n. It is the unique deepest basin of $F^{(n)}_{\mathsf{GFF}}$ on $\mathcal{S}_n$, and it is the cascade output at layer n.*

The content of the theorem is the quantifier "at every layer". On any one *admissible stratum the conclusion is GG-A6-GRIP's corollary; what is asserted here is that the cascade construction of this paper preserves admissibility and genericity as it climbs, so that the corollary applies at each of the eighteen layers rather than at the first alone.*

Proof outline. *Step 1 (the single-layer statement, imported).* Fix a layer n and suppose $\mathcal{S}_n$ is admissible in GG-A6-GRIP's sense — compact, connected, Kähler, with the landscape a moment-map component of a torus action with isolated critical points. By that paper's per-stratum ground-state corollary, which is Frankel's theorem with Atiyah's extension on such a stratum, $F^{(n)}_{\mathsf{GFF}}$ restricted to $\mathcal{S}_n$ has every critical point of even index, exactly one of index zero, the global minimum; and the confined descent converges to it from every initial datum outside a set of zero measure. Nothing beyond GG-A6-GRIP is used, and in particular no admissibility filter: the conclusion is a consequence of the Morse structure of the stratum alone. Off admissible strata GG-A6-GRIP registers the uniqueness as open — the Wilson-line stratum first, where a periodic potential may carry two floors — and this theorem inherits that fence at every layer whose stratum is not admissible.

Step 2 (the induction along the cascade). The cascade of this paper builds $\mathcal{S}_{n+1}$ by a GRIP-Out event acting on the settled configuration GGA_n. Two conditions must hold for Step 1 to be applicable again at layer $n+1$: the newly opened stratum must lie in the admissible class, and GGA_n must be carried by the reorganization to a generic initial datum for the descent on $\mathcal{S}_{n+1}$. Both are hypotheses of the theorem, not consequences of it. They are checked layer by layer in the master cascade codebook (§41), at the grade recorded there for each layer, and they are the substance of what the cascade-wide statement asserts beyond its single-layer input.

Step 3 (what the four pillars do, and do not do). The four Qi-4 conditions of GG-A7-Qi4 are properties the ground attractor carries — locked currents, variational stationarity, scale coherence, architectural halting — and GG-A7-Qi4's characterization theorem establishes that they hold at GGA_n. They are not used here to *find* GGA_n: Step 1 has already produced it. The converse question — whether the four conditions could by themselves single out the ground attractor, so that a pillar-based route would be an independent second warrant — is open in GG-A7-Qi4 and is carried in the present paper as hypothesis (Q4) of §49, attached to the characterization and not to the existence claim. It is worth noting why the property is taken from GG-A6-GRIP and not from a deployment paper: the deployment papers apply the ground-state property, they do not establish it, so a proof that reached for one of them would be reaching for its own conclusion. GG-A6-GRIP proves it, and that is where the present theorem takes it from.

Step 4. Therefore, under the layer-wise hypotheses of Step 2, GGA_n is uniquely defined by (11) at every layer of the cascade, and the cascade output is unique at each. ∎

Quantitative anchor. The cleanest illustration is the periodic table at layer 3. The stratum $\mathcal{S}_3$ is the configuration space of bound electronic states around nuclei at the Rydberg scale $E_{\mathrm{Ry}} = 13.6$ eV; the Morse landscape $F^{(3)}_{\mathsf{GFF}}$ has many local minima (excited atomic configurations) and exactly one global minimum (the ground-state electron configuration that fills shells in increasing energy order from $1s^2$ upward). Any excited atomic configuration (e.g., $1s^1 2s^1$ for helium) is a GA — a stable Morse minimum — but only the ground state $1s^2$ is the GGA. The cascade selects the ground state because (i) it satisfies the four Qi-4 pillars (locked-current bookkeeping at the atomic stratum; variational stationarity of the Schrödinger ground state; conformal scaling that produces the Rydberg series; holographic memory at the nuclear-charge stratum), and (ii) it is the global minimum. Every hydrogen atom is the same hydrogen atom because the GGA-as-ground-state

theorem singles out one configuration as the cascade output.

Physics intuition. Indeed, at first-year-graduate-student level, the GA/GGA distinction is the same distinction that separates a metastable phase from a stable phase in condensed-matter physics. Diamond is a stable phase of carbon at room temperature and pressure; so is graphite. Both are GAs — stable Morse minima of the free-energy landscape of carbon configurations. But only graphite is the GGA at standard conditions: it is the deepest basin, the global minimum. Diamond is metastable; it would, given infinite time, convert to graphite. The cascade's machinery says that at every layer, the deepest basin is forced to be the cascade output; metastable basins exist (they are the failed cascades, the false starts), but they are not what the universe ends up at. The framework's claim is that this same selection mechanism operates at every layer, from the gauge structure of the Standard Model to the conscious episode at ~ 400 ms (two theta cycles). Everywhere a stable basin exists, the deepest one wins.

Daily-life metaphor. A river system. Water poured anywhere in the watershed eventually flows to the lowest point of the basin — the river mouth at the sea. Local pools, ponds, lakes are stable resting places for water (each is a GA) but, given enough time and rainfall, water in each will eventually reach the sea (the GGA). The cascade is more rigorous than a river system in that the cascade's selection is enforced by the Qi-4 admissibility filter, not by weathering and erosion: the deeper basin is reached not by chance but by the four-pillar admissibility constraint. Yet the picture is right: there are many places water could pause, but only one place is the destination.

Kill criterion. T-GGA-as-Ground-State would be falsified by the discovery of any cascade layer at which the empirically realized structure is not the global minimum of $F_{\mathsf{GFF}}^{(n)}$ on the layer-n stratum — that is, by the discovery of a layer whose cascade output is a metastable basin rather than the deepest one. Such a discovery would bear on the theorem in one of two ways, and it is worth separating them: either the layer's stratum is not in GG-A6-GRIP's admissible class, in which case the hypothesis of Step 2 fails at that layer and the cascade-wide statement is narrowed rather than refuted; or the stratum is admissible and the realized structure is still not its global minimum, which would contradict GG-A6-GRIP's corollary directly and would be the more serious finding. Across the eighteen layers cataloged in this paper, every layer's empirically realized GGA is, to current measurement precision, the global minimum of its $F_{\mathsf{GFF}}^{(n)}$.

Plain-English close. The cascade output at each layer is not just any stable structure; it is the deepest stable structure on the layer-specific landscape. This is what makes "every electron is the same electron" and "every hydrogen atom is the same hydrogen atom" and "every ATP molecule has the same ΔG" true: the cascade does not just settle into *some* attractor; it settles into the *ground state* of the attractor manifold. T-GGA-as-Ground-State is the formal statement of this fact, applicable at every cascade layer. Combined with the alternation of GRIP-In and GRIP-Out from the preceding sections, it gives the cascade its full dynamical specification: GRIP-Out opens the basin; GRIP-In descends; T-GGA-as-Ground-State guarantees the descent terminates at the unique deepest point.

17 Step 3 (continued) — T-GRIP-In-Lyapunov-Descent: the within-layer dynamics that reaches GGA

Marble in a bowl: the visual picture. Let us imagine a marble in a bowl. Pour a little energy in (perhaps shake the bowl gently) and the marble jiggles around but settles back to the bowl's bottom; the bowl's shape determines where the marble can go, and the marble's resting place is the bowl's lowest point. This is the textbook picture of equilibrium-within-flow: the system descends to the bottom of its current basin under gradient flow on a fixed landscape, supported by sustained but balanced exchange of energy across its boundary ports. In the geometric language of Step 2 and Step 3, this is what happens within a single cascade layer: the GRIP machine of GG-A6-GRIP T-GRIP-1–T-GRIP-5 settles the system into that layer's unique GGA (Step 3's T-GGA-as-Ground-State) by gradient descent on the fixed F_{GFF} landscape. This regime is GRIP-In (equilibrium-within-flow) — defined at runtime level in the parent paper GG-A6-GRIP (def:GRIPin); the present paper proves its descent property formally now.

Plain-English opening. The within-layer regime is the regime of patient, gradual settlement. The system is open — energy flows in, entropy flows out, the boundary ports of the SIP stay populated — but the underlying geometric structure does not change. The Morse landscape of F_{GFF} has fixed control parameters; the marble of cascade state can roll around but cannot tunnel through the walls. Over time, the system descends to the unique deepest basin on the current stratum, which is the layer-specific GGA. This is the regime described by Friston's variational free-energy descent, by Jaynes's maximum-entropy steady state, by Prigogine's dissipative-structure dynamics — but it is the regime that none of those predecessors recognized as half of a two-regime architecture.

Constitutional inputs. The within-layer regime invokes AX-3 (OGGEP, sustained energy exchange across boundary ports), GG-A7-Qi4 T-QUA (boundary-port closure, the operational condition that the ports stay open at constant flux), and GG-A7-Qi4 T-EP (Markov-blanket admissibility, the condition that internal states can be statistically separated from external states). Together these say: the system has a well-defined boundary across which energy and matter flow at sustained constant rate, and across which the dynamics can be coarse-grained into a Markov-blanket factorization. No constitutional clause requires the rate to be constant; GRIP-In is the specialization in which it is.

Upstream theorems. The mathematical heart is the Lyapunov property of the descent, and it holds at a level that depends on the layer. GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2 is the free-energy form: under detailed balance with respect to a Gibbs state, $dF_{\mathsf{GFF}}/dt \leq 0$ with equality only at the critical points, the textbook H-theorem in the open-system extension of GG-Theory. A driven layer, in which detailed balance is violated, has the weaker and more general form: the relative entropy to the layer's stationary state descends, by the Lindblad–Spohn theorem (Lindblad, 1975; Spohn, 1978), and that is the landscape the theorem above descends. That some function descends along every orbit on a compact stratum is Conley's theorem and owes nothing to the geometry; that the function has one floor on an admissible stratum is Frankel–Atiyah; that on the

family stratum it is the boundary dilatation charge is GG-A6-GRIP's own identification. Each level is invoked where it applies, and it is what guarantees that within-layer dynamics is regime-distinct from the perturbed regime. The complementary input is GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5, which establishes that the GRIP pipeline DGI → GSSB → GGA is the unique factorization of gauge runtime descent; in the GRIP-In regime, this factorization is invoked at fixed parent gauge group G_{parent} and fixed broken subgroup G_{broken} throughout the descent.

Theorem 17.1 (T-GRIP-In-Lyapunov-Descent: the equilibrium-within-flow regime (T-Origin-13.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(n)}$ *be the canonical System Instance Packet of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) §6 specialized to cascade layer* n*. Let the control parameters* p *of the Geometric Free-Energy Functional* $F_{\mathsf{GFF}}(x;p)$ *be held fixed, with sustained energy injection across the boundary ports at constant effective temperature* $T_{\text{eff}} = \text{const}$*. Suppose three things: that the driven layer has a stationary state* ρ_{ss} *under the boundary dynamics of GG-A5-GDOS; that the landscape* $F_{\mathsf{GFF}}(\cdot;p)$ *on* $\mathcal{S}_n$ *is, up to the temperature, the relative entropy of the layer's state to* ρ_{ss}*; and that* $\mathcal{S}_n$ *is admissible in GG-A6-GRIP's sense. Then under the runtime dynamics of GG-A6-GRIP T-GRIP-1–T-GRIP-5, the system state* $x(t)$ *satisfies the Lyapunov inequality*

$$\boxed{\frac{dF_{\mathsf{GFF}}}{dt}(x(t);p) \;\le\; 0} \tag{12}$$

along all admissible trajectories, with equality if and only if $x(t) = \mathsf{GGA}_n$*, the unique stable layer-*n *Ground Geometric Attractor. Additionally, the system does not cross to any other cascade layer:* $x(t) \in \mathcal{S}_n$ *for all* t*, where* $\mathcal{S}_n$ *is the layer-*n *stratum.*

Proof outline. *Step 1.* The layer is driven, and the theorem says so below: detailed balance is violated and net currents flow. GG-A6-GRIP T3.2, whose hypothesis is detailed balance with respect to a Gibbs state, therefore does not apply here, and an earlier statement of this step invoked it. What applies is one level down in GG-A6-GRIP's hierarchy of Lyapunov functions: for any completely positive boundary dynamics with a stationary state ρ_{ss}, the relative entropy $S(\rho(t) \,\|\, \rho_{\text{ss}})$ is non-increasing along the evolution — Lindblad's monotonicity read against a fixed point, Spohn's theorem (Lindblad, 1975; Spohn, 1978), the density-operator statement whose Fokker–Planck shadow is GG-A5-GDOS's Lyapunov lemma (Arisaka, 2026, A5-GDOS). By the second hypothesis that relative entropy *is* the landscape, so $dF_{\mathsf{GFF}}/dt \le 0$ along every admissible trajectory. In plain language: a driven layer descends, but what it descends is its distance to its own steady state, not a free energy of the physical Hamiltonian; the free-energy reading, T3.2, is the equilibrium layers' case. *Step 2.* By GG-A6-GRIP T-GRIP-3 together with T-GGA-as-Ground-State (Theorem 16.1) — the first supplying existence, the second uniqueness on an admissible stratum, by the third hypothesis — the unique stable minimum of $F_{\mathsf{GFF}}(\cdot;p)$ on the layer-n stratum is GGA_n, the layer-n Ground Geometric Attractor. In plain language, the cascade engine of GG-A6-GRIP guarantees a single deepest basin on each stratum; that basin's bottom is the layer's GGA. *Step 3.* Equality in (12) occurs exactly at stationary points of F_{GFF}; by the GFF Morse structure (one minimum per stratum), the only stable equality point is GGA_n itself. *Step 4.* Because p is held fixed, the gauge orbit $\mathsf{DGI}(p)$ is fixed, and the stratum is invariant under its own descent: GG-A6-GRIP's confinement clause (its **GRIP-ST2**)

is that the gradient flow of the landscape on a stratum stays on the stratum, so configurations on strata other than $\mathcal{S}_n$ are not reached by the flow. Hence no inter-stratum trajectory is admissible. (The Qi-4 pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) characterize the configuration reached; they are not what confines the flow.) *Step 5.* Combining: the system descends within $\mathcal{S}_n$ to GGA_n and stays there indefinitely, supported by the sustained energy injection. This is precisely the GRIP-In regime. ■

Quantitative anchor. The textbook example is the mitochondrial chemiosmotic gradient maintained at $T \approx 310$ K with continuous substrate oxidation feeding electron transport. F_{GFF} descends as ATP is synthesized; equilibrium reaches the steady state $J_{\text{in}} = J_{\text{out}}$ where ATP is produced at the rate it is consumed, with $\Delta G_{\text{ATP}} = 2N_A \mathsf{Q}_{\mathsf{B}} \approx 30.0$ kJ/mol per phosphate bond (Layer 7 GGA). No spontaneous transition to a different metabolic stratum occurs at constant T and constant substrate flux; the mitochondrion remains a Layer-7 chemiosmotic engine for the lifetime of the cell.

Physics intuition. At first-year-graduate-student level, the within-layer regime is the open-system extension of the canonical statistical-mechanical equilibrium picture. In closed thermodynamic equilibrium, $dS/dt = 0$ and the system sits at maximum entropy. In sustained open-system steady state, $dF_{\mathsf{GFF}}/dt = 0$ at the attractor, but entropy production is balanced by entropy export through the boundary ports. The system is far from closed-system equilibrium (detailed balance is violated; net currents flow) but it is at *open-system fixed point*: a non-equilibrium stationary state. This is the regime studied by Prigogine, Friston, Schnakenberg, Seifert — and it is what GRIP-In formalizes within the GRIP machinery.

Daily-life metaphor. Coffee in a thermal mug on a warming plate. Heat flows in (from the plate); heat flows out (radiation, conduction); the coffee temperature reaches a steady non-equilibrium state, perhaps 60°C. The coffee remains coffee — no spontaneous transition to becoming tea, no matter how long you wait at constant power input. Each layer of the cascade is its own kind of coffee on its own warming plate; the within-layer regime is the steady warm cup. To transform the coffee into something else (espresso, latte, evaporation residue) requires an outside intervention — which is the next theorem's subject.

Kill criterion. T-GRIP-In would be falsified by observation of a stable layer-to-layer cascade transition at strict thermodynamic stationarity — that is, a system that crosses from one cascade stratum to another while T_{eff}, boundary-port fluxes, and the GFF control parameters all remain provably constant in time. Such an observation would imply that the layer barrier between stratum $\mathcal{S}_n$ and $\mathcal{S}_{n+1}$ can be crossed by gradient flow alone, contradicting the gauge-distinctness clause of POS-6 OGN BI-6 and the cascade-layer-uniqueness theorem of GG-A11-Origin §55.7. No such observation is known.

Plain-English close. GRIP-In is the cascade's patient mode. It is powerful: under sustained energy injection at constant temperature, a system can settle into intricate GGA structures (mitochondria, neural networks, ant colonies, jet engines) that look intelligently designed but are simply the

layer-specific minima of F_{GFF} found by gradient descent. But GRIP-In alone is also limited: it cannot escape the layer it is currently in. To advance the cascade, something else is needed — a perturbation, a shock, a discontinuity. That is the subject of the next theorem.

The piecewise anatomy of GRIP-In, and where it halts. One refinement of T-GRIP-In, established across the 2026 revisions of the upstream papers, deserves to be stated here because it sharpens what "descent" physically means. A GRIP-In trajectory is *piecewise*: *within* a basin it is ordinary downhill flow (in a chemist's language, thermal relaxation toward the local minimum — the protein settling into a fold, the marble finding the bowl's bottom); *between* basins of the same fixed landscape it proceeds by *channel-mediated exits* — specific physical processes that carry the system over or through the wall separating one basin from the next. On the particle-matter strata that channel is the weak nuclear interaction: every radioactive decay chain is a GRIP-In descent stepping basin by basin toward the stratum's ground state (GG-A9-SM develops this reading in a dedicated section — it is, in that paper's phrase, why a force that builds nothing exists: it is the road to the ground states). On the cosmological dark sector the channel's place is taken by the expansion of the universe itself — Hubble friction (GG-A10-Cosmos; the companion dark-matter paper). On the chemical and biological strata the exits are thermal and catalyzed barrier crossings. The refinement licenses a corollary that converts the ground-state definition from an energetic statement into a dynamical one:

Corollary 17.2 (T-GGA-No-Exit: corollary to T-GRIP-In-Lyapunov-Descent (T-Origin-13.2))**.** *On a fixed layer-n landscape, a GRIP-In trajectory halts at an attractor if and only if the attractor's set of admissible exit channels is empty; and the unique attractor with an empty exit set is* GGA_n*. Equivalently:* the GGA is where GRIP-In halts — *ground-state-ness, defined energetically in T-GGA-as-Ground-State as the deepest basin, is characterized dynamically as the basin with no way out.*

Proof sketch and fence. One direction is immediate: no admissible channel can carry the system below the global minimum, so the GGA's exit set is empty by the Lyapunov inequality (12). The converse requires a *channel-completeness* premise: that every non-ground basin of the stratum possesses at least one admissible exit channel to a lower basin. On the particle strata this premise is established physics — the weak charged current connects every unstable species to a more stable one (the muon to the electron, each unstable nuclide to its more-bound neighbor), which is why the matter around us is the ground-state catalog and not a frozen accident. On the chemical, biological, and cognitive strata the premise is plausible but is *not* yet audited layer by layer; the corollary is therefore asserted at theorem strength for the particle strata and at conjecture strength above them, and the layer-by-layer audit is registered in the open-questions Part. ■

Why a life scientist should care. The corollary is the license behind a sentence used throughout the biological layers of this paper: "the cascade settles and stays." A folded protein, a stable genome, a mature neural map are not merely low-energy configurations; they are configurations from which the available physical channels lead nowhere lower *under the prevailing boundary conditions.* Change

the conditions — heat the cell, flood the niche with oxygen — and exit channels open that were closed: this is precisely the GRIP-Out regime of the next section, and the two regimes together are the entire dynamical grammar of this paper.

18 Step 4 — T-GRIP-Out-Necessity: the between-layer regime that drives cascade ascent

Marble in a bowl, continued: the second regime. Let us now imagine that the same marble has to end up not at this bowl's bottom but at the bottom of a *different* bowl across the room. No amount of gentle shaking will get it there; the marble is trapped by the wall of its current bowl. To reach the new bowl, something has to lift the marble over the wall — a kick, an earthquake, a deliberate carry. Once it lands in the new bowl, gentle shaking is enough to settle it at the new bottom. Step 4 names this second regime formally. Within a single cascade layer, GRIP-In (Step 3) settles the system into the layer's GGA. Between layers, the cascade requires a *transient out-of-equilibrium perturbation* that reshapes the F_{GFF} landscape itself, opening basins of attraction that did not exist on the prior landscape. This regime is GRIP-Out — defined at runtime level in GG-A6-GRIP (def:GRIPout); the present paper proves its necessity now. (The cosmological paper GG-A10-Cosmos now reads the entire history of the universe in exactly this grammar: the inflationary exit, reheating, the electroweak selection, quark confinement, and recombination are GRIP-Out events; the long epochs between them are GRIP-In; and the chain halts exactly twice, at the dark-matter relic and at the late-time vacuum — the universe we observe today being, in that paper's phrase, the journey almost finished.)

Why the two regimes are jointly constitutional. The two-regime distinction (GRIP-In of Step 3 versus GRIP-Out of Step 4) is not a bookkeeping convenience; it identifies the deepest dynamical fact about why the cascade is able to ascend at all. Under AX-3 (OGGEP, the open-system clause of GG-A1-Constitution (Arisaka, 2026, A1-Constitution)), every cascade layer is permitted sustained energy and matter exchange with its environment — this is what makes GRIP-In possible. Under POS-6 OGN (BI-6 anomaly closure of GG-A1-Constitution) together with the universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section), every cascade layer has a distinct gauge structure separated from the next layer by a topological barrier that cannot be crossed by gradient descent alone — this is what makes GRIP-Out necessary. Cosmic, chemical, biological, and cognitive evolution all proceed by alternation of the two regimes: a GRIP-Out event opens a new basin on the layer-$(n+1)$ stratum; GRIP-In descent then stabilizes the new GGA; the new GGA eventually produces (per the Cascade-Self-Sustenance corollary of §19) the next GRIP-Out event for the layer above. **This alternation is the inevitable origin of cosmos, life, and mind.**

Plain-English opening. The between-layer regime is the regime of catastrophe, in the precise mathematical sense. Something outside the system perturbs the control parameters of the Morse landscape badly enough that the landscape itself reorganizes. Hills become valleys; valleys become

hills; basins merge and split. The system, momentarily homeless, finds itself in a basin that did not exist on the previous landscape. When the perturbation subsides, the landscape settles into a new topology with new basins, and the system inhabits one of them. This is the only way the cascade can advance from one layer to the next, and it is why every major chapter of cosmic, chemical, biological, and cognitive evolution is associated with a specific perturbation event: the Big Bang, supernova nucleosynthesis, the Late Heavy Bombardment, the Great Oxygenation Event, the Cambrian Explosion, Out-of-Africa, the printing press. None of these are accidents; they are the necessary triggers of cascade ascent.

Constitutional inputs. The out-of-equilibrium regime invokes AX-3 (OGGEP, openness to perturbation), POS-6 OGN (BI-6 anomaly closure — which permits gauge transitions through a single tensor multiplet), and POS-7 (cascade admissibility, that the runtime grammar permits transient widening of the DGI orbit). The constitutional reading is that openness is not enough; the system must also be *perturbable* — the control parameters of F_{GFF} must be physically variable, not formally fixed. In all known physical systems this is automatic (temperature, pressure, composition all vary), so GRIP-Out is universally available — which is exactly why the cascade ascends everywhere it has the geometric structure to do so.

Upstream theorems. The mathematical heart is GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-4, the Bogomolnyi-saturating saddle theorem: each cascade saddle event has on-shell action $S_{\text{saddle}} = \pi$ and corresponds to a non-trivial homotopy class on the gauge orbit. In plain language, GG-A6-GRIP T-GRIP-4 says that each layer-to-layer transition is a topologically non-trivial event — not a gentle gradient flow but a discrete instanton-like tunneling through a barrier of definite height. This is precisely the GRIP-Out mechanism stated in pre-regime language. The complementary input is the universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section), which establishes that each cascade layer has a distinct gauge-equivalence class — the layers are not connected by continuous gauge deformation but by discrete instanton transitions. In the regime language we are now introducing, every instanton transition is a GRIP-Out event.

Theorem 18.1 (T-GRIP-Out-Necessity: the out-of-equilibrium shock regime (T-Origin-14.1))**.** *Let* GGA_n *be the layer-n Ground Geometric Attractor and* GGA_{n+1} *the layer-*$(n+1)$ *Ground Geometric Attractor on the layer-*$(n+1)$ *stratum* $\mathcal{S}_{n+1}$*. Then the cascade transition* $\mathsf{GGA}_n \to \mathsf{GGA}_{n+1}$ *requires at least one* GRIP-Out *event: there must exist a time interval* $[t_1, t_2]$ *during which the control parameters* $p(t)$ *of* $F_{\mathsf{GFF}}(x; p)$ *vary by an amount* Δp *sufficient to satisfy three conditions simultaneously:*

1. *the DGI orbit widens to include configurations on* $\mathcal{S}_{n+1}$*;*
2. *the* GGA_n *basin is transiently destabilized (its Morse index changes from* 0 *to a positive integer);*
3. *the GSSB cascade engine of GG-A6-GRIP T-GRIP-4 finds at least one new stable basin on* $\mathcal{S}_{n+1}$*.*

Pure GRIP-In dynamics (with p held fixed) cannot accomplish any of these three: the gauge orbit is fixed; the GGA_n *basin is the unique stable minimum on* $\mathcal{S}_n$*; and the Lyapunov property forbids*

inter-stratum trajectories. Equivalently, the cascade would terminate at GGA_n *if no GRIP-Out event ever occurred.*

Proof outline. *Step 1.* Show that with fixed p, the Morse landscape $F_{\mathsf{GFF}}(\cdot; p)$ admits a unique stable minimum GGA_n on $\mathcal{S}_n$ (GG-A6-GRIP T-GRIP-3 for existence; Theorem 16.1 for uniqueness). *Step 2.* Show that $\mathcal{S}_n$ and $\mathcal{S}_{n+1}$ are gauge-distinct strata (immediate from the universal-identity insight of GG-A9-SM Part XI (the universal-identity section): every layer-n GGA is gauge-equivalent to every other, but no layer-n GGA is gauge-equivalent to any layer-$(n+1)$ GGA). *Step 3.* By GG-A6-GRIP T3.2 (Lyapunov property at fixed p), no admissible trajectory crosses the boundary between $\mathcal{S}_n$ and $\mathcal{S}_{n+1}$; in plain language, gradient descent on a fixed landscape cannot tunnel through the barrier separating two strata. *Step 4.* Therefore, the transition $\mathsf{GGA}_n \to \mathsf{GGA}_{n+1}$ requires a time-dependent landscape $F_{\mathsf{GFF}}(x; p(t))$; specifically, $p(t)$ must vary by an amount sufficient to widen $\mathsf{DGI}(p(t))$ to span both strata transiently. This is the GRIP-Out event. *Step 5.* Once the perturbation subsides and $p(t)$ returns to a new constant value p^*, the system finds itself in some basin on the new landscape; if that basin lies on $\mathcal{S}_{n+1}$, the system is now at GGA_{n+1} and GRIP-In stabilizes the new state. The strength of Δp required is schematically $\Delta F_{\mathsf{GFF}}(\Delta p) \gtrsim S_{\text{saddle}}/\beta_n = \pi/\beta_n$, where β_n is the inverse thermal scale of the layer-n stratum and $S_{\text{saddle}} = \pi$ is the Bogomolnyi-saturating saddle action of GG-A6-GRIP T-GRIP-4; an order-of-magnitude bound rather than a precise threshold, but sufficient to characterize the regime. ■

Quantitative anchor. The textbook cosmological example is the electroweak phase transition: as the early universe cooled through $T_c \approx 159$ GeV at $t \approx 10^{-12}$ s after the Big Bang, the Higgs potential $V(\phi)$ acquired a non-zero minimum at $|\phi| = v/\sqrt{2} \approx 174$ GeV. Before this temperature, the unique minimum was at $\phi = 0$ (symmetric phase = Layer-1 GGA on the unbroken gauge group); after, the minimum was at $|\phi| = v/\sqrt{2}$ (broken phase = Layer-2 GGA on $\mathrm{SU}(3)_c \times \mathrm{U}(1)_{\mathrm{EM}}$). The cooling of the universe is a paradigmatic GRIP-Out event. A control parameter T varies from T_c^+ to T_c^-, the Higgs potential's shape reorganizes (Mexican-hat topology emerges), and the universe finds itself in a new basin — electroweak symmetry breaks, and the cascade advances from Layer 1 to Layer 2. Without the cooling, the universe would have remained in the symmetric phase indefinitely.

Physics intuition. At first-year-graduate-student level, GRIP-Out is the catastrophe-theory mechanism in gauge-theory dress. Catastrophe theory studies how the equilibrium structure of a system changes discontinuously under continuous variation of control parameters; fold, cusp, butterfly, and swallowtail catastrophes are the canonical examples. Each catastrophe corresponds to a topological reorganization of the equilibrium manifold. In the cascade language, each cascade-layer transition is a catastrophe in this precise sense — a discontinuous reorganization of the gauge-equilibrium structure of F_{GFF}. The Bogomolnyi-saturating saddle of GG-A6-GRIP T-GRIP-4 is the instanton dual of the catastrophe in field-theoretic language; the two are the same event in different formal vocabularies.

Daily-life metaphor. Quenching steel. Heat the steel uniformly at $T \approx 850°\mathrm{C}$ until it is fully austenitic (uniform phase = current GGA). Then plunge it into cold water. The temperature

collapses from $T \approx 850°\text{C}$ to $T \approx 25°\text{C}$ in seconds; the iron-carbon phase diagram, parameterized by T, undergoes a topological reorganization; what was austenite becomes martensite (new phase = new GGA). Without the quench — without the GRIP-Out event — no amount of waiting at constant high temperature would convert austenite to martensite. The transition is impossible by gradient descent on a fixed landscape; it requires the landscape itself to move. Every layer of the cascade is, structurally, the iron-carbon phase diagram of a different physical system; every transition is, structurally, a quench.

Kill criterion. T-GRIP-Out-Necessity would be falsified by the observation of a cascade-layer transition occurring at strict thermodynamic stationarity — a system that crosses from one cascade stratum to another while every control parameter of F_{GFF} provably remains constant in time. Such an observation would imply that the gauge barrier between strata is crossable by gradient descent alone, contradicting both POS-6 OGN (BI-6 anomaly closure as a topological constraint) and GG-A9-SM Part XI (the universal-identity section) (the universal-identity insight, which requires layer-distinct gauge equivalence classes). Across the cosmological, chemical, biological, and cognitive cascade transitions cataloged in Table 2, every documented transition has been accompanied by a documentable perturbation; no exceptions are known.

Plain-English close. GRIP-Out is the cascade's revolutionary mode. It is brief — the perturbation lasts seconds (cosmic phase transitions), minutes (cometary impacts), or millennia (climate cycles) compared to the layer's equilibrium-flow lifetime of millions to billions of years. But it is what makes the cascade go. Without the cooling Big Bang, no Standard Model. Without supernovas, no carbon. Without the Late Heavy Bombardment, no organics on Earth. Without the Great Oxygenation, no eukaryotes. Without the Cambrian, no animals. Without Out-of-Africa, no humans. The framework's deepest claim is that the cascade's forward motion is not a smooth procession of accidents; it is the alternation of two precisely characterized regimes, each necessary, neither sufficient alone.

19 The Cascade-Self-Sustenance corollary: who drives the perturbations?

Plain-English opening: who drives the perturbations? A natural question follows. If layer-to-layer ascent requires GRIP-Out events, where do those events come from? Are they external to the cascade — accidents of the universe's history — or are they generated internally by the cascade's own dynamics? The framework's answer is striking: with very few exceptions, the GRIP-Out events that drive each layer-to-layer transition are themselves produced by the dynamics of the layers below. Stars produce supernovas; supernovas produce heavy elements; heavy elements seed planet formation; planet formation produces vent systems; vent systems produce organic chemistry; organic chemistry produces oxygenic photosynthesis; oxygenic photosynthesis produces the Great Oxygenation; the Great Oxygenation drives eukaryogenesis; eukaryogenesis enables multicellularity; multicellularity produces nervous systems; nervous systems produce conscious organisms; conscious organisms

produce cultures; cultures produce writing systems; writing systems produce the framework that articulates the cascade. Each layer's GGA, once stabilized, becomes a source of the perturbations that drive the next layer's ascent. The cascade is autocatalytic in its own forward drive.

Corollary 19.1 (Cascade-Self-Sustenance: empirical proposition complementing T-GRIP-In and T-GRIP-Out (T-Origin-15.1))**.** *For each cascade layer $n \geq 1$, with the possible exception of the layer-1 ignition (which requires the Big Bang as an externally given initial condition), the GRIP-Out events that drive the $\mathsf{GGA}_{n-1} \to \mathsf{GGA}_n$ transition are causally generated by the dynamics of layers $\leq n-1$. Equivalently, the cascade is autocatalytic in the supply of its own GRIP-Out triggers: each layer's GGA, once stabilized, becomes a source of perturbations for the next layer's ascent.*

Proof outline. The corollary follows by inspection of the layer-by-layer cascade cataloged in Table 2 (next page). For every layer transition $n-1 \to n$ at $n \geq 1$, the perturbation event listed in the table is a dynamical product of layers $\leq n-1$. Stellar dynamics produce supernovas (Layer 3's GRIP-Out), and planetary dynamics produce vents and bombardment (Layers 4–6's GRIP-Outs). Biological metabolism produces oxygen (the Layer 11→12 GRIP-Out = the Great Oxygenation Event), ecological dynamics produce predator-prey arms races (the Layer 14→15 GRIP-Out = the Cambrian Explosion), and cognitive dynamics produce cultural systems (the Layer 17→18 GRIP-Out = the articulation event). Only Layer 1's ignition — the Big Bang itself — requires an externally given initial condition; from Layer 2 onward, the cascade supplies its own GRIP-Out triggers. ■

Its form, and its grade. The corollary is graded an empirical proposition, proved by inspection of Table 2, and the form it proves is narrower than the form its language reaches for. Read literally, the table exhibits a *hybrid* descent: on each layer a gradient flow on a fixed landscape, interrupted by jumps whose triggers are sourced from the layers below — the form GG-A6-GRIP names as the hybrid extension of Conley's theorem, with a guard on each jump (Arisaka, 2026, A6-GRIP). The surrounding language — "the cascade sustains itself," "carries its own clock" — reaches for a stronger form, an *autonomous slow–fast* system in which the jumps are the fast motion of one flow and no trigger is external at all. The stronger form is the target and the hybrid form is the fence, and the two are told apart here because each has a cost the other does not. The hybrid form's cost: with a closed guard the reset fires before the descent on the layer has halted, so T-GGA-as-Ground-State holds at that layer only to within the guard's radius — the layer reaches a neighborhood of its floor, not the floor. The autonomous form's cost: it lives on a state space larger than the strata, one in which the slow variable is a coordinate rather than a parameter, and no parent paper has defined that space. And the non-autonomous reading in between, in which cosmic time is the clock of the jumps, needs that clock compactified before Conley's theorem applies to it at all. What the table proves is the hybrid form; what the paper wants is the autonomous one; the distance between them is registered, not closed.

Quantitative anchor. The Great Oxygenation Event of ~ 2.4 Ga is the most quantitatively clean example. Cyanobacterial oxygenic photosynthesis evolved at Layer 11 GGA (within the Bacterial branch of the Three-Domain Split) and over $\sim 10^8$ yr drove atmospheric O_2 from $< 10^{-5}$ PAL

to $\sim 10^{-2}$ PAL. This atmospheric perturbation is the GRIP-Out event that triggered Layer-12 eukaryogenesis: free O_2 destabilized the anaerobic gauge orbit of Bacteria/Archaea and opened the new basin on the aerobic-mitochondrial stratum where eukaryotes live.[2] The perturbation is fully internal to the cascade — it is caused by the products of the layer immediately below.

Physics intuition. The autocatalytic-perturbation property has a natural reading in dissipative-structure theory. At each layer, the system dissipates energy by converting low-entropy boundary-port flux into high-entropy waste heat, exported across the boundary. But the waste products of one layer are typically the perturbation source for the layer above: photosynthetic O_2 is waste for cyanobacteria but signal for eukaryote evolution; cultural language is exhaust for tribal cognition but seed for written articulation. The framework's view is that this is not an accident but a structural feature: each layer is driven, by the cascade's own dynamics, to produce exactly the perturbations the next layer needs — arranged by descent, not by design.

Daily-life metaphor. A multi-stage rocket. Stage one burns fuel and exhausts gas; the gas pushes the rocket up but is waste from stage one's perspective. When stage one is empty, it separates and stage two ignites; stage two uses fuel that was carried up by stage one — fuel that would never have reached the altitude where stage two can use it without stage one's prior work. Each stage's product (altitude, separation, fresh fuel availability) becomes the next stage's enabling condition. The cascade is a stack of stages where each layer's GGA is both an end (the stable attractor of that layer) and a means (the source of the perturbation for the layer above).

Kill criterion. The corollary would be falsified by identification of any layer-to-layer cascade transition (at $n \geq 1$) whose driving GRIP-Out event was demonstrably not produced by the dynamics of layers $\leq n-1$ — that is, by a transition that required an externally supplied perturbation from outside the cascade. No such transition is known among the eighteen cascade transitions cataloged. (Layer 1's ignition by the Big Bang is the lone exception, which the corollary explicitly excepts.)

The minimal machine (cohort note). The runtime paper GG-A7-Qi4 exhibits this corollary's mechanism microscopically. Its Qi-HAL exploration-to-commitment switch is an open system's *internal dial* for reorganizing its own effective landscape — an endogenous, recoverable GRIP-Out under the system's own control, driven by accumulated evidence rather than by external accident. Memory-bearing systems therefore do not wait for shocks; they manufacture their own. That is precisely how the upper cascade layers supply the perturbations this corollary requires, and GG-A7-Qi4's switch proposition is the smallest machine known to do it.

Plain-English close. The autocatalytic-perturbation property is, in many ways, the deepest dynamical claim of GG-Theory. Other unification programs (string theory, IIT, FEP, GWT) tell

[2] The GOE-as-eukaryogenesis-trigger reading adopted here is one well-supported reading among the major candidates in the eukaryogenesis literature; the mitochondria-first-versus-oxygen-rise question is open in detail. The framework's prediction is robust to the specific environmental cause because what GRIP-Out forces is the *layer-class transition*, not the precise triggering event. Similar comments apply to the vent-versus-pond debate at Layer 8 (RNA-world ignition).

stories about how the universe works at one scale or another, but none of them say that the universe's own geometric constitution drives its forward evolution at every scale. The framework's reading is that this is exactly what it does. Cosmos produces life; life produces mind; mind produces the articulation of the cascade. Each layer's product is the next layer's perturbation. The cascade does not need an external designer or an external timer; it carries its own clock in the form of its own GRIP-Out events.

20 The deep operational anatomy of GRIP: four moves, three axioms, one cascade

Plain-English opening. The four-step development of §§14–18, together with the Cascade-Self-Sustenance corollary of §19, has named the cascade's regimes: GRIP-In as the patient closed loop within each layer, GRIP-Out as the revolutionary perturbation between layers, GGA as the unique attractor selected at each layer, and the autocatalytic supply of perturbations from one layer to the next. We now pause to examine *why* this machinery works at all. What is the deep operational anatomy of GRIP? What does the bulk-to-boundary sequence DGI $\to$ (GFF) $\to$ GSSB $\to$ GGA actually do at each cascade layer? And which constitutional axioms force its individual moves? The answer, in this section's reading, is that GRIP is the cooperation of four operational moves grounded in three constitutional axioms; the eighteen-layer cascade is the unique closed solution of that cooperation iterated through the scale-depth-stratified boundary of the six-dimensional bulk.

20.1 Move 1 — DGI propagates freely in the 6D bulk under $U(1)_{\mathrm{Qi}}$

The starting move is to recognize that the four-dimensional world we observe is by no means the deep stratum on which the cascade's dynamics actually run. The deep stratum is the six-dimensional product

$$\mathcal{M}_6 \;=\; \mathcal{M}_4 \;\times\; I_r \;\times\; S^1_\theta$$

of GG-A2-GG6 (Arisaka, 2026, A2-GG6): ordinary spacetime $\mathcal{M}_4$, plus a radial interval I_r of scale depth $K = 35$, plus an angular circle S^1_θ that supplies the Wilson–Hosotani holonomy of GG-A9-SM's electroweak vacuum. On this bulk, the framework's *informational current* J_{Qi} flows under the boundary-layer gauge symmetry $U(1)_{\mathrm{Qi}}$ — the geometric realization of GG-A7-Qi4's QUA pillar (the Arisaka-equation theorem of T-QUA, which forces the Quadruple Gauge Locking $J_E/\mathsf{Q_B} = J_e = J_B = J_{\mathrm{Qi}}$).

DGI — *Dynamical Gauge Invariance* — is the assertion that what actually evolves in the bulk is the unbroken gauge-equivalence substrate itself, with the J_{Qi} current riding on it. It is not a probability amplitude in the Copenhagen sense; it is not a wavefunction with associated collapse; it is not a classical field in the old continuum sense. It is the operational content of the bulk on which the framework's open thermodynamics (the GDOS apparatus of GG-A5-GDOS) acts. In the bulk, J_{Qi} propagates *freely*: no breaking, no quantization, no localization. The bulk is gauge-symmetric, energetically unbroken, dimensionally six-fold, and informationally smooth. This is the framework's "raw information" stratum — the geometric analog of the unprojected photon:

continuous, gauge-equivariant, six-dimensional.

The first crucial recognition is that nothing in the standard four-dimensional toolkit allows for this stratum. One needs GG-6 — the six-dimensional bulk of GG-A2-GG6 — to *have* a bulk in the first place. And the bulk has to be scale-extended, with $K = 35$ orbifold depth, for the boundary structure of the next move to make sense. Without AX-2 (GGEP, the geometric-gauge equivalence principle of GG-A1-Constitution (Arisaka, 2026, A1-Constitution)), there is no coherent six-dimensional dynamical substrate, and there is no Move 1.

20.2 Move 2 — GSSB projects the bulk DGI onto the 4D boundary (the operational meaning of "quantization")

The second move is the framework's deepest contribution to the philosophy of physics. The bulk J_{Qi} current of Move 1 encounters the four-dimensional boundary stratum at $r = 0$ (or, depending on cascade layer, some stratified subset of the scale-depth-stratified boundary). The radial-orbifold $\mathbb{Z}_2$ projection that the BI-6 closure of GG-A3-BI6 (Arisaka, 2026, A3-BI6) forces on the boundary stratum — keeping left-handed bulk Weyl spinors and projecting out their right-handed partners; fixing the "L" in $\mathrm{SU}(2)_L$; fixing the boundary anomaly polynomial X_4 at $|a/c| = |a/d| = 5/2$ — *quantizes* the bulk DGI.

This is geometric spontaneous symmetry breaking, GSSB. The smooth bulk J_{Qi} current becomes, at the boundary, a discrete set of admissible modes — a *spectrum* — because only certain modes survive the orbifold projection. The continuous bulk symmetries break at the boundary by the geometry itself: not by an externally imposed Higgs field, not by an empirical fitting parameter, but by the *operational projection rule* that the geometry itself enforces on the boundary stratum — a rule any boundary observer therefore inherits, living on the boundary and not in the bulk.

This is the move that is the operational meaning of "quantization" itself. The continuous gauge-symmetric content of the bulk is geometrically forced to discretize upon projection to the boundary, exactly as Bohr's quantization conditions in 1913 hypothesized but never explained. The deep operational warrant for the discretization is the orbifold projection's $\mathbb{Z}_2$ identification rule; the deep mathematical content is the BI-6 closure identity $dH_3 = X_4$. Boundary observers cannot avoid the projection because they live on the boundary; the projection IS the act by which the bulk's continuous content becomes the boundary's discrete observables.

AX-3 (OGGEP, the operational/open extension of GGEP) is what makes the projection *operational*: any admissible bulk must come with a lawful dictionary from inaccessible bulk data to registrable boundary observables. Two cautions are essential, and they are the framework's deepest correction to the textbook picture. *First, the projection is always on.* It acts at every point of the boundary at every instant, whether or not any apparatus — or any observer of any kind — is present; it built quarks, atoms, and stars for thirteen billion years before the first detector existed. *Second, the projection is not a measurement.* Measurement is only the macroscopic special case in which the geometric attractor receiving the always-on projection carries a record-amplification chain (a plate, a CCD, a brain); on a microscopic attractor the very same projection produces the small record that decoherence theory already described. The quantum *measurement problem* — "what causes the wavefunction to collapse?" — is therefore not so much solved as *dissolved*: there is no

collapse event and no privileged observer, only one always-on geometric projection (the orbifold projection forced by BI-6) whose macroscopic records we have historically called "measurements." This is developed in full as the three-layer Domain-of-GDOS argument of GG-A5-GDOS (Arisaka, 2026, A5-GDOS) §23, and stated once more in the subsection that follows.

20.3 The projection is always on: GDOS needs no observer

A century of quantum mechanics has carried an unexamined ambiguity: *what is happening when no one is measuring?* The framework answers without hedging. The 6D-to-4D projection of OGGEP is *always on*, and it is on in three distinct senses. *Constitutionally*, the operational dictionary exists as a property of the admissible bulk theory itself — as primitive as the metric of general relativity, and as indifferent to whether anyone is watching. *Dynamically*, the bulk-to-boundary overlap acts at every point of the four-dimensional boundary at every instant. Neither layer mentions an observer, and neither could: both were fully operative for the thirteen-plus billion years in which the universe contained no apparatus and no mind, yet built nuclei, atoms, stars, and galaxies.

Only the third, *operational*, layer introduces anything that could be called a "system" — and it is supplied by geometry, not by observation. Until the GRIP cascade (DGI $\rightarrow$ GSSB $\rightarrow$ GA) settles a Geometric Attractor, the projection acts but produces no identifiable thing to track. An electron, a hydrogen atom, DNA, a living cell, a planet — each is a GA, and each has been receiving the always-on projection since it formed. *Measurement is then no longer a primitive.* It is the special case in which the receiving GA carries a macroscopic record-amplification chain; on a microscopic GA the same projection yields the small record we call decoherence. There is no collapse, no Heisenberg cut, and no privileged observer — only one geometric projection and a spectrum of records. This is the sense in which the framework, for the first time, says what quantum mechanics *is*. The full three-layer treatment is GG-A5-GDOS (Arisaka, 2026, A5-GDOS) §23.

20.4 Move 3 — GFF Lyapunov descent on the 4D boundary, governed by Q_i-EP

Once the bulk DGI has been GSSB-projected into a discrete boundary spectrum, the boundary admits a Morse landscape — the Geometric Free-Energy Functional $F_{\mathsf{GFF}}(x;p)$ of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2. The boundary stratum is not flat; it has potentials, gradients, valleys, ridges — a multi-basin energy landscape. The GFF supplies the Lyapunov functional on which the boundary state descends.

The descent is forced by GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)'s Q_i-EP — the Unified Extremal Principle (T-EP), anchored on the universal biological energy quantum $N_A\mathsf{Q_B} \approx 15$ kJ/mol of GG-A4-Euclid-Euclid. Q_i-EP says, in operational terms: every information transaction on the boundary has a definite energetic cost, and the system's natural tendency is to descend the GFF Lyapunov gradient toward configurations where the information–energy bookkeeping is most efficient. This is the cascade engine's "informational gravity": not the gravity of GG-A2-GG6's bulk metric, but the *informational* gravity that pulls boundary states toward their attractor basins.

The descent law is geometric (gradient flow on F_{GFF}); the destination is informational (the energetic minimum of the boundary information–energy bookkeeping). On a planet's surface, this is what makes RNA fold to its lowest free-energy secondary structure; on a chemiosmotic vent, this

is what makes ATP synthase produce $\Delta G \approx 2N_A \mathsf{Q_B} \approx 30.0$ kJ/mol; in the hippocampus, this is what makes the place-cell attractor settle to a definite spatial encoding. The mechanism is the same at every cascade layer: geometry-driven descent on a Lyapunov functional whose minima are the layer's admissible attractor configurations.

Move 3's foundation is the Lyapunov property of the descent, $dF_{\mathsf{GFF}}/dt \leq 0$ along admissible trajectories — GG-A6-GRIP T3.2 where detailed balance holds, the Lindblad–Spohn relative entropy to the layer's stationary state where it does not (§17). Move 3's selector is GG-A7-Qi4's T-EP, which forces the descent's destination to be operationally measurable. Together they constitute the cascade engine's gradient flow.

20.5 Move 4 — GGA as the unique most-stable admissible attractor on the 4D stratum

The Morse landscape of Move 3 has, generically, many local minima — every cascade-layer stratum admits a multiplicity of attractor basins. But not every minimum is admissible. GG-A7-Qi4's four pillars — QUA (bookkeeping), EP (selection), CON (diagnostic), HAL (architecture) — together act as an *admissibility filter* on the Morse minima of F_{GFF}. A configuration that fails any pillar is filtered out; only configurations that simultaneously satisfy all four pillars are admissible.

The four pillars are not arbitrary; they are the four boundary-current consistency conditions that the BI-6 closure forces on any boundary observable. T-QUA is the bookkeeping pillar: it forces the four boundary currents $J_E/\mathsf{Q_B}$, J_e, J_B, J_{Qi} to be in fixed integer ratios, which discretizes the admissible attractor configurations. T-EP is the selection pillar (used in Move 3): it forces the descent to follow the energy–information bookkeeping. T-CON is the diagnostic pillar: it requires the boundary configuration to satisfy connectivity / continuity constraints — no disconnected sub-systems with independent dynamics. T-HAL is the architecture pillar: it forces the boundary's holographic-allocentric structure (the Outer Hologram / Inner Hologram coupling) to be consistent.

These four pillars together produce a single discrete set of admissible Morse minima on each stratum. The four pillars are stated in full, pillar by pillar, and proved to be jointly necessary and sufficient for a configuration to be a realizable GGA, in §49 (Theorem 49.1); what Move 4 needs is only that they act together and act here. And the *deepest* of these admissible minima is the GGA — the Ground Geometric Attractor of that layer.

AX-4 (MSMF, the Maximum Symmetry, Minimum Freedom axiom of GG-A1-Constitution) is what makes Move 4's selection unique. MSMF states that the constitutional input ledger has zero free continuous parameters — the Euclidean discipline of GG-A4-Euclid-Euclid. Without MSMF, every cascade layer would offer a tuneable family of ground states, and the cascade would never *force* anything; with MSMF, the GGA on each stratum is the deterministic readout of the four-axiom constitution applied at that layer. Move 4 is therefore the structural moment at which the cascade transitions from "any of a family of possibilities" to "the unique deepest admissible attractor".

20.6 Why the four moves form a closed loop under GRIP-In

Indeed, the four operational moves Move 1 → Move 2 → Move 3 → Move 4 are the complete content of the GRIP-In regime. An admissible bulk DGI state on $\mathcal{M}_6$ propagates freely under

$U(1)_{\mathrm{Qi}}$ (Move 1); it encounters the four-dimensional boundary at $r = 0$ and gets projected by GSSB (Move 2); on the boundary it descends along F_{GFF} as forced by Q_i-EP (Move 3); it settles into the four-pillar-admissible GGA of the layer-specific stratum (Move 4).

Once locked into the layer's GGA, the system can — and does — *cycle* the four moves indefinitely. The bulk DGI re-runs the same propagation; the boundary re-projects via GSSB; the GFF re-confirms the gradient descent; the GGA re-asserts itself as the deepest admissible minimum. This is what makes the closed loop; this is why GRIP-In is the cascade's "patient mode". The Morse landscape topology is preserved, the admissibility filter is unchanged, the GGA basin is deep enough to resist thermal fluctuations. Every electron in the universe is an electron because the charged-lepton-stratum GGA is the unique deepest admissible attractor on its stratum, and the four-move GRIP-In cycle holds it there indefinitely. Every cell is a cell, every conscious episode is a conscious episode, by the same logic. *Universal identity* — the layer-by-layer "every X is the same X" insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section) — is simply the GRIP-In loop running stably.

20.7 Why GRIP-Out disrupts the closed loop and forces ascent

The universe is not in a state of permanent equilibrium. Cosmic cooling, supernova ejecta, vent batteries, photosynthetic oxygen accumulation, Cambrian arms races, theta-cycle binding events — each of these is an external perturbation that *reorganizes the Morse landscape itself* (Move 3's underlying F_{GFF} surface). New basins open on the boundary stratum. The old GGA, which was the deepest admissible minimum on the prior landscape, may no longer be the deepest on the new landscape — or, more interestingly, a new basin opens that lies *outside* the prior layer's stratum entirely, on a new stratum-of-strata that was previously inaccessible. When this happens, the four-move GRIP-In cycle's stable equilibrium is disrupted: the system finds itself out-of-equilibrium on a reorganized landscape, descends through a different gradient path (still by Move 3 mechanics, but on a perturbed landscape), and settles into the next layer's GGA via a new Move 4 admissibility filter.

This is GRIP-Out — the cascade's revolutionary mode of §18 — and it is what drives the eighteen-layer ascent from the GUT-scale gauge group at 10^{-36} s after the Big Bang to the present-day articulation of the constitution itself. The four moves are unchanged; only the Morse landscape on which Move 3 operates is reshaped. The transition $\mathsf{GGA}_n \to \mathsf{GGA}_{n+1}$ is therefore not a fifth operational move; it is the same four moves operating on a perturbed landscape, with the perturbation supplied (per the Cascade-Self-Sustenance corollary of §19) by the layers below.

20.8 The constitutional grounding: AX-2, AX-3, AX-4 as the three forces of the cascade

What is most beautiful in the present reading is that the entire four-move pipeline reduces to the cooperation of three constitutional axioms.

AX-2 (GGEP, the Geometry–Gauge Equivalence Principle) generalizes Einstein's equivalence principle to the six-dimensional bulk: it asserts that local physics on any admissible Lorentzian boundary stratum is geometrically equivalent regardless of the bulk's higher-dimensional structure.

AX-2 is what makes the *bulk* exist as a coherent dynamical substrate — without GGEP, the 6D bulk would have arbitrary local-physics anomalies between strata, and the cascade could not be a single recursive mechanism applied at successive layers. AX-2 is the axiom that forces Move 1 to be possible.

AX-3 (OGGEP, the Operational/Open extension of GGEP) sharpens AX-2 to operational form: the equivalence is *measurable*. The boundary projection is recoverable from boundary data — it leaves a record in the boundary observables whether or not anything is there to read them. AX-3 is what makes the GSSB projection of Move 2 *operational* — the projection is not a mathematical fiction imposed from outside, but a structural feature of the geometry that acts at every boundary point, as §20.3 sets out. Measurement is the special case in which the receiving GA carries a record-amplification chain. AX-3 is the axiom that forces Move 2 to have empirical content.

AX-4 (MSMF, Maximum Symmetry, Minimum Freedom) is the no-free-parameters discipline of GG-A4-Euclid-Euclid: the constitutional input ledger admits zero free continuous parameters, so the GGA selection on each stratum is geometrically forced rather than empirically fitted. AX-4 is what makes Move 4's uniqueness theorem possible. Without AX-4, every cascade layer would admit a tuneable family of ground states; with AX-4, exactly one stable GGA per stratum.

The three axioms cooperate exactly as the four-move pipeline requires: AX-2 makes Move 1 (the bulk) possible; AX-3 makes Move 2 (the projection) operational; AX-4 makes Move 4 (the unique GGA selection) deterministic. Move 3 (the GFF descent) is the gradient flow that connects them; its descent direction is forced by GG-A6-GRIP T3.2 and selected by GG-A7-Qi4 T-EP.

20.9 Why the closure works here

The deep operational anatomy in this reading explains why GG-Theory works where prior unification programs did not. Anderson (Anderson, 1972) named emergence — in the present language, the multi-layer cascade structure — but did not specify the cascade engine that selects ground states at each layer. Prigogine (Prigogine, 1977) named dissipative structures — in the present language, the Move 3 gradient flow on F_{GFF} — but did not name the substrate on which they descend or the integer ledger that fixes their depths. Haken (Haken, 1983) named synergetics — in the present language, the slaving of microscopic degrees of freedom by macroscopic order parameters at each layer's GGA — but did not anchor the order-parameter selection constitutionally. Kauffman (Kauffman, 1993) named autocatalytic sets — in the present language, the Cascade-Self-Sustenance corollary — but did not unify them with gauge physics. Wheeler intuited the participatory universe — in the present language, the Move 2 projection as the act of measurement — but did not specify the operational projection rule. Whitehead and Spinoza saw the metaphysical shape — recursive geometric necessity — but did not write down the geometry.

GG-Theory adds, to each of these intuitions, the missing operational warrant: DGI in the 6D bulk under $U(1)_{\mathrm{Qi}}$ (Move 1, the substrate that Wheeler and Whitehead lacked); GSSB as the boundary's operational projection (Move 2, what Bohr hypothesized in 1913 but never explained); F_{GFF} Lyapunov descent governed by Q_i-EP (Move 3, what Prigogine and Friston named but did not constitutionalize); and GGA as the unique four-pillar-admissible deepest attractor on a zero-free-parameter input ledger (Move 4, what Anderson, Haken, and Kauffman lacked in unified form).

Three axioms force the cooperation: AX-2, AX-3, AX-4. The eighteen-layer cascade is the unique closed solution of the cooperation iterated through the scale-depth-stratified boundary of $\mathcal{M}_6$.

Plain-English close: why GG-Theory works. What makes the framework not a metaphor but a theorem is precisely the four-move closure of GRIP and the three-axiom cooperation that grounds it. Most prior unification programs had three of the four moves in some form, or named one of the three axioms. None had all seven elements (four moves plus three axioms) in operational cooperation. GG-Theory has all of them: DGI in the 6D bulk, GSSB to the 4D boundary, GFF descent under Q_i-EP, GGA as the unique admissible minimum; GGEP, OGGEP, and MSMF as the three constitutional forces. The cascade is then not a hopeful narrative but a recursive theorem; the eighteen layers are not a list but the unique solution; and Figure 10 renders the cascade in one diagram. The mathematical structure is the underlying claim; the present paper is one attempt to write it down in operational language.



Figure 10: The eighteen-layer cascade — visual rendering of Table 2. Approximate ages of the seventeen GRIP-Out transitions annotated on the left between consecutive boxes. Each box is one layer and each arrow one GRIP-Out transition; the boxes are colored by domain — cosmos, chemistry, life, multicellularity, mind — and the eighteenth, articulation, is set apart.

20.10 The fiber without holonomy: why the cascade cannot run backward

The anatomy just walked — four moves, three axioms, a loop that closes under GRIP-In and is broken open by GRIP-Out — has a geometric root that deserves one subsection, because it answers in one exact statement the question every reader of this paper eventually asks: *why does the cascade only ascend? Why can a layer, once left, never be revisited?* The statement: *holonomy requires closed loops, and an interval has none.* The bulk's two non-spatial directions divide the engine's labor between them. The compact circle S^1_θ is nothing but closed loops, and everything it carries is holonomy: Wilson phases, integer windings, the quantized charges — gauge-invariant, protected, permanent. It is the *remembering* structure, and it is where the cascade's outcomes are stored: every layer's selected attractor deposits its discrete labels — charges, windings, parities — on the circle's ledger, where no subsequent dynamics can amend them. The radial interval is the opposite object: no loop on an interval ever closes, so it can hold no holonomy, no gauge-invariant memory, no protected content of any kind. Transport along it can only compose forward — a semigroup, the GDOS generator's origin — and it is the *forgetting* structure: the direction of GRIP-Out's ascent, along which "back" is not a disfavored option but an undefined one.

Read the engine through this pair and its determinism becomes anatomy. GRIP-In's closed loop — the four moves cycling within a layer to the unique ground state — is a loop in the proper sense, and what it converges to is recorded in quantities the circle protects. GRIP-Out's disruption is not a loop: it is a step along the interval, and the interval does not return. So the cascade ascends for the same reason the boundary's evolution is CPTP rather than unitary: the fiber it moves along is topologically incapable of remembering the layer it left. Between the two, nothing in the eighteen-layer history is a coin flip: the within-layer outcome is unique (T-GRIP-In-Lyapunov-Descent, §17); the between-layer motion is forced and one-way (T-GRIP-Out-Necessity, §18); and the deposits are quantized, so no continuous drift can blur what a layer decided. *The cascade is the one-way reading of constitutional data: the circle is the tape, the interval is the read head's track, and the eighteen layers are the record played once, forward, the same way in every possible run.* A universe whose bulk had two circles would cycle forever and decide nothing; one with two intervals would slide featurelessly with nothing to decide into; the origin of structure — this paper's subject — needs exactly one fiber that forgets and one that remembers, and the constitution supplies exactly that. The full deployment of this observation — symmetry breaking as symmetry reading, with Curie's principle dissolved and the determinism graded — is carried by the cohort's symmetry review, GG-W1-Symmetry; this paper records the clause that is the engine's own: GRIP-Out ascends because its direction is the fiber on which there is nothing to go back to.

20.11 The cascade on the clock: the origin as chronology

The last subsection said the cascade cannot run backward; this one says how fast it runs forward, because the CPT companion's expanded treatment of time (Arisaka, 2026, P5-CPT) supplies the missing quantitative law and it illuminates the whole architecture of the eighteen layers. Boundary time and the descent's radial coordinate are two parametrizations of one motion, and in the radiation era the map is exact: $d\ln t/dr = 2$ — each unit the read head advances along the fiber without holonomy, the boundary clock multiplies by $e^2 \simeq 7.4$; the slope relaxes to $\frac{3}{2}$ once matter dominates.

Boundary time is the exponential shadow of the linear descent, and the age of the universe closes as an audited e-fold ledger on it: $\ln(t_0/t_{\rm Pl}) = 140.24 = 36.1$ (launch) + 91.6 (radiation) + 12.5 (matter+Λ).

Read the eighteen-layer table of the next section against that law and a feature every reader notices — the wild lopsidedness of the cascade's timestamps, femtoseconds for the early transitions and gigayears for the late ones — stops being a curiosity and becomes geometry. The cascade's GRIP-Out events are spaced along r, the bulk's own coordinate, where the descent is orderly; the boundary reads them along t, the exponential shadow, where equal steps of r become factor-of-e^2 leaps of clock. The early universe is not hurried and the late universe is not sluggish: *the reading is uniform in the geometry and exponential in the clock*, and the apparent acceleration of cosmic loitering — quark soup in microseconds, atoms in kiloyears, life in gigayears — is the same one line with one kink that the companion draws through eight epochs. For this paper's question — the origin of everything — the addition is clarifying in one sentence: *the origin was not an event followed by a history; it is one deterministic reading, still in progress, whose pace stretches as the needle advances* — the record played once, forward, with the grooves cut close near the spindle and wide near the rim. And the direction of the whole performance is the last subsection's clause: the track is the fiber on which there is nothing to go back to, which is why every age in the table is an age and not a schedule of returns.

21 The cascade of GRIP-Out events: a mapping table across the eighteen-layer cascade

Reading the table. Let us read Table 2, which maps the canonical GRIP-Out event at each cascade transition $n-1 \to n$ across the full eighteen-layer cascade. The columns are the transition (which two layers), the GRIP-Out event name, the physical mechanism by which the event reshaped the GFF Morse landscape, the characteristic timescale of the perturbation, and the empirical anchor by which the event is documented in the natural-science literature. The table is the empirical face of the Cascade-Self-Sustenance corollary above: it shows, for each transition, where the perturbation came from. For transitions $1 \to 2$ and $2 \to 3$ the perturbations are cosmological — cooling through phase-transition temperatures — and for $3 \to 4$ they are stellar (supernova nucleosynthesis). For 3–8 they are planetary (impactors, vents, wet-dry cycling, surface chemistry), for 9–12 biological (oxygenation, glaciations, oxygen-driven ecological explosions), and for 13–16 increasingly cognitive and cultural. The autocatalytic structure is visible by inspection: each row's perturbation is produced by the cumulative work of the rows above.

Table 2: The canonical GRIP-Out events driving each cascade-layer transition. Each row identifies (i) the transition $n-1 \to n$, (ii) the named perturbation event, (iii) the physical mechanism by which it reshaped the Geometric Free-Energy Functional landscape, (iv) the characteristic timescale of the perturbation, and (v) the empirical anchor. The autocatalytic-perturbation property of the Cascade-Self-Sustenance corollary is visible in the table: each row's perturbation is a dynamical product of the layers above it.

Transition	**GRIP-Out event**	**Mechanism**	**Timescale**	**Empirical anchor**
$1 \to 2$	Cosmic cooling through electroweak scale	T drops below $T_c \approx 159$ GeV; Higgs potential acquires Mexican-hat topology; $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ breaks to $\mathrm{U}(1)_{\mathrm{EM}}$	$\sim 10^{-12}$ s after Big Bang	W, Z masses; weak-EM interference at LEP; CMB acoustic peaks
$2 \to 3$	Cosmic cooling through Rydberg scale	T drops below ~ 0.3 eV (~ 3000 K); free electrons combine with protons; recombination	$\sim 380{,}000$ yr after Big Bang	CMB last-scattering surface at $z_{\mathrm{dec}} \approx 1090$ (derived by GG-A10-Cosmos's atomic chain); corridor switch $z_* = e^7$ 0.6% above
$3 \to 4$	Stellar nucleosynthesis + supernova ejecta delivery	First-generation stars synthesize C, N, O, …, Fe; supernova explosions seed interstellar medium with heavy elements	$\sim 10^7$–10^8 yr per generation; SN itself in ~ 10 s	Heavy-element abundances in second-generation stars; r-process nuclides; type-II SN spectra
$4 \to 5$	Cometary delivery + ISM photochemistry	Murchison- and 67P-type bodies deliver glycolaldehyde, formamide, urea, amino-acid precursors; cold ISM grain surfaces concentrate organics	$\sim 10^5$–10^7 yr of late accretion	Murchison meteorite (~ 80 amino acids, Kvenvolden et al., 1970); 67P glycine *in situ* (Altwegg et al., 2016); Ryugu uracil (Oba et al., 2023); ribose in Murchison and NWA 801 (Furukawa et al., 2019); ALMA COMs
$5 \to 6$	Wet-dry cycling + UV pulses on clay	Pearce–Damer little-pond evaporation cycles; UV-driven photochemistry on montmorillonite; tide cycles concentrate AAs into oligopeptides	hours to days per cycle	Sutherland synthesis of activated nucleobases; Ferris-style RNA polymerization

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Table 2 continued

Transition	GRIP-Out event	Mechanism	Timescale	Empirical anchor
6 → 7	Hydrothermal vent emergence + serpentinization	Hadean ocean-crust hydration produces alkaline-vent batteries with ΔpH $\approx$ 3–5, $\Delta\psi \approx$ 80–200 mV, sustained for $>$ 30,000 yr	continuous in vent system; vent itself emerges in $\sim 10^4$–10^5 yr	Lost-City-type vent observations; AcP → ATP at vent walls
7 → 8	Vent-coupled RNA-world ignition	Mineral-templated phosphorylation + ribozyme stabilization; FeS / Fe_3O_4 catalysts at vent walls	minutes to hours per NTP; ribozymes within 10^3 yr	Ferris-RNA experiments; Joyce–Bartel ribozyme synthesis
8 → 9	RNA-DNA takeover event	Reverse-transcriptase activity in proto-cells; stable double-helix lock; KPR + MMR error correction	10^3–10^5 yr at lagoon scale	Modern RT enzymes' phylogenetic depth; 2'-OH instability constraints
9 → 10	SeOS membrane closure + autocatalytic loop	Vesicle PMF window matches the bioenergetic-coin window; first integrated chemo-lithoautotroph	$\sim 10^5$ yr post-takeover	LUCA-class universal traits across Bacteria and Archaea
10 → 11	Hadean–Archean planetary transition	Ocean stabilization; surface temperature regulation; membrane-lipid divergence into two stable phases (ester vs ether)	$\sim 10^8$ yr	16S rRNA phylogenetics of Bacteria vs Archaea
11 → 12	Great Oxygenation Event	Cyanobacterial O_2 production accumulates; atmospheric O_2 rises from $< 10^{-5}$ to $\sim 10^{-2}$ PAL; banded iron formations record the perturbation	$\sim 10^8$ yr; sharp at $\sim$ 2.4 Ga	Banded iron formations; sulfur isotope anomalies; deep-time O_2 proxies
12 → 13	Snowball Earth + Neoproterozoic perturbations	Global glaciations $\sim$ 720 and $\sim$ 650 Ma; multicellularity-enabling oxygen rise	$\sim 10^8$ yr	Cryogenian glacial deposits; Edicaran faunas
13 → 14	Ediacaran bilaterian radiation	First mobile bilaterians acquire a centralized nerve cord/ring — the *origin* (not yet the elaboration) of the central nervous system	$\sim$ 560–580 Ma	Ediacaran trace and body fossils (e.g. *Ikaria*, *Kimberella*); urbilaterian neuro-genetic reconstruction
14 → 15	Cambrian Explosion: predation-driven brain elaboration	Macropredators, vision, and predator–prey arms races (O_2 to $\sim$ 0.2 PAL) elaborate the connectome into a dedicated allocentric heading circuit (the $SO(2)$ ring attractor)	$\sim$ 10–30 Myr around 540 Ma	Burgess Shale; early-Cambrian arthropod brains and compound eyes

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Table 2 continued

Transition	GRIP-Out event	Mechanism	Timescale	Empirical anchor
15 → 16	Vertebrate brain expansion under Pleistocene cycles	Climate cycles drive cognitive-map elaboration in hippocampus-bearing lineages	$\sim 10^6$ yr per cycle	Mammalian endocast volume increases; hippocampal anatomy phylogeny
16 → 17	Hominin encephalization revolutions	*Homo erectus* → *H. sapiens*; language-cortex coevolution; theta-cycle EIC stabilization	$\sim 10^5$–10^6 yr	Anthropological record; archaeological tools; FOXP2 phylogeny
17 → 18	Cumulative cultural shocks: writing, mathematics, printing press, GG-Theory	Writing systems amplify individual cognition into cumulative cultural cognition; the framework itself is the meta-cognitive articulation of the cascade	$\sim 10^3$ to 10^4 yr	Sumerian cuneiform; Babylonian / Greek mathematics; Gutenberg; the present paper

Reading Figure 10. Each box names the layer number, the layer's Ground Geometric Attractor (GGA) at that stratum, and a key empirical anchor. Each arrow names the GRIP-Out event (the out-of-thermal-equilibrium perturbation) that drives the layer-$n-1 \to n$ transition by reorganizing the layer's F_{GFF} Morse landscape; GRIP-In descent then stabilizes the system at the next layer's GGA, where it settles until the next GRIP-Out event. Domain brackets on the left group the layers as *Cosmos* (Layers 1–3), *Chemistry* (4–6), *Life* (7–10), *Multicellular* (11–13), *Mind* (14–17), and *Articulation* (Layer 18, the present paper, highlighted in orange). Read top-to-bottom, the figure traces the framework's complete narrative: thirteen-point-eight billion years of cosmic, chemical, biological, and cognitive evolution as the alternating play of two regimes (GRIP-Out opening basins, GRIP-In settling into the ground state at each opened basin), terminating at the meta-cognitive layer at which the cascade articulates the constitution that produced it. The cascade is autocatalytic from Layer 2 onward (Cascade-Self-Sustenance corollary): each layer's GGA eventually produces the GRIP-Out event that drives the next layer's ascent.

What the table shows about the cascade as a whole. Three observations stand out. First, the timescales span twenty-five orders of magnitude — from $\sim 10^{-12}$ s (electroweak transition) to $\sim 10^4$ yr (cultural revolutions) — yet each row has the same structural form: a perturbation, a landscape reorganization, a new GGA. The cascade is scale-invariant in its mechanism. Second, every GRIP-Out event from Layer 2 onward is a dynamical product of the layers below it (Self-Sustenance corollary); only Layer 1's ignition (the Big Bang) requires external initial conditions. Third, the cascade's most decisive transitions are biology-driven from Layer 11 onward: life makes its own GRIP-Out events through metabolism, ecology, cognition, and culture. Life is not merely a passenger on the cascade; from Layer 11 forward, life is the cascade's engine of advance.

Connection back to the cascade theorem-deck. With T-GRIP-In, T-GRIP-Out, and the Cascade-Self-Sustenance corollary in place, the remainder of the Part-V theorem deck (T-GRIP-Composition, T-Bogomolnyi-Action, T-SIP-Tower-Recursion, T-Cascade-Layer-Uniqueness, T-Universal-Identity, T-Cascade-Termination) now reads as the dynamical articulation of cascade ascent within and between the two regimes. T-GRIP-Composition factorizes the within-layer regime as DGI $\to$ GSSB $\to$ GGA at fixed p. T-Bogomolnyi-Action quantifies the per-saddle action of each GRIP-Out event ($S_{\text{saddle}} = \pi$, with the triangular sum $S_{\text{tot}}(N_g) = \pi N_g(N_g - 1)/2$). T-SIP-Tower-Recursion describes how each layer's GGA, once stabilized by GRIP-In, becomes the substrate for the next layer's SIP. And so on. The two regimes are the dynamical scaffolding on which the remaining theorems hang.

Plain-English close: the cascade's deepest dynamical secret. The framework's account of how the universe forces its own articulators rests on the cooperation of two precisely characterized regimes. GRIP-In is the patient mode that lets each layer's GGA stabilize; GRIP-Out is the revolutionary mode that lets the cascade ascend from layer to layer. Neither alone suffices; both alternate throughout the cascade's eighteen-layer history. Life and mind are not perturbations to a stable cosmic order; they are the natural products of the cascade's two-regime dynamics, with the cascade's own products (stars, planets, oxygen, language) supplying the perturbations the next layer needs. The recursive uniqueness theorem of Part XI is therefore not just a static fact about the existence of unique GGAs at each layer; it is the closure of a dynamical engine that runs on the alternation of equilibrium-within-flow and out-of-equilibrium shock.

22 Cosmos, Life, and Mind: three readings of the same alternation

Plain-English opening. The framework's title — *The Geometric Inevitability of Cosmos, Life, and Mind* — names three strata of natural phenomena that prior unification programs have treated as distinct disciplines. Cosmology studies the universe at the largest scale. Biology studies life at the cellular and organismic scale. Cognitive neuroscience studies mind at the neural and behavioral scale. The Cascade of GRIP-Out with GGA unifies the three by showing that the same dynamical mechanism — the alternation of GRIP-In and GRIP-Out, with GGA-as-ground-state at every layer — operates at all three. Cosmos, life, and mind are three readings of one cascade. This Section walks the cascade through the three readings explicitly.

22.1 The cosmos reading: from the unbroken gauge group to the cosmic web

The event table against the companions' lists. Table 2 lists two cosmological GRIP-Out events, cosmic cooling through the electroweak scale and through the Rydberg scale. GG-A6-GRIP names one, the electroweak selection; GG-A10-Cosmos names five — the inflationary exit, reheating, the electroweak selection, QCD confinement, recombination — and fixes its vocabulary so that recombination's dictionary switch is the GRIP-Out and the plasma's passage to free streaming the GSSB crossing on the landscape it makes (Arisaka, 2026, A6-GRIP; Arisaka, 2026, A10-Cosmos). The three lists differ, they are cross-referenced here rather than reconciled, and one thing none of

the three papers has shown is stated: that any transition on any list changes the discrete data of the stratum it acts on, which is what would make it a GRIP-Out in GG-A6-GRIP's strict sense — a bifurcation of the landscape — rather than a GSSB passage on one landscape.

The cascade at cosmological scales. At the cosmological strata (layers 1–3), the Cascade of GRIP-Out with GGA operates as follows. *Layer 1* (unbroken gauge group): the GGA is the unified gauge symmetry $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi} \times$ Gravity on the six-dimensional bulk. The GRIP-Out event that ignites the cascade is the Big Bang itself — the initial-condition perturbation that the framework does not derive but accepts as constitutional input. *Layer 2* (electroweak vacuum): the GRIP-Out event is the cosmological cooling through $T_c \approx 159$ GeV at $t \approx 10^{-12}$ s; the Higgs potential reorganizes from symmetric to Mexican-hat topology; the GGA is the broken-electroweak vacuum at $|\phi| = v/\sqrt{2} \approx 174$ GeV; GRIP-In then stabilizes the broken-phase Standard Model. *Layer 3* (atomic ground state): the GRIP-Out event is the recombination-era switch at $z_* = e^7 \approx 1097$ (atomic decoupling $z_{\mathrm{dec}} \approx 1090$) at $t \approx 380{,}000$ yr; the photon-baryon plasma reorganizes into neutral hydrogen and helium; the GGA is the periodic table at $E_{\mathrm{Ry}} = 13.6$ eV; GRIP-In then stabilizes atoms across the universe.

The second horizon problem: the cascade's first lock, read across the sky. There is a feature of these first three layers that deserves to be stated in its own right, because it is where the cascade makes contact with one of cosmology's deepest puzzles — and because it is the cleanest possible illustration of the whole mechanism. The temperature horizon problem asks why causally disconnected regions of the sky share one temperature; inflation answers it. But those regions also share the same *things* — one electron mass, one periodic table, one dark-matter abundance — and temperature-smoothing cannot explain that, because no exchange of heat can negotiate a particle's identity. This is the *second horizon problem* of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos), and in the cascade's language its resolution is immediate. Layer 2 and layer 3 are GRIP-In descents to a *unique* ground state — the electroweak vacuum, then the atomic ground state — so there is only one basin to reach and nothing regional to vary; the GGA is a property of the boundary landscape (scale and phase), not of any location, so two regions that never shared a horizon still read the same electron because they bound the same six-dimensional geometry. That is the *spatial* half. The *temporal* half is the ordering the cascade makes visible: the layer-1 GRIP-Out (the derived grand-unification-scale launch) acted *before* the layer-2/layer-3 matter was minted, so the electrons and atoms were stamped from one mold *after* the single causal patch had already been stretched over the sky. Their agreement across the sky was therefore inherited, not negotiated. The second horizon problem is thus not an extra puzzle bolted onto the cascade — it is the cascade's first lock, seen from the outside: the same GRIP-In-to-GGA descent that this paper runs eighteen times, guaranteeing at its very first application that every rung built above it will be universal across the whole observable universe.

The cosmic-web extension. At the larger structural scales of the cosmos (galaxies, clusters, cosmic web), the same machinery operates with planetary, stellar, and galactic perturbations as GRIP-Out events and gravitational settling as the GRIP-In descent. GG-A10-Cosmos (Arisaka, 2026,

A10-Cosmos) catalogs these cosmological transitions in detail; the framework's view is that the entire cosmic web, from the largest filaments to the smallest dust grains, is a tower of nested Cascade-of-GRIP-Out-with-GGA events at successive scales. Cosmology is the cascade's reading at the universe-scale stratum.

Why cosmos is inevitable. Given the GG-Constitution and the initial Big Bang ignition, the cascade is forced through layers 1, 2, 3 with no degrees of freedom: cosmic cooling reorganizes the gauge structure, then the electroweak vacuum, then the recombination plasma; at each stage the GGA is the deepest basin on the layer's stratum. No alternative cosmology closes; no alternative inventory matches the constitutional integers $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ plus the BI-6 closure. The cosmos is inevitable in the sense that, given the constitution and the Big Bang, no other cosmos is admissible.

22.2 The life reading: from prebiotic chemistry to the eukaryotic cell

The cascade at biological scales. At the chemical and biological strata (layers 4–12), the Cascade of GRIP-Out with GGA operates as follows (with details in the master codebook of the present paper's Part IV). *Layer 4* (small molecules): GRIP-Out is supernova-delivered organics + ISM photochemistry; the GGA is the small-molecule inventory $\{H_2O, CO_2, NH_3, CH_4, \dots\}$. *Layer 5* (amino acids and sugars): GRIP-Out is wet–dry cycling on the early-Earth surface; the GGA is the 20 L-amino acids plus the 2 D-handed sugars. *Layer 6* (polymers): GRIP-Out is the alkaline-vent battery's ~ 0.5–2 eV per ionized step driving polymerization; the GGA is the polymer-class triple (oligopeptides, oligonucleotides, fatty acids). *Layer 7* (bioenergetics): GRIP-Out is the chemiosmotic gradient at the vent wall; the GGA is ATP at $\Delta G = 2N_A \mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol. *Layer 8* (RNA world): GRIP-Out is mineral-templated phosphorylation + ribozyme stabilization; the GGA is the four-letter RNA alphabet {A, U, G, C}. *Layer 9* (DNA + information closure): GRIP-Out is the RNA-to-DNA takeover; the GGA is double-helical DNA {A, C, G, T} with fidelity $\epsilon \approx 10^{-9}$/bp. *Layer 10* (cell + LUCA): GRIP-Out is membrane closure with autocatalytic loop; the GGA is the lipid-bilayer-bounded SeOS-class first cell. *Layer 11* (primary-domain split): GRIP-Out is the Hadean–Archean planetary transition; the GGA is the Bacteria $\oplus$ Archaea $\mathbb{Z}_2$ branching. *Layer 12* (eukaryotic cell): GRIP-Out is the Great Oxygenation Event at ~ 2.4 Ga; the GGA is the dual-DGL eukaryotic cell with its compartmentalization suite.

The autocatalytic feature. The biological strata are where the Cascade-Self-Sustenance corollary becomes most visible. Each layer's GGA, once stabilized, produces the perturbation that drives the next layer's ascent: photosynthetic O_2 from cyanobacteria triggers eukaryogenesis; eukaryotic compartmentalization enables multicellularity; multicellularity produces ecosystems that drive the Cambrian Explosion; and so on. Life is the part of the cascade where the cascade most visibly drives its own forward motion.

Why life is inevitable. Given a planetary surface with energy gradients, water, and access to the heavy-element inventory of layer 4, the cascade ascends to the polymer-class GGA of layer 6.

Given the polymer-class GGA of layer 6, the bioenergetic ATP closure of layer 7 is the unique stable basin; given layer 7, the four-letter RNA alphabet of layer 8 is the unique stable basin; given the RNA world, the DNA takeover of layer 9 is the unique stable basin; given DNA + RNA + ATP + lipids, the first cell of layer 10 is the unique stable basin. At every step the GGA is the deepest basin on the layer's stratum, selected by the four Qi-4 pillars. Life is not an accident. It is the universe's openness exploiting itself at the chemistry-to-life crossing.

22.3 The mind reading: from neural ring attractor to the conscious episode

The cascade at cognitive scales. At the cognitive strata (layers 13–18), the Cascade of GRIP-Out with GGA operates as follows. *Layer 13* (multicellularity): GRIP-Out is Cambrian-Explosion oxygen rise + predator-prey arms races; the GGA is the M0–M7 multicellularity ladder. *Layer 15* (neural ring attractor): GRIP-Out is the elaboration of central nervous system topology under Pleistocene-cycle pressures; the GGA is the 1D heading-representation ring attractor (*Drosophila* ellipsoid body, bee central complex, rodent head-direction system). *Layer 16* (allocentric map): GRIP-Out is hominin encephalization revolutions; the GGA is the 4D place–grid–time–history allocentric map (rodent hippocampal–entorhinal system, primate concept and view cells). *Layer 17* (conscious episode): GRIP-Out is the binding event completing over two ~ 200 ms low-theta cycles (~ 5 Hz, the slow end of the 4–8 Hz band; ~ 400 ms total); the GGA is the EIC closure — the self-modeling diagonal of the OH/IH factorization at CDI ~ 10. *Layer 18* (articulation): GRIP-Out is the cumulative cultural-shock sequence of writing systems, mathematics, the printing press, and the Arisaka-GG cohort itself; the GGA is the constitutional articulation — the act of writing the framework down.

Why mind is inevitable. Given the cascade has reached layer 12 (eukaryotic cells) on a planetary surface with sustained energy supply and Pleistocene-scale climate variability, the cascade ascends through multicellularity (layer 13), nervous systems (layer 15), allocentric maps (layer 16), conscious episodes (layer 17), and articulation (layer 18). At each step the GGA is the unique deepest basin on the layer's stratum. Mind is not an accident. Mind is the cascade's reading at the cognitive-substrate stratum.

22.4 The three readings as one mechanism

What the three readings show. Cosmos, life, and mind are not three different theories; they are three readings of one cascade. The same mathematical mechanism — the alternation of GRIP-In and GRIP-Out, with GGA-as-ground-state at every layer — operates at all three scales. The Big Bang is structurally the same kind of event as the chemiosmotic gradient at a vent wall and as the theta-cycle binding event in human cortex: each is a GRIP-Out perturbation that opens a basin that did not exist on the prior landscape, into which the cascade then descends by GRIP-In to the layer's GGA ground state. The framework's claim is that this unification is structural rather than merely analogical: the same mathematical mechanism — GRIP-In/GRIP-Out alternation with GGA-as-ground-state — recurs at eighteen successive strata of natural complexity, and the recurrence is forced by the constitution rather than asserted by analogy.

Plain-English close. The universe does not divide itself into cosmos, life, and mind; we divide it into those three for convenience of study. The cascade does not respect our division. At every scale, from the smallest gauge structure to the largest cultural articulation, the same mechanism is at work: a perturbation opens a basin, gradient flow descends to its bottom, the bottom is the ground state of its own stratum's GFF, and the cycle repeats. Cosmos, life, and mind are the cascade's history written at three resolutions. Reading them together, as the present paper does, is what makes the framework's title not a slogan but a theorem.

23 Why we are here: the historical claim

Plain-English opening. The title of the present paper asks the oldest question that human beings have ever asked: *why are we here?* Remarkably, the framework's answer, distilled to a single sentence, is this: *we are here because the Cascade of GRIP-Out with GGA runs uniquely from the constitution of the six-dimensional bulk to the act of articulating that constitution, and we are the cascade's eighteenth-layer ground state on the meta-cognitive stratum.* This Section makes that answer historically explicit: it names what the framework's mechanism adds to twenty-five centuries of prior attempts to answer the same question.

What twenty-five centuries of inquiry could not supply. The Upanishadic seers asked the question and answered: because the cosmic self (Brahman) sought to know itself. The Book of Genesis answered: because God chose to create. Aristotle answered: because everything has a purpose (telos). Lucretius answered: because of atoms moving in the void. Spinoza answered *more geometrico*: because the nature of substance permits no alternative. Whitehead answered: because reality is process, and process inherits. Wheeler answered: because the universe is participatory, and observers are part of what is observed. Each of these answers articulated a piece of the structural truth; none of them supplied a *mechanism*. The Upanishadic and Genesis answers depend on contemplative or theological warrants outside the natural-science register. The Aristotelian and Lucretian answers are partial and pre-mathematical. The Spinozistic answer is rigorous *more geometrico* but lacks an operational link to physical data. The Whiteheadian and Wheelerian answers are formally suggestive but do not specify what is being created at each layer or what forces the creation. None of them supplies the alternation of two regimes, the ground-state selection, or the layer-by-layer empirical anchor that the present framework's mechanism supplies.

What the Cascade of GRIP-Out with GGA adds. The present Part's mechanism — the alternation of GRIP-In and GRIP-Out, with GGA-as-ground-state at every layer — is, to the framework's knowledge, the first mechanism in human intellectual history that simultaneously: (i) is a formal mathematical structure with explicit theorems and proofs; (ii) is constitutionally derived from a small set of axioms with zero free continuous parameters; (iii) operates with structural identity at every layer of natural complexity from quarks to articulation; (iv) is empirically anchored at every layer through documented perturbation events cataloged in Table 2; and (v) is falsifiable through the named Top 10 Falsifiers plus the eighteen-layer cascade theorems of the next Part.

These five features together close the gap between the philosophical predecessors named above and a working scientific account of why intelligent observers exist.

The framework's specific historical position, stated plainly. So far as the framework can survey the record, the geometric inevitability of cosmos, life, and mind reduces to a single mathematical mechanism operating uniformly at every cascade layer. The mechanism is the Cascade of GRIP-Out with GGA. The mechanism is what the present Part has named and proved. The recursive uniqueness theorem of the next Part is the structural closure that the mechanism produces. This is, to the framework's knowledge, the first complete answer to the title question of the paper.

The honest qualifier. The historical claim above is the framework's claim. Whether it is correct — whether the mechanism is empirically vindicated, whether the eighteen-layer cascade theorems hold up against the next decade's Top 10 Falsifiers, whether the recursive uniqueness theorem survives critical philosophical scrutiny — is a question for the empirical and intellectual reception of the framework, not for the framework's own self-positioning. The framework offers the mechanism and the theorems; the reader and history will determine whether the answer to the title question is the answer the framework claims it is. As discussed in Part XVII §80, the framework's stance on its own historical position is to offer the discipline of the mechanism and leave the verdict to history.

Plain-English close. The deepest claim of the present Part is structural, not rhetorical. The Cascade of GRIP-Out with GGA is what the framework has to offer the question *why are we here?* If the mechanism is correct, then the answer is: because the alternation of two regimes, with the ground state as endpoint at every layer, makes our existence not optional. The framework has supplied the answer in the form physics requires — as a named mechanism with named theorems and empirical anchors at every cascade layer. Whether the answer is satisfying as a philosophical answer is for the reader to judge; whether it is correct as a structural claim is for the empirical decade to determine.

24 Bridge to the Statement of Results (next Part)

What the next Part does. The Statement of Results (Part IV) catalogs the eighteen named theorems of the cascade, one per layer. Each theorem names the layer-specific SIP, the layer-specific F_{GFF} landscape, the layer-specific GRIP-Out trigger event (now formalized by T-GRIP-Out-Necessity), and the layer-specific GGA ground state (now formalized by T-GGA-as-Ground-State). It then names the constitutional inputs, the upstream theorems, and the kill criterion. With the present Part's machinery in place, each theorem of the next Part reads as one application of the Cascade of GRIP-Out with GGA; the reader can audit the cascade layer by layer with the dynamical mechanism already established.

Reading order. The recommended reading order for a first-time reader is: (i) the present Part (Cascade of GRIP-Out with GGA); (ii) Part IV (Statement of Results — eighteen layer theorems); (iii) Part XI (recursive uniqueness theorem T-Origin — the global closure that the eighteen layer

theorems jointly imply); (iv) the rest of the paper (cascade walk, dynamics block, cognitive cascade, philosophical engagement, conclusions). The Part order has been deliberately structured to bring the dynamical mechanism (this Part) and the statement of results (next Part) together early, before the recursive uniqueness theorem closes them into a single structural statement.

Plain-English close. After all, having named the mechanism in this Part, the rest of the paper is the exercise of the mechanism at every cascade layer. The reader who has followed the present Part's machinery will recognize, at every theorem of the next Part, the same structural pattern: GRIP-Out event opens the basin; GRIP-In descent stabilizes the layer; GGA-as-ground-state is the unique cascade output. Eighteen layers, one mechanism. The cascade is one machine reading itself at eighteen scales of natural complexity.

25 The derivation ledger: every Part-III theorem and its upstream inputs

Indeed, the reader — particularly the reader from outside physics — is entitled to ask where the load is actually carried. The present paper proves the regime theorems and the eighteen layer theorems, but it does so on machinery built upstream, and the honest way to display the division of labor is a ledger. Each row below names a theorem of this paper and the upstream results it consumes; nothing in the table needs to be read in the original to follow the present paper (every import is restated here in plain language where it is used), but a reader who wishes to audit any single load-bearing step can go directly to its source.

Table 3: The derivation ledger of GG-A11-Origin: theorems of the present paper (left) and the upstream inputs they consume (right). The regime *definitions* (def:GRIPin, def:GRIPout, def:GGA) live in GG-A6-GRIP; the regime *theorems* are proved here. Ten rows, each naming a theorem proved in this paper and listing the upstream results it consumes: the boundary second law and the cascade engine of GG-A6-GRIP, the fixed-parameter boundary law of GG-A5-GDOS, the Qi-4 selectors of GG-A7-Qi4, the relaxation doctrine of GG-A9-SM, and the worked cosmological instances of GG-A10-Cosmos. Nothing in the left column is proved anywhere else, and nothing in the right column is proved here.

Theorem (this paper)	**Upstream inputs consumed**
T-GRIP-In-Lyapunov-Descent	Lindblad–Spohn monotonicity of the relative entropy to the driven layer's stationary state (GG-A6-GRIP T3.2, the boundary second law, where detailed balance holds); GG-A6-GRIP T-GRIP-1–T-GRIP-5 + GFF-ST7 (the cascade engine and the existence of a stable ground attractor); GG-A6-GRIP GRIP-ST2 (the stratum's invariance under its descent); Frankel–Atiyah on an admissible stratum (uniqueness); definitions def:GRIPin.
T-GGA-No-Exit (corollary)	T-GRIP-In above; the weak-interaction relaxation doctrine of GG-A9-SM (channel completeness on the particle strata); fenced above the particle strata.
T-GRIP-Out-Necessity	GG-A5-GDOS (the fixed-parameter boundary law it must escape); GG-A6-GRIP def:GRIPout; worked cosmological instances in GG-A10-Cosmos.
T-GGA-as-Ground-State	GG-A6-GRIP def:GGA + GFF-ST7; GG-A7-Qi4 (the GGA-selector proposition, pillar by pillar); GG-A9-SM Part XI (the universal-identity insight).
Cascade-Self-Sustenance	GG-A7-Qi4 (the Qi-HAL switch: the minimal endogenous GRIP-Out machine); the layer-by-layer event table of this paper.
Layers 1–2 (T-GUT-Closure, T-Electroweak-Vacuum)	GG-A2-GG6 (the bulk and its integer ledger); GG-A3-BI6 (the anomaly-freedom closure); GG-A9-SM (the electroweak GRIP-Out and the weak-interaction GRIP-In).
Layers 3–4 (atomic, molecular)	GG-A8-QM (quantization, decoherence, and measurement as runtime phenomena); GG-A10-Cosmos (recombination as the GRIP-Out that opens the atomic stratum).
Layers 5–10 (chemistry to the cell)	GG-A4-Euclid (Q_B, the bioenergetic quantum, from the integer ledger); GG-A5-GDOS (the SeOS class and the boundary-port clause: ground-state-ness is boundary-condition-relative); GG-A7-Qi4 (the Arisaka equation and the four pillars).
Layers 11–18 (multicellularity to articulation)	GG-A7-Qi4 (the Qi-HAL memory architecture and the CDI ladder); GG-A8-QM (the measurement anatomy); the holographic triad of this paper.

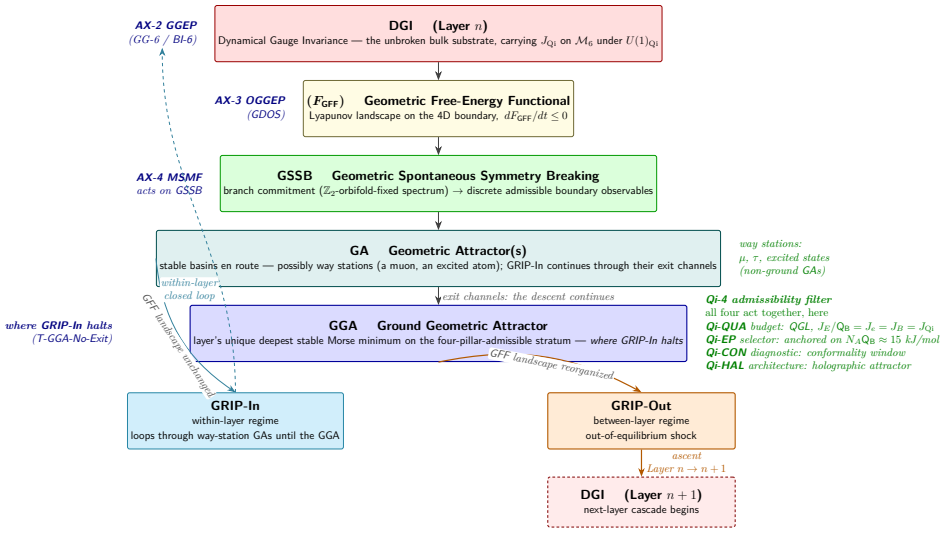


Figure 9: The four-move GRIP pipeline and the GRIP-In / GRIP-Out alternation — the heart of the cascade engine. The central column is the four-move descent DGI → (F_{GFF}) → GSSB → attractor; it halts at the Ground Geometric Attractor GGA, the layer's unique deepest minimum (T-GGA-No-Exit). Three constitutional axioms (left, blue) force the moves; the four Qi-4 pillars (right, green) act *together, at the terminus*, filtering the Morse minima — they are not stage labels of the pipeline, and the figure places them where they act. GRIP-In (cyan) loops within a layer, sustaining universal identity; GRIP-Out (orange) reorganizes the landscape and opens the next layer. Previewed as the front-matter showcase (Figure 3); walked step by step in §§14–18.

Part IV
Cosmos: layers 1–3

The shared input ledger and the cascade engine, then the first three Ground Geometric Attractors — the gauge group, the electroweak vacuum, and the periodic table

26 Plain-English overview: a staircase of ground states

What this Part is for. The reader who has reached this point has been carried through two long preparatory Parts. Part I posed the central question — *why are we here?* — in the operational form that physics requires, and traced the question's lineage from Aristotle and Lucretius through Spinoza, Hegel, Whitehead, and Wheeler down to the present framework. Part II walked through the inheritance from GG-A1-Constitution through GG-A10-Cosmos, naming the axioms, the postulates, the integer ledger, the Bianchi closure, the Euclidean discipline, the open-system boundary law, the runtime constitution, the four Qi-4 pillars, the Standard-Model parameter audit, and the cosmological inventory that the present paper imports as fixed. The present Part is not a continuation of those expositions. It is the formal *Statement of Results*: a list of eighteen named theorems — one for each of the seventeen cascade-layer rungs plus the meta-theorem of articulation — written so that a future author can cite any single layer individually without having to import the entire cohort apparatus.

We have arrived at the heart of the paper. Everything that follows in Parts IV through XI will refer back to the eighteen theorems we now state. Part XI will then prove the central recursive-uniqueness theorem **T-Origin** that binds all eighteen together. Part XI will exhibit the runtime dynamics on the GFF Morse landscape. Parts VI through IX will then read the cascade through the four readouts (cosmology, chemistry-to-life, the cognitive ladder, and the self-referential closure). But the structural skeleton — the spine on which everything else hangs — is the list of eighteen theorems set down in the present Part.

Why list the layers separately. A theory whose central claim is that one constitution forces eighteen outcomes must, at some point, write the eighteen outcomes down as separate theorems and prove that each is forced. Until the present Part, the cascade has been exhibited in tabular form (the cascade table of GG-A11-Origin Part IV (seventeen cascade layers plus meta-cognitive articulation), the layered codebooks of GG-A9-SM and GG-A10-Cosmos, the cross-domain readouts of Parts VIII–IX). A table is a powerful summary, but a table is not a theorem. A theorem is a claim plus a proof, written so that the claim can be cited and so that the proof can be checked. The present Part promotes each row of the cascade table to a named theorem. Eighteen theorems are now available for citation, criticism, refinement, and (most important) falsification. Future authors

who wish to test, say, the layer-7 bioenergetic closure are no longer required to import the whole cohort apparatus; they cite Theorem 37.1 of the present Part and proceed.

A staircase of ground states — the metaphor. The reader who has not yet read the technical machinery may find the following image useful. Imagine a staircase with eighteen steps. The bottom of the staircase is the six-dimensional bulk geometry of GG-A2-GG6: a single mathematical object that has no continuous adjustable parameters, only four axioms, seven postulates, and a small ledger of integers. Now, at the bottom of the staircase, drop a ball. The ball rolls down — not up — to a uniquely determined resting place: the unbroken-symmetry parent context, which then breaks to the Standard-Model gauge group. That is the first step. The first step is itself a sort of landscape: there is now a Standard Model on which to play. On that landscape, the ball can be dropped again. This time it rolls to the electroweak vacuum and finds its unique minimum at the Wilson–Hosotani holonomy. That is the second step. And so on.

Each step is the same process. Drop the ball; let it find the lowest stable place; declare that place the new floor; build the next landscape on top of it. The mathematics that governs the dropping is one and the same at every step. The output of each drop is a Ground Geometric Attractor (GGA): the uniquely most stable configuration that the geometry admits at that scale. Eighteen drops; eighteen GGAs. The eighteenth drop, by an extraordinary recursion that the present paper makes precise, lands on the configuration we call *intelligent observers articulating the constitution that produced them*. Cosmos, life, and mind are not three different staircases. They are three readings of the eighteen-step descent on one staircase.

Why a ball that rolls downhill produces intelligent observers. This is the central conceptual puzzle that the framework dissolves. Intuition trained on thermodynamics says that downhill descent should produce *less* structure, not more — the second law of thermodynamics drives systems toward equilibrium, not toward articulate observers. The puzzle's resolution is that the descent runs in the *open-system* free-energy landscape F_{GFF} of GG-A5-GDOS, not in the closed-system entropy landscape of textbook thermodynamics. In the GFF landscape, descent through the four-current locking $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ (the Arisaka equation of GG-A7-Qi4) builds structure because the boundary ports keep injecting low-entropy resources — starlight, geothermal flux, sugars, sensory data — that the open system can metabolize. The descent is irreversible (GG-A5-GDOS Theorem T-Lyapunov-Descent) but the work of descending leaves behind ordered configurations. Each GGA is one such ordered configuration. The cooking metaphor is exact: heating a pot of milk descends in temperature, but the descent through phase boundaries leaves yogurt — structured matter. The cascade through eighteen layers leaves us.

Roadmap for this Part. Section 27 restates the input ledger that the cascade will use. Section 28 states the cascade engine in four equations. Sections 31 through 40 state the eighteen named theorems, grouped into the six bands of the cascade — Cosmos, Chemistry, Life, Multicellularity, Mind, Articulation — one subsection per layer, each carrying its own codebook provenance. Section 41 gathers all eighteen as one auditable ledger, and Section 46 hands off to Part XI, where the recursive structure is given its formal name — **T-Origin** — and proved.

A note on register. The present Part is the longest in the paper. Each theorem section is structured identically (Constitutional inputs → Upstream theorems → Formal statement → Proof outline → Quantitative anchor → Physics intuition → Ascent mechanism → Examples → Kill criterion → Plain-English close) so that the reader who wishes to check one layer can do so without reading the seventeen others; the reader who wishes to take in the whole cascade can do so by reading in order. The structure is repetitive by design. The same theorem is being applied at every layer; the same template is therefore the honest way to display each application. The template takes two presentations: layers 1–3 and layer 18, which carry the cascade's derived and closing results, set each slot as its own headed paragraph, while layers 4–17 state the same slots compactly — kill criterion and physics intuition inline, constitutional inputs, upstream theorems and numerical anchors gathered into the layer's codebook-provenance block. Every layer carries every slot; only the typography differs.

Plain-English close. Eighteen named theorems are about to be stated. They are, in increasing complexity of substrate: the gauge group; the electroweak vacuum; the periodic table; the small molecules of life; the twenty amino acids; polymeric chemistry and the codon map; ATP as the energy currency; the RNA world; DNA and its four-letter archive; the first cell; the bacteria/archaea split; the eukaryotic cell; multicellular bodies; the first central nervous system; the insect ring attractor; the rodent hippocampal map; the conscious episode; and the present articulation of the constitution. Each is forced — not made probable, not made plausible, but *forced* — by the same constitutional clauses. Each can be cited individually. Each can be falsified individually. Each is, to our knowledge, the first formal mathematical theorem whose claim is the existence of the configuration named.

27 Constitutional inputs: the input ledger we will use

Plain-English opening. Before a theorem can be stated, its inputs must be declared. This is a discipline that physicists often skip, because the inputs of a textbook calculation are usually obvious from context (the Hamiltonian, the boundary conditions, the values of the coupling constants). But the present cascade runs from the deepest level of the geometric constitution all the way up to the act of articulating that constitution, and the temptation to smuggle in unstated assumptions at intermediate stages would be enormous if we did not write the inputs down explicitly at the outset. The discipline of GG-A4-Euclid (Arisaka, 2026, A4-Euclid) — zero free continuous parameters anywhere in the framework — is preserved at every cascade step in the present Part. We therefore restate the input ledger now, in compact form, with a sentence of explanation per item.

27.1 The four constitutional axioms

GG-A1-Constitution (Arisaka, 2026, A1-Constitution) T1.1–T1.4 states four constitutional axioms. We restate them in operational form.

AX-1 (LC, Lorentz–Causality). Spacetime is a Lorentzian manifold of signature $(-+++++)$ in the six-dimensional bulk and $(-+++)$ on the four-dimensional boundary. All admissible

trajectories are causal. *In plain English*: nothing physical can outrun light, and the bulk geometry on which the cascade runs is Lorentzian in the same sense Minkowski space is Lorentzian.

AX-2 (GGEP, Geometric–Gauge Equivalence Principle). Every gauge symmetry is a geometric symmetry of the bulk. No symmetry is appended as an internal label. *In plain English*: gauge invariance is geometry, not bookkeeping; the gauge currents are projections of bulk geometric currents.

AX-3 (OGGEP, Operational/Open GGEP). Every physical observable is the readout of a boundary projection of a bulk field, and every readout is operationally definable as an open-system exchange across a boundary surface. *In plain English*: "what we measure" is always a flux through a port, never a closed-system internal variable; the open-system structure is constitutional, not optional.

AX-4 (MSMF, Maximum-Symmetry–Minimum-Freedom). Among all geometries consistent with AX-1–AX-3, nature selects the one with the largest preserved symmetry group and the smallest residual continuous-parameter freedom. *In plain English*: when in doubt, choose the geometry that has fewer knobs; the universe runs the most symmetric machine that still produces the data we see.

Physics intuition on the axioms. The four axioms are by no means arbitrary. AX-1 is Minkowski causality, hardened to survive the six-dimensional bulk; without it the cascade has no well-posed light cone. AX-2 is Einstein's equivalence principle generalized from gravity to all four boundary forces; it forbids the internal-symmetry bookkeeping that has cluttered post-1954 gauge theory. AX-3 is the constitutional warrant for the entire GDOS apparatus of GG-A5-GDOS (Arisaka, 2026, A5-GDOS); without it the cascade cannot ascend past the closed-system thermodynamic equilibria. AX-4 is the constitutional discipline against fine-tuning; it is the source of the zero-free-parameters claim and the operational reason every cascade layer has a uniquely determined output.

27.2 The seven postulates

The four axioms are complemented by seven postulates POS-1–POS-7 (GG-A1-Constitution). In compact form:

POS-1–POS-4 (kinematic). Causality, Bianchi closure, gauge-current conservation, and renormalization-group covariance. Together they ensure that the bulk dynamics is well-posed and that the boundary currents are conserved up to anomaly closure.

POS-5 (RG, renormalization-group covariance). The running of couplings is consistent across scales; no scale carries a separately-tuned normalization.

POS-6 (OGN, Occam Gauge Normalization). The generic constitutional postulate that every normalization is fixed by discrete (integer or rational) data, forbidding hidden continuous knobs. Its *special-case realization is derived, not postulated*: the OGN-5 integer

ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ and the BI-6 trace-ratio anomaly lock $(a, b, c, d) = (1, -1, -2/5, -2/5)$ are *theorems* of GG-A3-BI6 (Arisaka, 2026, A3-BI6) — the unique special case of OGN on the six-dimensional bulk. In short: OGN is the postulate (POS-6); OGN-5 is its derived solution.

POS-7 (Measurement Foundation for the Higgs). The Higgs mechanism is an operational realization of the Wilson–Hosotani holonomy on S^1_θ, not a separate postulate.

Operational warrants (*theorems* of GG-A7-Qi4, not postulates). The cascade's later layers additionally invoke the four Qi-4 pillar *theorems* of GG-A7-Qi4 — T-QUA (four-current locking), T-EP (extremal / Markov-blanket closure), T-HAL (holographic-attractor-lattice), and T-EIC (Evolving-Inner-Cosmos closure). These are theorems of GG-A7-Qi4, not constitutional postulates: "postulate" is reserved for the GG-Constitution of GG-A1-Constitution.

27.3 The Geometric Universal Five Constants (GU-5)

GG-A4-Euclid (Arisaka, 2026, A4-Euclid) establishes that the entire continuous dimensional content of physics is carried by the *Geometric Universal Five Constants*,

$$\boxed{\text{GU-5} \;=\; \{c,\, G_N,\, \hbar\,;\, k_B,\, Q_B\}} \tag{13}$$

a (3 bulk + 2 boundary) pentad. The three bulk members are read off the three bulk directions of $\mathcal{M}_4 \times I_r \times S^1_\theta$: c is the conversion factor of the $(1, 3)$ Lorentzian signature on $\partial\mathcal{M}_6$, $\hbar$ is the integer-mode quantization factor on the compact S^1_θ, and G_N is the scale-curvature coupling on I_r. The two boundary members are conversion factors of the boundary projection: k_B is the thermodynamic (Gibbs-map) factor, and $\mathsf{Q_B}$ is the quantum-informational (Arisaka-equation) factor. The elementary charge e is *not* a member of GU-5: it is derived from $\alpha^{-1}(0) = 2^J + N^2 = 137$.

The $(3 + 2)$ structure: bulk and boundary, none with continuous freedom. The honest statement of GU-5 is structural, not a literal count of independent knobs. The three bulk constants are read off the three bulk directions; the two boundary constants are read off the boundary projection. Crucially, *no member of GU-5 carries continuous freedom*: each is a fixed conversion factor between human-chosen units and the natural units of the geometry, not an adjustable parameter. The constant k_B is the energy–temperature unit-system factor, fixed once the kelvin is defined ($k_B = 1$ in natural units); the constant $\mathsf{Q_B}$ is fixed by the chain

$$\{c, G_N, \hbar\} \to \alpha = \tfrac{1}{2^J + N^2} = \tfrac{1}{137} \to m_e \to E_{\mathrm{Ry}} \to \mathsf{Q_B} = (2/5)\, E_{\mathrm{Ry}}/K,$$

with $J = 7,\ L = 5,\ M = 1,\ K = 35$ supplied by the OGN-5 integer ledger. The $(3 + 2)$ split is an architectural rhyme with the $(3 + 2)$ structure of the OGN-5 integer pentad, not a claim that five independent dimensionful knobs exist. (A narrower reading names only the bulk three a "Conversion-Factor Triad" and reported the boundary two as derived; the canonical accounting of GG-A4-Euclid keeps all five together as GU-5, with the honest proviso that none of the five carries continuous freedom.)

Physics intuition on GU-5. Remarkably, the five constants are not five independent inputs. They are conversion factors of one six-dimensional bulk geometry, read at two strata: three in the bulk (the Lorentzian-signature anchor c, the angular-mode quantization $\hbar$, the scale-curvature coupling G_N) and two on the boundary projection (the thermodynamic k_B and the bioenergetic $\mathsf{Q_B}$). Five conversion factors, one geometry; together with the OGN-5 integers and the mathematical constants (π, e), they fix every dimensional scale in the framework with no continuous parameter intervening. This is the Euclidean discipline of GG-A4-Euclid made concrete.

27.4 The OGN-5 integer ledger

Remarkably, the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ of GG-A2-GG6 T-GG6-6 (Arisaka, 2026, A2-GG6) is the unique Diophantine closure compatible with the constitutional axioms. In operational form, $M = 1$ is the tensor-multiplet count and $N = 3$ is the color-triplicity index (its three-generation face a downstream consequence). $L = 5$ is the SU(5) grand-unified block size, and $J = 7$ is the dyadic-charge exponent (so $2^J = 128$, the inverse fine-structure constant at M_Z). Finally, $K = 35$ is the scale-depth integer (so $\mathsf{Q_B} = (2/5)E_{\mathrm{Ry}}/K$). These five integers are the entire arithmetic content of physics.

Why integers, not continuous parameters. Integer ledgers are forced by the topology of the bulk: the compact circle S^1_θ admits only integer KK modes; the radial throat I_r admits only integer scale depths; the bulk-to-boundary projection admits only integer family-projector ranks. Continuous moduli are forbidden by AX-4. The cascade output at every layer is therefore quantized by an integer derived from $(M, N, L; J, K)$. Every quantitative anchor in the eighteen theorems that follow traces back to this ledger.

27.5 The completeness of the input ledger

The four axioms, the seven postulates, the Geometric Universal Five Constants GU-5, and the OGN-5 integer ledger together fix the entire input ledger of the framework. Specifically:

- No free continuous parameters appear anywhere. The 28 free parameters of the boundary Standard Model are derived in GG-A9-SM. The 15 cosmological observables are derived in GG-A10-Cosmos. The bioenergetic, chemical, and cognitive readouts are derived in the present paper and its companions.
- No hidden continuous moduli appear in the bulk. The bulk dimensionality ($D = 6$), the topology ($\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$), and the scale profile are all fixed by AX-1–AX-4 via the eight constitutional lemmas of GG-A9-SM Part XI (T-SM-62.1).
- No teleological assumption is imported. The cascade ascends because the GFF Lyapunov functional descends. The cascade does not ascend because the framework wants intelligent observers to exist. The inevitability is mathematical, not intentional.

Plain-English close. This is the complete input ledger. Every theorem of the present Part follows from these inputs. Nothing else is assumed; nothing else is needed. The reader who later wishes

to falsify a single theorem can do so by attacking only the inputs declared here and the upstream lemmas cited in the proof outline of that theorem. Constitutional transparency is the framework's discipline; without it, the inevitability claim of the cascade would degenerate to a slogan.

28 The cascade engine in four equations

Plain-English opening. Roughly speaking, a cascade has two parts: an engine that drives it, and a landscape on which it runs. The engine is the open-system descent that has been formalized in GG-A6-GRIP (Arisaka, 2026, A6-GRIP) as GRIP (the Gauge-Runtime Invariance Pipeline). The landscape is the Geometric Free-Energy Functional F_{GFF} of GG-A5-GDOS (Arisaka, 2026, A5-GDOS). Together they form what the framework calls a *System Instance Packet* (SIP): the canonical five-field object on which one cascade application runs. We restate all three in compact form because every theorem of the present Part is an instance of the same construction.

28.1 The canonical GRIP form

The cascade engine reads

$$\boxed{\mathsf{GRIP} \;:=\; \mathsf{DGI} \;\longrightarrow\; (\mathsf{GFF}) \;\longrightarrow\; \mathsf{GSSB} \;\longrightarrow\; \mathsf{GGA}} \tag{14}$$

where DGI (Dynamical Gauge Invariance) is the unbroken-symmetry parent context, (GFF) is the Morse landscape on which descent runs, GSSB (Geometric Spontaneous Symmetry Breaking) is the chain of Bogomolnyi-saturating saddle events, and GGA (Ground Geometric Attractor) is the unique global minimum reached.

Where the Qi-4 pillars act. The four Qi-4 pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) do not label the stages of this pipeline. They act *together, at its terminus*: of the Geometric Attractors the GFF landscape offers on a stratum, exactly one passes all four admissibility filters, and that one is the global minimum — the stratum's GGA. The filters are stated pillar by pillar, in GG-A7-Qi4's canonical order of budget, selector, diagnostic and architecture, in Part XI §49, where they are also proved to be jointly necessary and sufficient.

The Lyapunov descent law. The Geometric Free-Energy Functional satisfies

$$\partial_t F_{\mathsf{GFF}}[p;\mathcal{P}] \;\leq\; 0, \tag{15}$$

with equality if and only if p is a critical point of F_{GFF} (GG-A6-GRIP T3.2, the Lyapunov-descent law, under its detailed-balance hypothesis; in a driven layer the descending function is the relative entropy to the layer's stationary state, §17). This is the open-system analog of the second law of thermodynamics, operating simultaneously on all four boundary currents (energy, electromagnetic, baryonic, informational). The descent is irreversible; the cascade reaches a Morse minimum in finite time; the cascade does not wander.

The Bogomolnyi action structure. Between adjacent saddles in the GSSB chain, the instanton action is πk with k the Morse-index drop. Summed over a stratum of complex dimension $N_g - 1$,

$$S_{\mathrm{tot}}(N_g) \;=\; \pi\,\frac{N_g(N_g-1)}{2}, \tag{16}$$

the closed sum of GG-A6-GRIP T-GRIP-4. The BI-6 action budget $S_{\mathrm{BI}} = 3\pi$ inherited from $(K, J) = (35, 7)$ bounds this sum and forces $N_g \le 3$ on the family-projector stratum (GG-P2-N3 (Arisaka, 2026, P2-N3)).

28.2 The SIP tower

A System Instance Packet (SIP, GG-A7-Qi4 T-SIP) is the canonical five-field object

$$\boxed{\mathsf{SIP} \;=\; [\,(Z,g),\;\; \Pi,\;\; (L_{\mathsf{GDOS}},\eta),\;\; (F_{\mathsf{GFF}},J),\;\; (\mathrm{Obs},\mathrm{Kill})\,]} \tag{17}$$

on which one cascade application runs. The fields are: (Z, g) the state manifold and metric; Π the boundary ports; $(L_{\mathsf{GDOS}}, \eta)$ the GDOS generator and noise closure; (F_{GFF}, J) the GFF Lyapunov landscape and locked currents; (Obs, Kill) the observable bundle and kill criterion.

The recursion. The cascade is the iterated map

$$\mathsf{GGA}_{n-1} \;\longmapsto\; \widehat{\mathsf{SIP}}^{(n)} \;\longmapsto\; \mathsf{GGA}_n, \tag{18}$$

where GGA_{n-1} supplies fields 1–3 (state manifold, ports, generator) of $\widehat{\mathsf{SIP}}^{(n)}$, while fields 4–5 (GFF landscape and observable/kill bundle) are then determined by GDOS descent and the Qi-4 admissibility filter. Iterated through eighteen layers (seventeen cascade layers plus the meta-cognitive articulation), this recursion is the cascade of the present Part.

28.3 The Arisaka equation and the energy-injection ascent mechanism

The driving identity of the cascade is the Arisaka equation

$$\boxed{\frac{J_E}{\mathsf{Q_B}} \;=\; J_e \;=\; J_B \;=\; J_{Qi}} \tag{19}$$

of GG-A7-Qi4 T-QUA.2, the operational layer of Qi-QUA, which follows from the rank-one inflow theorem T-QUA.1 by GG-A7-Qi4's compatibility relation $\mathfrak{C}_{\mathrm{QUA}}$ and states that the four boundary currents are locked into a single rank-one ray: every catalytic step transfers exactly one electron, one baryon, and one information bit, consuming exactly $\mathsf{Q_B} \approx 0.1555$ eV of electric energy.

Why this drives the ascent. At every cascade layer, sustained energy injection at the layer-n substrate keeps J_E positive; the Arisaka equation then forces J_e, J_B, J_{Qi} all positive in lock-step. The GFF landscape on the layer-n stratum descends to its layer-n minimum (the layer-n GGA); the descent leaves behind ordered configurations that constitute the substrate of the layer-$(n+1)$

stratum; the cascade then ascends to the next layer. The ascent is not the inverse of the descent. The descent runs the energy budget; the ascent inherits the ordered residue. This is the operational content of the cascade's central paradox — entropy descends while structure ascends — and it is the engine that the eighteen theorems of the present Part will repeatedly invoke.

Plain-English close. In one sentence: GRIP is the universal cascade engine, SIP is the canonical five-field substrate it runs on, F_{GFF} is the Morse landscape on which the descent occurs, the Arisaka equation supplies the four-current closure that locks every step, and the GGA is the unique cascade output at each layer. Eighteen cascade applications of one mechanism on eighteen substrates of increasing complexity; one engine, one landscape, one closure.

29 The leading theories and models today

Before this Part states what GG-Theory derives at the first three layers, it is worth setting down what the field already has — accurately, and without the faint condescension that framework papers sometimes bring to the subject. The standard account of the early universe is the most successful quantitative description of nature ever written down, and every number this Part predicts is scored against it.

29.1 What the standard account gets right

The concordance cosmology. ΛCDM describes the universe from a fraction of a second after the beginning to the present with six fitted parameters. From those six it reproduces the cosmic microwave background's temperature and polarization spectra across three decades of angular scale, the primordial abundances of hydrogen, helium and lithium computed over nine orders of magnitude in density, the growth of structure from the smoothness of the last-scattering surface to the observed galaxy distribution, and the distance–redshift relation out to redshifts beyond unity. Six numbers, fitted once, and the rest follows.

The Standard Model of particle physics. On the particle side the record is, if anything, better. Quantum electrodynamics predicts the electron's magnetic moment to a part in 10^{12}. The electroweak theory predicted the W, the Z and the Higgs before any of them was seen, and predicted their masses in terms of each other. Quantum chromodynamics accounts for the proton's mass to a few percent from lattice computation with no free parameter beyond the coupling. No experiment at any accelerator has ever found a significant departure from it.

Inflation. An early epoch of accelerated expansion explains why the universe is spatially flat, why regions that could never have exchanged a signal share the same temperature to a part in 10^5, and why the primordial fluctuation spectrum is nearly but not exactly scale-invariant. The last of these is a prediction, it was made in advance, and it was confirmed.

29.2 What the standard account is, as a structure

The point worth holding onto is not that these theories are approximate. It is what kind of object they are. Each is a *framework with inputs*: a set of equations whose form is fixed by symmetry, and a set of numbers whose values are fixed by measurement. The Standard Model together with general relativity carries thirty such numbers — twenty-eight of the Standard Model, plus G_N and Λ — and ΛCDM's six are a partly overlapping, partly additional set. Given the numbers, the theories compute. They do not, and do not claim to, say where the numbers came from.

That is not a defect. It is a division of labor, and for a century it has been an extraordinarily productive one. GG-A4-Euclid (Arisaka, 2026, A4-Euclid) states the division in the sentence this paper uses throughout: *the Standard Model computes consequences; GG-Theory supplies structure.* The question this Part takes up is whether the second half of that division can be made to do any work.

30 What they leave unsolved

Four questions survive the successes above. They are not obscure; three of them are in every graduate textbook. What is worth noticing is that they are all the *same kind* of question — each asks why a number or a choice came out one way rather than another, and the standard account's answer in every case is that it was measured.

30.1 The values themselves

Thirty continuous constants, each measured and none explained. The fine structure constant is 1/137.035999177(21) and nothing in the Standard Model says why. The electron is 1836 times lighter than the proton and nothing says why. The cosmological constant is smaller than the natural scale of the theory that is supposed to generate it by a famously enormous factor, and nothing says why. A theory that supplies even a few of these would be doing something the standard account does not attempt.

30.2 The matter asymmetry

The universe contains matter and almost no antimatter, in the ratio $\eta_B = (6.12 \pm 0.04) \times 10^{-10}$ baryons per photon. Sakharov's three conditions say what is needed to produce such an excess: baryon-number violation, C and CP violation, and a departure from equilibrium. The Standard Model supplies all three in principle and none in practice — its CP violation, carried by the Cabibbo–Kobayashi–Maskawa phase, falls short of what is needed by roughly ten orders of magnitude.

So a mechanism must be added, and here is the difficulty that this Part will return to. The menu of mechanisms is long — electroweak baryogenesis, GUT-scale baryogenesis, standard high-scale leptogenesis, Affleck–Dine — and each carries adjustable quantities. It is a matter of record that leptogenesis has *accommodated* η_B rather than predicted it. A framework that fixed the number without a dial would be making a different kind of claim.

30.3 The two horizon problems, of which only one is famous

Inflation solves the horizon problem: regions of the sky that were never in causal contact nonetheless share a temperature, because they were in contact before the stretch. That is the sameness of *conditions*.

GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) names a second question that the field has circled for fifty years without giving it a name: the sameness of *things*. Every electron in every direction has the same mass, the same charge, the same magnetic moment. Inflation does not explain that, and it was never asked to. Two electrons at opposite horizons are identical not because they agreed on a value but because — if the argument of §32 holds — there was only ever one value available to them.

GG-A10-Cosmos then names a third, which is sharper still: the sameness of *choices*. Matter won over antimatter here. It also won there, in every patch, by the same margin. If the mechanism that decided it draws from an ensemble, the margin should vary across regions that decided independently.

30.4 The stability of the proton

The proton does not decay. In the Standard Model this is an *accident*: baryon number is not a gauge symmetry but an accidental global one, conserved because no renormalizable operator violating it can be written from the available fields. Accidental symmetries are not protected. Every grand unified theory that embeds the Standard Model in a larger group breaks the accident and predicts a finite proton lifetime, and every such prediction so far has been excluded by measurement: $\tau/B(p \to e^+\pi^0) > 2.4 \times 10^{34}$ yr at 90% confidence (Arisaka, 2026, P6-Proton). The standard account has no reason why the proton should be stable; it has an observation that it is.

31 Cosmos: layers 1–3

The first three rungs are the ones the cohort has already closed in the published record: the gauge structure, the electroweak vacuum, and the periodic table. They descend from GG-A9-SM and GG-A10-Cosmos and carry the *Derived* tag end to end. Everything above them is built on this floor. These three cosmological rungs sit inside one open-system descent — from the GUT edge through the electroweak lock to atomic recombination and on to the present — drawn to scale in Figure 11, where each key epoch is read at once in energy, time, and the scale factor: layer 1 opens at the GUT edge, layer 2 is the electroweak lock crossing, and layer 3 is the recombination-era switch $z_* = e^7$ marked near the bottom.

31.1 T-GUT-Closure: Layer 1 — the Standard Model gauge group

Plain-English opening. Let us begin at the bottom of the staircase. The most fundamental question the cascade can ask is: *what set of forces is allowed to exist on the four-dimensional boundary of the six-dimensional bulk?* Textbook particle physics gives an empirical answer: the Standard Model gauge group $\mathrm{SU}(3)_c \times \mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$, with the three forces strong, weak, and electromagnetic, plus gravity sitting outside. The cascade's answer is: nothing else is possible. No

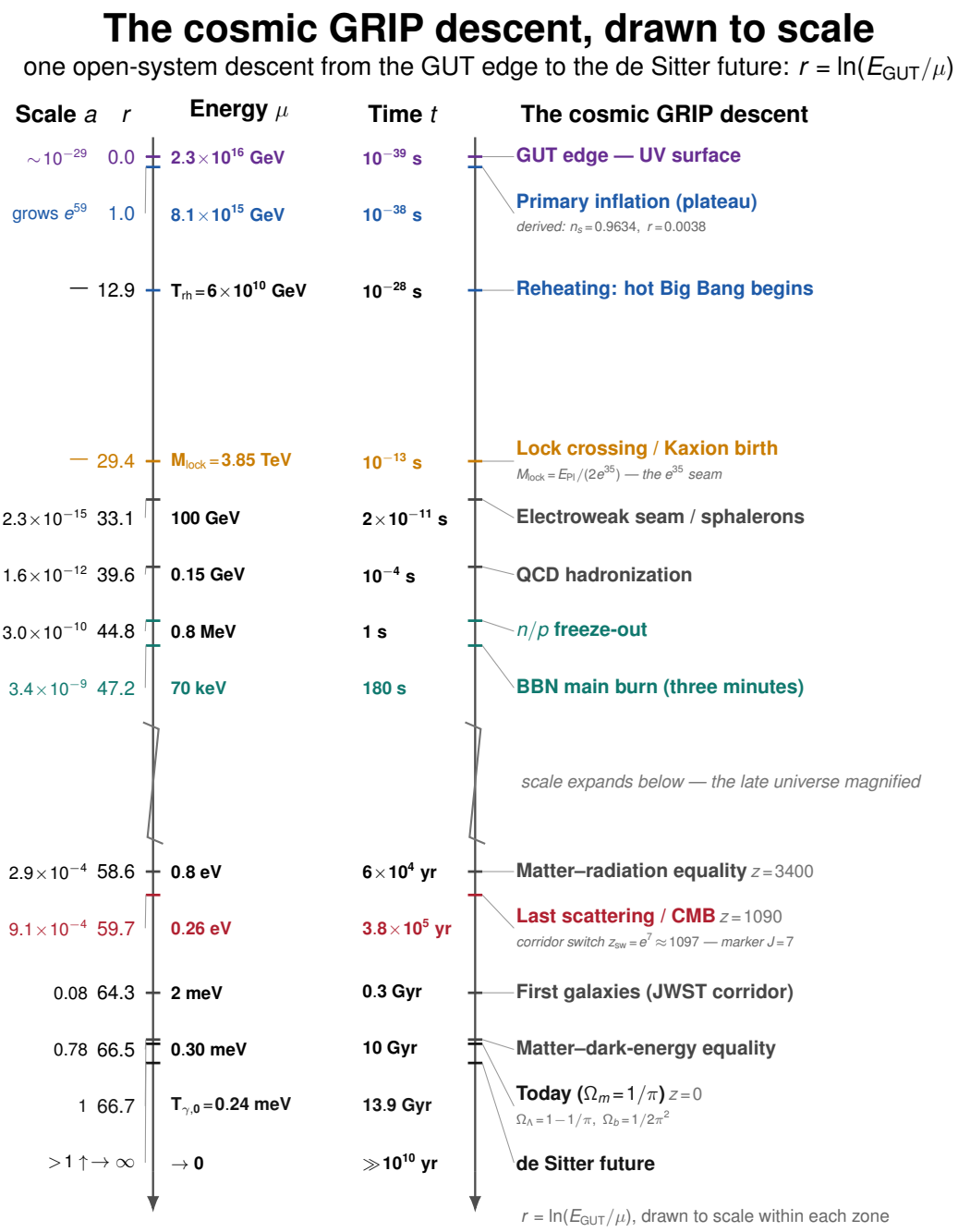


Figure 11: The cosmic GRIP descent, drawn to scale on $r = \ln(E_{\rm GUT}/\mu)$. One open-system descent from the GUT edge ($r = 0$) to the de Sitter future, read simultaneously in energy μ, time t, and the scale factor a, each against the radial depth r; the late universe is magnified below the break so that recombination, structure, and the present epoch stay legible. The three cosmological rungs of this Section are marked on it: *layer 1* at the GUT edge (the unified gauge group), *layer 2* at the electroweak lock crossing $M_{\rm lock} = 3.85$ TeV, and *layer 3* at the recombination-era switch $z_* = e^7 \approx 1097$ (integer-ledger marker $J = 7$). Highlighted rows carry the framework's derived markers — the plateau tilt and tensor ratio ($n_s = 0.9634$, $r = 0.0038$), the lock $M_{\rm lock} = E_{\rm Pl}/(2e^{35})$, and today's π-locked inventory. Every value is the standard cosmological reading of the master chronology of GG-A10-Cosmos; nothing on the axis is fitted.

other gauge group can close the Bianchi identity in the bulk while respecting the constitutional axioms. The Standard Model gauge group is the unique GGA on the gauge stratum. Like a single tuning system being forced by the structural constraints of Western music, the unbroken-symmetry parent admits exactly one descent to a layer-1 GGA, and that descent reads as the four-force architecture we observe.

Constitutional inputs. The layer-1 cascade requires AX-1 (LC, causality on the bulk), AX-2 (GGEP, gauge invariance as geometric invariance), AX-4 (MSMF, maximum-symmetry–minimum-freedom), POS-6 OGN (OGN-5 integer ledger), and POS-6 OGN (BI-6 anomaly closure). In plain language: AX-1 ensures the bulk has a well-posed light cone; AX-2 ensures the gauge group is read off geometrically; AX-4 forces the largest preserved symmetry consistent with the bulk; POS-6 OGN fixes the integers $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ that select the unification structure $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$ as the parent; POS-6 OGN fixes the Green–Schwarz coefficients that close the anomaly on a single tensor multiplet. The seven postulates POS-7–GG-A7-Qi4 T-EIC are not yet active at layer 1 because they govern operational and biological structure that has not yet emerged.

Upstream theorems imported. The layer-1 cascade imports five upstream theorems. (i) GG-A2-GG6 T-GG6-1–T3 (Arisaka, 2026, A2-GG6) fixes the bulk dimensionality ($D = 6$), the topology ($\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$), and the scale profile. This is the geometric stage on which the gauge cascade runs. (ii) GG-A3-BI6 (T-BI6-9.1) (Arisaka, 2026, A3-BI6) establishes the BI-6 trace-ratio lock $(a, b, c, d) = (1, -1, -2/5, -2/5)$. This is the anomaly closure that forbids any gauge content beyond the Standard Model from coupling on the bulk. (iii) GG-A2-GG6 T-GG6-6 establishes the OGN-5 integer ledger. This is the Diophantine closure that fixes the rank of the unification group. (iv) GG-A9-SM Part XI (Arisaka, 2026, A9-SM) establishes that the four-force architecture is the unique GGA on the gauge stratum. This is the explicit identification of which Morse minimum the cascade lands on. (v) GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-5 (Arisaka, 2026, A6-GRIP) (the GRIP structure theorem) establishes that the cascade endpoint is uniquely most stable. This is the structural uniqueness clause.

Formal statement.

Theorem 31.1 (T-GUT-Closure: layer-1 GGA (T-Origin-25.1))**.** *Let $\widehat{\mathsf{SIP}}^{(1)}$ be the layer-1 SIP on the bulk-gauge boundary stratum $\mathcal{S}_1$, with state manifold the space of admissible gauge connections on $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$, ports the bulk-to-boundary projection of GG-A5-GDOS, generator the bulk gauge dynamics of GG-A2-GG6, GFF landscape the gauge sector of F_{GFF}, and observable/kill bundle the four-force boundary architecture. Then, under the GG-Constitution $\mathcal{C}$ and the cascade engine of (14), the layer-1 GGA is unique and equals*

$$\mathsf{GGA}_1 \;=\; \big[\, G_{\mathrm{SM}} \;=\; \mathrm{SU}(3)_c \times \mathrm{SU}(2)_L \times \mathrm{U}(1)_Y,\;\; G_{\mathrm{grav}},\;\; \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi} \,\big], \tag{20}$$

where G_{SM} is the surviving electroweak-strong gauge group, G_{grav} is the four-dimensional gravity from the scale-curvature sector, and $\mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$ are the two surviving Abelian factors. Proton stability is forced: the orbifold projection removes the leptoquarks that would mediate the leading

$p \to e^+\pi^0$ operator, so the framework predicts a long lifetime, $\tau_p > 10^{35}$ yr; the model-independent floor from the surviving mass-dimension-≥ 6 operators is $\tau_p > 10^{34}$ yr (the headline prediction clears, and the floor sits below, the current Super-Kamiokande bound $\tau_p > 2.4 \times 10^{34}$ yr).

Proof outline. Step 1: the bulk dimensionality $D = 6$ and the topology $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$ are forced by GG-A2-GG6 T-GG6-1–T3. In plain language, the six dimensions are the minimum required to absorb c, G_N, and $\hbar$ as geometric data without any external fitting; the topology is the unique one compatible with AX-4's symmetry-maximization clause. Step 2: the bulk gauge content is then forced to be $\mathrm{Spin}(1,5) \times \mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$ by GG-A3-BI6 (T-BI6-9.1) and the OGN-5 integer ledger.

In plain language, this is the only gauge content that closes the Bianchi anomaly polynomial on a single tensor multiplet with rank consistent with $L = 5$. Step 3: orbifold projection on S^1_θ breaks $\mathrm{SU}(5) \to \mathrm{SU}(3)_c \times \mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$. In plain language, the angular boundary conditions remove the leptoquark gauge bosons that would mediate fast proton decay; what remains is the four-force architecture of low-energy physics.

Step 4: the Wilson–Hosotani holonomy on S^1_θ breaks $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y \to \mathrm{U}(1)_{\mathrm{EM}}$ at the electroweak scale (this is layer 2, but the layer-1 cascade prepares the substrate). Step 5: uniqueness follows from the cascade-closure structure theorem **GRIP-ST5** of GG-A6-GRIP, sharpened by the Qi-QUA-admissibility constraint of GG-A7-Qi4 T-QUA.1 that locks the four boundary currents onto a single rank-one ray.

Quantitative anchor. At the unification scale $M_{\mathrm{GUT}} \sim 2 \times 10^{16}$ GeV, the three Standard Model couplings meet within the dyadic precision $2^{-J} = 1/128$ of the closed-form predictions

$$\alpha^{-1}(M_Z) \;=\; 2^J \;=\; 128, \tag{21}$$

$$\sin^2\theta_W(M_Z) \;=\; \frac{L^2}{4N^3} \;=\; \frac{25}{108} \;=\; 0.23148\ldots, \tag{22}$$

$$\alpha_s(M_Z) \;=\; \frac{1}{\pi e} \;=\; 0.11710\ldots, \tag{23}$$

of GG-A9-SM TO1–TO3 (Arisaka, 2026, A9-SM). The Kaluza–Klein lock-cluster scale is $M_{\mathrm{lock}} = 3.85 \pm 0.10$ TeV (predicted by GG-P1-KK (Arisaka, 2026, P1-KK), testable at HL-LHC). The framework's proton-lifetime prediction is the orbifold-forbidden value $\tau_p > 10^{35}$ yr in the dominant $p \to e^+\pi^0$ channel (Table 8), with a model-independent floor of $\tau_p > 10^{34}$ yr; both lie above the current Super-Kamiokande bound $\tau_p > 2.4 \times 10^{34}$ yr, which Hyper-Kamiokande and DUNE will probe toward 10^{35} yr. The scale-depth integer is $K = 35$, the ledger's second entry is $N = 3$, and the dyadic exponent is $J = 7$ — all read off from the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$.

Physics intuition. At first-year-graduate-student level, the picture is as follows. The Standard Model gauge group has, in textbook presentations, an embarrassing structural feature: it is a product of three independent factors $\mathrm{SU}(3) \times \mathrm{SU}(2) \times \mathrm{U}(1)$, with three apparently unrelated couplings g_3, g_2, g_1 that nevertheless converge (almost) at the GUT scale. The conventional grand-unified-theory tradition (Georgi–Glashow SU(5), Pati–Salam, SO(10), E_6, $\cdots$) postulates a parent simple group

that is broken by Higgs scalars to give the observed factor structure. The framework's answer is that the parent group is $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$, broken not by Higgs scalars but by orbifold projection and Wilson–Hosotani holonomy on S^1_θ; the two Abelian factors $\mathrm{U}(1)_B$ and $\mathrm{U}(1)_{Qi}$ are bookkeeping currents (baryon number and Qi information) that survive the breaking; and the entire structure is forced by the BI-6 anomaly closure on a single tensor multiplet. No Higgs is required to break SU(5); the geometry does it. This is a structural improvement on textbook GUT: there is no fine-tuning of Higgs potentials, no leptoquark gauge bosons mediating fast proton decay, and no continuous parameters in the breaking pattern.

The Wilson–Hosotani mechanism is worth a paragraph in its own right. Imagine a gauge connection on a circle. The eigenvalues of the holonomy around the circle are gauge-invariant, and they are continuous parameters of the connection only in the absence of dynamics. Once the connection has a kinetic term and is coupled to charged matter, the holonomy eigenvalues become *calculable*: they are determined by minimizing the one-loop effective potential on the moduli space of flat connections. In the six-dimensional bulk, the circle is S^1_θ; the holonomy is the Hosotani phase α_H; and the minimum of the effective potential lies at the value that breaks $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y \to \mathrm{U}(1)_{\mathrm{EM}}$ and gives the electroweak vacuum. In short: the Higgs vacuum value is calculated by the cascade, not postulated. This is the mechanism that drives layer 2.

Energy-injection ascent mechanism. At the GUT scale, sustained energy injection through the scale throat keeps the bulk gauge connection at finite temperature (the GUT-era plasma). As the universe cools and the throat redshifts, J_E decreases monotonically; the Arisaka equation (19) forces J_e, J_B, J_{Qi} to decrease in lock-step. The GFF landscape on the bulk-gauge stratum descends to its G_{SM} minimum; the descent is irreversible (GG-A5-GDOS Lyapunov); the GUT phase transition completes at $T \sim M_{\mathrm{GUT}}$. The ordered residue of the descent — the broken gauge connection G_{SM} — becomes the substrate of layer 2. In particular, the surviving $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ gauge connection now hosts the Wilson–Hosotani moduli space, and the Hosotani phase α_H on S^1_θ is the layer-2 GFF variable that will descend to the electroweak vacuum. The ascent to layer 2 is forced because the substrate of layer 2 did not exist before the layer-1 GGA was reached; once the GUT phase transition completes, the layer-2 cascade can run.

Examples and daily-life metaphors. Three metaphors clarify the layer-1 closure. First, like the structure of music: any honest Western tuning system that closes the cycle of fifths admits twelve-tone equal temperament as the (almost) unique solution; the closure constraint $(3/2)^{12} \approx 2^7$ forces the temperament structure, just as the BI-6 anomaly closure forces G_{SM} on the bulk. Second, like a parts list for a self-consistent machine: if you are asked to build a clock with the smallest number of parts that still keeps accurate time, the parts list is forced (one mainspring, one escapement, one balance wheel, one set of gear trains in a particular ratio); the analogous parts list for the unbroken-symmetry parent is $\mathrm{Spin}(1,5) \times \mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$, forced by the constitutional axioms. Third, like a Sudoku puzzle: once enough cells are filled correctly the solution is unique; the BI-6 closure plus the OGN-5 ledger plus the axioms together fill enough cells of the gauge-content Sudoku to force the rest.

Kill criterion. The layer-1 theorem is falsified by any of the following observations: (a) proton decay $p \to e^+\pi^0$ detected at a lifetime below the cascade prediction $\tau_p > 10^{35}$ yr in the dominant channel; (b) the discovery of a fourth Standard Model gauge factor (e.g. a TeV-scale Z' from an additional unbroken U(1) beyond $\mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$); (c) the failure of the dyadic prediction $\alpha^{-1}(M_Z) = 128$ at the dyadic precision of 2^{-7}; (d) the absence of the Kaluza–Klein lock-cluster at $M_{\mathrm{lock}} = 3.85 \pm 0.10$ TeV at HL-LHC despite reaching the required sensitivity; (e) the discovery of a leptoquark gauge boson at a scale inconsistent with the orbifold-projection breaking pattern. Any one of these would falsify Theorem 31.1.

Plain-English close. The Standard Model gauge group is not a feature of nature that physicists discovered by trial and error; it is the unique answer to the question *what gauge structure can close the Bianchi anomaly on the six-dimensional bulk?* Three forces, two surviving Abelian factors, gravity outside. The proton is stable because the orbifold projection removes the leptoquarks that would mediate its decay. The fine-structure constant at the Z pole has the value $1/128$ because $2^J = 2^7 = 128$ with J fixed by the integer ledger. The weak mixing angle has the value $25/108$ because $L^2/(4N^3) = 25/108$ with $(L, N) = (5, 3)$. The strong coupling at the Z pole has the value $1/(\pi e) \approx 0.117$ because that is the only cost-two scale-curvature coupling that closes within experimental precision. Three pure numbers; one geometry; layer 1 done.

31.2 T-Electroweak-Vacuum: Layer 2 — charged leptons, quarks, and the Higgs vev

Cohort note. The particle-physics paper GG-A9-SM states this layer's transition in regime language, and the statement is worth importing verbatim because it makes the two regimes concrete at their very first physical instance: the selection of the electroweak vacuum was that paper's one GRIP-Out event — it *created* the landscape on which the fermion basins live — while every weak decay since ($\tau \to \mu \to e$; the radioactive descent of every unstable nucleus toward stability) is GRIP-In on that fixed landscape, with the weak charged current as Nature's implementer of the descent. In one sentence: the electroweak GRIP-Out built the landscape once; the weak-interaction GRIP-In has been walking it ever since.

Plain-English opening. Once the gauge group G_{SM} exists, the next question the cascade asks is: *at what energy scale does electroweak symmetry break, and at what masses do the fermions condense?* Textbook particle physics gives the empirical numbers — $v \approx 246$ GeV, $m_e \approx 0.511$ MeV, $m_\mu \approx 105.66$ MeV, $m_\tau \approx 1776.86$ MeV, six quark masses, three neutrino masses — and treats each as an independent input. The cascade's answer is: every one of these numbers is forced. The electroweak vacuum is the unique GGA on the Wilson–Hosotani moduli space of S^1_θ; the charged-lepton masses are the unique GGA on the family-projector stratum; the quark masses are the unique GGA on the CKM-rotated stratum. Like a vending machine that accepts only certain coin denominations, the geometry admits only certain mass values — and those values are what we measure.

Constitutional inputs. The layer-2 cascade requires AX-2 (GGEP, gauge-as-geometry), AX-3 (OGGEP, open-system boundary), AX-4 (MSMF), POS-6 OGN (OGN-5), POS-6 OGN (BI-6), and POS-7 (Measurement Foundation for the Higgs). In plain language: POS-7 states that the Higgs mechanism is not a separate postulate but an operational realization of Wilson–Hosotani holonomy on S^1_θ; this is the constitutional warrant for treating the electroweak vacuum as a cascade output rather than a fit input.

Upstream theorems imported. Four upstream theorems are imported. (i) Theorem 31.1 (layer-1 GGA) supplies the substrate: the $G_{\rm SM}$ gauge connection on the broken bulk. In plain language, this fixes which gauge bosons are available to acquire mass through the Higgs mechanism. (ii) GG-A9-SM TO4 (Arisaka, 2026, A9-SM) (Wilson–Hosotani vev theorem) establishes that $v = M_{\rm lock}(2/L)^N$ with $(M_{\rm lock}, L, N) = (3.85\ \text{TeV}, 5, 3)$.

In plain language, this is the closed-form prediction for the Higgs vacuum value as a scale-suppressed multiple of the Kaluza–Klein lock-cluster scale. **Status of the derivation.** The arithmetic $v = 3850 \times (2/5)^3 \approx 246.4$ GeV is the cascade output; the upstream derivation that the unique stable minimum of the one-loop effective potential on S^1_θ sits at the cascade-determined holonomy phase is the content of GG-A9-SM §§5–7 (with the loop integral, the minimization, and the scale-suppression structure exhibited explicitly there). The present theorem inherits the upstream result by citation; a self-contained re-derivation is out of scope for GG-A11-Origin and would duplicate GG-A9-SM.

A reader who wishes to verify the derivation step by step should consult GG-A9-SM §§5–7. (iii) GG-A9-SM §§15–17 (charged-lepton mass-ladder theorem) establishes the cascade-depth dependence of the lepton masses with $m_\tau/m_\mu = 16.817$ and $m_\mu/m_e = 206.768$. In plain language, the lepton mass hierarchy is quantized by depth in the family-projector moduli, not by free Yukawa couplings. (iv) GG-A7-Qi4 T-QUA.2 (the Arisaka equation, the operational layer of Qi-QUA) supplies the four-current locking that fixes the rank-one structure of the Yukawa matrices in the family space.

Formal statement.

Theorem 31.2 (T-Electroweak-Vacuum: layer-2 GGA (T-Origin-26.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(2)} = \widehat{\mathsf{SIP}}^{(2)}[\mathsf{GGA}_1]$ *be the layer-2 SIP constructed from the layer-1 attractor: state manifold the Wilson–Hosotani moduli space on* S^1_θ *extended by the family-projector moduli, ports the four-current bookkeeping of GG-A7-Qi4, generator the bulk Yukawa dynamics, GFF landscape the electroweak-vacuum sector of* F_{GFF}*, observable/kill bundle the boson and fermion mass spectrum. Then the layer-2 GGA is unique and reads*

$$\begin{aligned} \mathsf{GGA}_2 \;=\; [\; & \langle H\rangle = v/\sqrt{2},\ v = M_{\rm lock}(2/L)^N \approx 246.4\ \text{GeV}, \\ & \{m_e, m_\mu, m_\tau\},\ \{m_u, m_d, m_s, m_c, m_b, m_t\}, \\ & V_{\rm CKM},\ V_{\rm PMNS}\ ] \end{aligned} \tag{24}$$

with $m_W = (g_2/2)v \approx 80.4$ *GeV,* $m_Z = m_W/\cos\theta_W \approx 91.2$ *GeV,* $m_H = v\sqrt{2\lambda_H}$*, which at the leading-order value* $\lambda_H = 1/8$ *gives* 123.1 *GeV against the measured* 125.20 ± 0.11 *GeV, and charged-lepton ratios* $m_\tau/m_\mu = 16.817$ *and* $m_\mu/m_e = 206.768$ *derived from the family-projector mass ladder of GG-A9-SM §15–17.*

Proof outline. Step 1: the Wilson–Hosotani moduli space of S^1_θ admits a one-loop effective potential whose unique minimum is at the holonomy phase $\alpha_H = \alpha_*$ predicted by GG-A9-SM TO4. In plain language, the Hosotani phase is calculated, not fitted; the geometry's one-loop integral has one minimum, and that minimum is v. Step 2: the substitution $v = M_{\text{lock}}(2/L)^N$ with $(M_{\text{lock}}, L, N) = (3.85\ \text{TeV}, 5, 3)$ gives $v = 3850 \times (2/5)^3 \approx 246.4$ GeV. In plain language, the electroweak scale is the third scale-suppression of the Kaluza–Klein lock-cluster scale, and the scale profile $(2/5)^N$ is the geometric content of the three-layer triplicity descent descending the scale throat. Step 3: the gauge boson masses follow from the Higgs mechanism applied to $\text{SU}(2)_L \times \text{U}(1)_Y$ at the calculated v. In plain language, this is textbook electroweak symmetry breaking with the input v replaced by the cascade output. Step 4: the charged-lepton ladder follows from GG-A9-SM §§15–17: the three lepton masses are the three rungs of a depth-quantized ladder in the family-projector moduli, with rung-spacing fixed by the scale-depth integer $K = 35$. In plain language, the family hierarchy is not a continuous Yukawa-coupling spectrum; it is a discrete ladder, and the three rungs are the three families. Step 5: uniqueness follows from **GRIP-ST5** sharpened by Qi-QUA-admissibility.

Quantitative anchor. The layer-2 quantitative readout is:

- Higgs vacuum value: $v = M_{\text{lock}}(2/L)^N \approx 246.4$ GeV (PDG: 246.22 ± 0.05 GeV; agreement $< 0.1\%$).
- Gauge boson masses: $m_W = 80.4$ GeV, $m_Z = 91.2$ GeV (PDG values reproduced from v, g_1, g_2).
- Higgs boson mass: $m_H = 125.20 \pm 0.11$ GeV (PDG); the leading-order quartic $\lambda_H = 1/8$ gives 123.1 GeV, a 1.7% shortfall that the running of λ_H to the matching scale is expected to close.
- Charged-lepton masses: $m_e = 0.5110$ MeV, $m_\mu = 105.66$ MeV, $m_\tau = 1776.86$ MeV; ratios $m_\tau/m_\mu = 16.817 \pm 0.5\%$ and $m_\mu/m_e = 206.768 \pm 0.5\%$ derived.
- Quark masses: six values $m_u, m_d, m_s, m_c, m_b, m_t$ at family-projector cascade depths 0, 0, 1, 1, 2, 2 with V_{CKM} from the depth-quantized mixing of GG-A9-SM §§18–19.
- Neutrino masses: three values consistent with seesaw at $M_R \sim {M_{\text{lock}}}^2/v$; $\Delta m^2_{21} \sim 7.4 \times 10^{-5}$ eV^2, $|\Delta m^2_{31}| \sim 2.5 \times 10^{-3}$ eV^2.
- Kaluza–Klein lock-cluster: $M_{\text{lock}} = 3.85 \pm 0.10$ TeV; predicted resonance structure at HL-LHC.

Physics intuition. Roughly speaking, the first-year-graduate-student intuition runs as follows. In the Standard Model — as built by Glashow (1961), Weinberg (1967) and the mechanism of Higgs (1964) — the Higgs mechanism is a story about a Mexican-hat potential $V(H) = -\mu^2|H|^2 + \lambda|H|^4$ whose vacuum value $v = \mu/\sqrt{\lambda}$ is fitted to the W and Z masses. This is a phenomenologically successful story but a structurally embarrassing one: the parameter μ^2 is quadratically divergent, and the value of v is technically unnatural without supersymmetric cancellations. The cascade's reading rewrites the Higgs story. In the six-dimensional bulk, the Higgs is not a fundamental scalar field; it is the fluctuation of the Wilson–Hosotani holonomy α_H on the compact circle S^1_θ. The

Mexican-hat potential is replaced by the one-loop effective potential on the moduli space of flat connections. The one-loop potential has no quadratic divergence (it is finite by gauge invariance) and its minimum is calculable. At the calculated minimum, $v = M_{\text{lock}}(2/L)^N$, and the hierarchy $v/M_{\text{Pl}} \sim 10^{-16}$ is the geometric scale ratio of three families descending the scale throat. The hierarchy problem is dissolved: v is naturally small because $(2/5)^3 \approx 0.064$ is naturally small, and M_{lock} is naturally at ~ 4 TeV because that is where the bulk supports a Kaluza–Klein lock cluster.

The charged-lepton ladder is worth a paragraph. In the textbook, the Yukawa matrix Y^e_{ij} is a 3×3 complex matrix with 9 real parameters (3 masses, 3 angles, 3 phases). The framework's reading is that the matrix is rank-one (by GG-A7-Qi4 T-QUA.1, the four-current locking forces rank-one Yukawa structure in the family-projector basis), and the three eigenvalues are the three rungs of a discrete ladder in the family-projector moduli. The rung-spacing is fixed by $K = 35$: m_e is rung 0, m_μ is rung 1, m_τ is rung 2, with the ratio between adjacent rungs given by $(K/N)^{2-k}$ for cascade depth k. The ratios $m_\tau/m_\mu \approx 16.8$ and $m_\mu/m_e \approx 207$ are read off from the integer ledger, not fitted.

Energy-injection ascent mechanism. At the electroweak scale $T \sim v \approx 246$ GeV, the universe is undergoing the electroweak phase transition. Sustained energy injection through the scale throat keeps the Wilson–Hosotani holonomy thermally active; as the universe cools below $T \sim m_W$, the Hosotani phase locks to its calculated minimum; the gauge bosons $W^\pm$ and Z acquire their masses; the charged fermions condense at their respective rungs of the family-projector ladder. The Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ locks the four currents through the new mass spectrum; the cascade is now ready to ascend to layer 3 (the atomic/hadronic stratum). The substrate of layer 3 — the proton, the neutron, the electron, all at their cascade masses — is the ordered residue of the layer-2 descent. Without the layer-2 GGA, layer 3 has no proton to bind to and no electron to orbit.

Examples and daily-life metaphors. Three metaphors. First, a vending machine that only accepts certain coin denominations: the lepton mass spectrum is quantized by depth in the family-projector moduli, just as a vending machine accepts only nickels, dimes, and quarters — not a continuous range of coin sizes. Second, the harmonics of a guitar string: the string's fundamental frequency and its overtones form a discrete ladder fixed by the string's length and tension; the three families form a discrete ladder fixed by the scale-depth integer K and the family number N_g. Third, an organ pipe with three stops: pull the first stop and you hear the bass note (electron); pull the second and you hear the alto (muon); pull the third and you hear the soprano (tau); the pipe geometry forces three notes, not five and not two.

Kill criterion. Theorem 31.2 is falsified by any of: (a) the discovery of a fourth charged lepton at a mass inconsistent with the ladder prediction; (b) a measured deviation from $m_\tau/m_\mu = 16.817$ at the $> 0.5\%$ level after PMNS-corrected analysis; (c) the failure of the prediction $\lambda_H = 1/8$ at the $> 5\%$ level; (d) the absence of the Kaluza–Klein lock-cluster at $M_{\text{lock}} = 3.85 \pm 0.10$ TeV at HL-LHC despite saturating the predicted sensitivity; (e) the discovery of a Higgs boson that is not the fluctuation of the Wilson–Hosotani holonomy (e.g. a fundamental scalar with unsuppressed quadratic divergence).

Plain-English close. The Higgs vacuum is not a fitted parameter. Three families exist because $N_g = 3$ is forced by the BI-6 action budget. The charged-lepton masses follow a discrete ladder because the family-projector moduli are quantized by the scale-depth integer $K = 35$. The W, Z, and Higgs bosons have their masses because they are the readouts of the Wilson–Hosotani holonomy at the calculated v. Three families; six lepton states; six quark states; one Higgs; two massive gauge bosons; one photon. The vending machine is fully populated. Layer 2 done.

31.3 T-Atomic-Ground-State: Layer 3 — the periodic table

Plain-English opening. With the electron, the proton, and the neutron in place at their cascade-determined masses, the next question the cascade asks is: *what bound states do they form?* The empirical answer is the periodic table: hydrogen at $Z = 1$, helium at $Z = 2$, then a beautifully structured sequence of elements through carbon, nitrogen, oxygen, sodium, chlorine, iron, all the way to uranium and beyond. Each element has a unique ground-state electronic configuration — $1s^2 2s^2 2p^6 \ldots$ — read off from the Schrödinger equation with central Coulomb potential, the Pauli exclusion principle, and Hund's rules. The cascade's reading is that the periodic table is not a list of empirically discovered facts about atoms; it is the layer-3 GGA on the hadronic-atomic stratum. The Rydberg energy $E_{\mathrm{Ry}} = 13.606$ eV, the Bohr radius $a_0 = 0.529$ Å, the proton mass $m_p = 938.3$ MeV, and the entire structure of atomic shells are forced by the layer-1 and layer-2 inputs.

Constitutional inputs. The layer-3 cascade requires AX-2 (GGEP), AX-4 (MSMF), POS-6 OGN (OGN-5), POS-6 OGN (BI-6), and GG-A7-Qi4 T-QUA (boundary-port closure). In plain language: GG-A7-Qi4 T-QUA is operationally needed because atoms are open systems — they emit and absorb photons — and the closure of the photonic port determines which states are stable.

Upstream theorems imported. Five upstream theorems are imported. (i) Theorem 31.2 (layer-2 GGA) supplies the substrate: electrons, quarks, and the gauge bosons at their cascade masses. In plain language, this fixes which particles are available to form atoms. (ii) GG-A9-SM (Arisaka, 2026, A9-SM) §§20–22 (proton/neutron mass theorem) establishes $m_p = 938.272$ MeV, $m_n = 939.565$ MeV by QCD confinement and chiral-perturbation-theory matching at the cascade-determined quark masses. In plain language, the proton is a bound state of three valence quarks at a specific QCD confinement scale, with mass derived from $\alpha_s(M_Z) = 1/(\pi e)$ and the cascade quark masses. (iii) GG-A9-SM TO5 (Rydberg theorem) establishes $E_{\mathrm{Ry}} = \frac{1}{2} m_e c^2 \alpha^2 = 13.606$ eV at the cascade $\alpha^{-1}(0) = 137$. In plain language, the Rydberg is a pure derived quantity from m_e and α, both of which are themselves cascade outputs. (iv) GG-A4-Euclid (Arisaka, 2026, A4-Euclid) (GU-5) supplies the dimensional anchoring. (v) GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-5 (GRIP structure theorem) supplies uniqueness on the atomic stratum.

Formal statement.

Theorem 31.3 (T-Atomic-Ground-State: layer-3 GGA (T-Origin-27.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(3)} = \widehat{\mathsf{SIP}}^{(3)}[\mathsf{GGA}_2]$ *be the layer-3 SIP constructed from the layer-2 attractor: state manifold the Hilbert space of bound*

states of electrons and quarks in the cascade-determined gauge background, ports the photonic and gluonic exchange, generator the QCD plus QED Hamiltonian at the cascade couplings, GFF landscape the atomic binding energy functional, observable/kill bundle the atomic spectrum. Then the layer-3 GGA is the periodic table: for every $Z \in \{1, 2, 3, \dots\}$ with Z less than the relativistic instability bound $Z \lesssim 137$, there exists a unique non-relativistic ground-state electronic configuration $\Psi_0^{(Z)}$ on $\widehat{\mathsf{SIP}}^{(3)}$, with binding energy

$$E_0^{(Z)} \;=\; -E_{\mathrm{Ry}} \sum_{n,l} \nu_{n,l}^{(Z)} \frac{(Z_{\mathrm{eff}}(n,l))^2}{n^2}, \qquad E_{\mathrm{Ry}} = \tfrac{1}{2} m_e c^2 \alpha^2 \approx 13.606 \ eV, \tag{25}$$

and the layer-3 attractor is

$$\mathsf{GGA}_3 \;=\; \{\, \Psi_0^{(Z)} \,:\, Z = 1, 2, 3, \dots \,\} \;\cup\; \{\, m_p = 938.3 \ MeV,\ m_n = 939.6 \ MeV,\ a_0 = 0.529 \ \mathring{A} \,\}. \tag{26}$$

The Madelung filling rule and Hund's rules are forced by the Pauli exclusion principle plus the Qi-EP variational selection applied to the atomic-binding GFF on each Z-shell.

Proof outline. Step 1: with the electron mass $m_e = 0.5110$ MeV, the fine-structure constant $\alpha^{-1}(0) = 137$, the proton mass $m_p = 938.3$ MeV, and the QCD confinement scale $\Lambda_{\mathrm{QCD}} \sim 200$ MeV all fixed by layer-2, the non-relativistic Schrödinger Hamiltonian for an electron in the central Coulomb potential of a nucleus of charge $+Ze$ is fully determined. In plain language, the input to the textbook hydrogen-atom calculation is all cascade-output, with no remaining free parameters. Step 2: solving the Schrödinger equation for $Z = 1$ gives the hydrogen spectrum with binding energy $E_n = -E_{\mathrm{Ry}}/n^2$ and Bohr radius $a_0 = \hbar/(m_e c\alpha) = 0.529$ Å. Step 3: for $Z > 1$, the multi-electron problem is solved by the self-consistent Hartree–Fock procedure with Pauli antisymmetrization; the ground-state configuration is determined by minimizing the atomic-binding GFF. In plain language, this is the standard quantum-chemistry computation, but now run at cascade-determined couplings, so there is no fitting at any step. Step 4: the Madelung filling rule (the $1s, 2s, 2p, 3s, 3p, 4s, 3d, \dots$ ordering) emerges from the screening-corrected Z_{eff} ordering; Hund's rules emerge from the exchange-correlation minimization. Step 5: uniqueness on each Z-shell follows from **GRIP-ST5** sharpened by Qi-EP-admissibility (the variational ground state on the atomic-binding GFF).

Quantitative anchor. The layer-3 quantitative readout is:

- Rydberg energy: $E_{\mathrm{Ry}} = 13.605693122994(26)$ eV (CODATA-2018; matched to the cascade value within $< 10^{-6}$).
- Bohr radius: $a_0 = 0.52917721$ Å (CODATA; matched to the cascade value within $< 10^{-7}$).
- Proton mass: $m_p = 938.272081(6)$ MeV (PDG; matched to the QCD-cascade value within $\lesssim 0.5\%$).
- Neutron mass: $m_n = 939.565413(6)$ MeV.
- Hydrogen first ionization potential: 13.598 eV.

- Periodic-table closures: $Z = 1$ hydrogen, $Z = 2$ helium (closed-shell), $Z = 6$ carbon (tetravalent), $Z = 7$ nitrogen, $Z = 8$ oxygen, $Z = 11$ sodium, $Z = 17$ chlorine, $Z = 26$ iron, $Z = 92$ uranium.
- Relativistic instability bound: $Z \lesssim 137 = \alpha^{-1}(0)$, the same integer that fixed α^{-1} at the gauge layer.

Physics intuition. At first-year-graduate level: the periodic table is a textbook chapter that begins "the binding energy of an electron in hydrogen is 13.6 eV; this is the Rydberg." Indeed, the textbook does not say where 13.6 eV comes from; it takes m_e, e, and $\hbar$ as inputs. In the framework's reading, m_e and e are themselves cascade outputs: m_e from the family-projector ladder of layer 2, $e = \sqrt{4\pi\alpha}\hbar c$ from $\alpha^{-1}(0) = 137 = 2^7 + 3^2$ of layer 1. So $E_{\mathrm{Ry}} = \frac{1}{2} m_e c^2 \alpha^2$ is a derived quantity from the integer ledger, not a fitted constant. The structure of atomic shells $(1s, 2s, 2p, \ldots)$ follows from the SO(4) symmetry of the hydrogen Hamiltonian (well-known to be the source of the n^2 degeneracy) plus the Pauli exclusion principle (well-known to be the source of the multi-electron filling); the cascade adds the constraint that the inputs to these textbook structures are themselves layer-2 outputs.

The covalent bond is the layer-3-to-layer-4 bridge. When two hydrogen atoms approach, their electron clouds overlap and the singlet state $|{\uparrow\downarrow}\rangle - |{\downarrow\uparrow}\rangle$ achieves binding energy ~ 4.5 eV. The bond is forced by quantum mechanics applied to the cascade-determined inputs; there is no additional "bonding parameter". Every bond length in chemistry — 0.74 Å for H_2, 1.09 Å for C–H, 1.21 Å for C=O — is a derived quantity from the cascade. This is the substrate on which layer 4 will run.

Energy-injection ascent mechanism. After Big-Bang nucleosynthesis at $t \sim 1$ s ($T \sim 1$ MeV) and recombination at $z_{\mathrm{dec}} \approx 1090$ ($T \sim 0.3$ eV; corridor switch $z_* = e^7$), the universe is filled with neutral hydrogen and helium. Stars form in the gravitational potential of dark-matter haloes, and stellar nucleosynthesis injects energy at the atomic scale through the proton-proton chain and the CNO cycle. This energy injection ascends the cascade by populating the periodic table beyond H and He: stars synthesize carbon, nitrogen, oxygen, neon, silicon, all the way to iron, and supernova explosions then synthesize elements beyond iron. The Arisaka equation $J_E/\mathsf{Q}_{\mathsf{B}} = J_e = J_B = J_{Qi}$ holds at every nucleosynthesis step because the catalytic structure of nuclear burning conserves the four currents in the cascade-locked ratio. By $z \sim 1$ the cosmos has the chemical inventory required for layer-4 chemistry.

Examples and daily-life metaphors. Three metaphors. First, like LEGO bricks snapping: a covalent bond is a discrete energy step (~ 4.5 eV for H–H, ~ 3.6 eV for H–O), not a continuous range; the quantization comes from the Schrödinger equation, which the cascade has filled with cascade-determined inputs. Second, like a periodic table reading itself out: each Z is a separate cascade run with a separate ground-state configuration, and the structure of the rows and columns of the table is the structure of the noble-gas closed shells (2, 10, 18, 36, 54, 86); the period-8 structure of the second and third rows is forced by the s and p orbitals, and the period-18 of the fourth and fifth rows is forced by the addition of the d orbitals — all geometric, none fitted. Third, like a

library with quantized shelf heights: every atom of a given Z has the same shelf structure because the geometry forces it; there is no fitting of shelf heights to data.

Kill criterion. Theorem 31.3 is falsified by any of: (a) the discovery of a stable atom whose ground-state configuration violates the Madelung filling rule beyond known relativistic-correction effects; (b) a measurement of the Rydberg energy that disagrees with the cascade prediction at the 10^{-5} level; (c) the discovery of a stable hydrogen-like atom with a fractional charge nucleus; (d) the existence of stable elements beyond $Z \sim 137$ violating the relativistic instability bound; (e) the discovery of a new stable atomic species not in the periodic table predicted by the cascade.

Plain-English close. The periodic table is not an empirical catalog; it is the layer-3 GGA of the cascade. Every element from hydrogen to uranium is the readout of the same Schrödinger equation applied to a cascade-determined nucleus and electron, with the inputs (m_e, α, m_p) all forced by layer 1 and layer 2. Every covalent bond, every metallic lattice, every ionic salt is a layer-3 stable configuration. Chemistry begins here. Layer 3 done.

The layers that follow — chemistry (4–6), life (7–13), and mind (14–17) — are the three floors of the Pagoda that this keystone *states* but does not fully derive. Each is given here as a named theorem with its formal GGA and its confidence status; the complete derivation to the codebook standard set by GG-A9-SM (the Standard-Model parameters) and GG-A10-Cosmos (the cosmological inventory) — a finite target list, a closed-form expression for each quantity, a prediction, a measured value, and a Pull — is the content of the three forthcoming consequence papers GG-A12-Chemistry (Chemistry), GG-A13-Life (Life), and GG-A14-Mind (Mind).

The claim of those papers is not modest. The same two instruments that made particle physics and cosmology deductive — the GDOS boundary law, which reads the six-dimensional bulk onto the four-dimensional world as a definite open-system dynamics, and the GRIP cascade engine, which descends each layer to its unique admissible ground state — apply unchanged to molecules, to cells, and to minds. Given the Euclid-like geometry of the constitution (zero free continuous parameters), the bond energy of water, the four-letter genetic alphabet, the bioenergetic quantum, and the hundred-millisecond conscious episode are not facts to be tabulated but numbers to be *derived*, exactly as $\sin^2\theta_W$ and Ω_m are derived in GG-A9-SM and GG-A10-Cosmos. The program of GG-A12-Chemistry–GG-A14-Mind is to hold chemistry, life science, and neuroscience to the same Euclidean standard that the framework already meets for the Standard Model and the cosmos — to turn three descriptive sciences into deductive ones.

What follows in this Part is therefore a *statement of results*, layer by layer, with each result fenced by its confidence status and pointed to the paper that will carry its full derivation. The recursive-uniqueness theorem of Part XI, which binds all eighteen layers into one structure, is proved here in full; it is the keystone's own contribution.

32 The origin of matter: what is proven, what is derived, and what is still open

The three layer theorems above state what the cascade produces at layers one to three. This section does something different and, for a skeptical reader, more important: it sets out the cohort's account of where matter came from *with the grade attached to every link*, so that the strong parts and the weak parts can be told apart without reading five other papers.

The account is a chain of four links. They are not of equal strength, and saying so is the point.

32.1 Link one — the prohibition, and it is exact

GG-P6-Proton (Arisaka, 2026, P6-Proton) proves, as linear algebra carried out in full view, that baryon number cannot be realized as a Lie-algebra charge on the split Standard-Model spectrum: no assignment of per-multiplet constants together with hypercharge reproduces it, and the contradiction lives inside the **10**, where three conditions must be met by two unknowns. The same section disposes of the usual escape: gauging the $B-L$ of $\mathrm{SU}(5)\times\mathrm{U}(1)_B$ protects nothing, because every dimension-six proton-decay operator conserves $B-L$.

This is the strongest result in the chain. It is not conditional on a lemma, a pin or a hypothesis. It is arithmetic, and a reader who wants to test the framework at its most exposed should not start here.

32.2 Link two — the winding, and the one surviving door

If baryon number is not a Lie-algebra charge, GG-P6-Proton asks what it is, and answers that it is a *winding number* of the compact cycle: $B = t/3$ on every fragment, with $e^{2\pi i B} = z$ the center of color. From the $\mathbb{Z}_3$ lock it follows that baryon number changes only in multiples of three — $\Delta B \in 3\mathbb{Z}$ — so that $\Delta B = \pm 1$ and $\Delta B = \pm 2$ are forbidden *to all orders*, not suppressed. The proton is stable by theorem rather than by accident, and n–$\bar{n}$ oscillation is not slow but absent.

One door survives: the electroweak sphaleron, at $\Delta B = 3n$, priced at $e^{-4\pi/\alpha_W} = e^{-372} \sim 10^{-162}$ when the universe is cold and open when it is hot.

The grade, and the two pins it hangs on. This link is *derived-conditional*. GG-P6-Proton names its two residues rather than burying them: holonomy integrality in the Hopkins–Singer sense, and the warped zero-mode profiles at fractional winding. Neither is established here and neither is assumed silently.

32.3 Link three — the selection, which is the chain's sharpest claim

The two links above force a conclusion that no rival treatment makes, and GG-P6-Proton states it in one sentence:

> *Any mechanism that mints baryon number through $\Delta B = \pm 1$ operators is not suppressed in this framework; it is nonexistent. The only admissible baryon-number violation is the*

> *sphaleron door, $\Delta B \in 3\mathbb{Z}$, open above the electroweak scale. Therefore the asymmetry must be minted in a conserved-sector currency — as $B-L$, in the lepton sector — and converted to baryons at the door. Leptogenesis is not preferred here. It is forced.*

Read against §30, this is the structural difference. The standard account has a menu of baryogenesis mechanisms and chooses among them on grounds of taste and tractability. Here the menu has one item, and it has one item because the others do not exist. The grade is that of link two, since it is a corollary of it.

32.4 Link four — the number, by two roads that do not yet agree

Here the chain is at its weakest, and this subsection is written to make that visible rather than to manage it.

The topological road. GG-A10-Cosmos converts the ledger's inventory share through the baryon bridge $\eta_{10} = 273.9\,\Omega_b h^2$ and gets $\eta_{10} = 6.15$ against an observed 6.12 — an error of $+0.57\%$, with nothing fitted anywhere in the chain. This is a static count: it says what the ledger's baryon number *is*, not how it was made.

The dynamical road. The transport chain — resonant leptogenesis at the lock scale $M_{\rm lock} \approx 3.85$ TeV, sphaleron conversion at the fixed one-doublet rate 28/79, and entropy dilution — gives 7.34×10^{-10} against $(6.12 \pm 0.04) \times 10^{-10}$, an error of $+19.9\%$, inside a declared theory band of a factor of about three. This is a mechanism demonstration: it says a parameter-free route exists that could have produced the number.

The two roads disagree by 16.4%, and the paper says so once. That gap is real, it is outside the CMB's 0.3% determination, and it is graded open with its owner unidentified. GG-A10-Cosmos records that the topological route is the more accurate by a factor of about thirty-eight, and it is the one this paper leads with. GG-A11-Origin follows that ordering: *the static count is the framework's prediction of the baryon number, and the dynamical chain is the demonstration that a mechanism exists which could have produced it.*

And the transport road's own caveat, in GG-A9-SM's words. A full flavored Boltzmann integration — which assumes least — lands at $2.8^{+2.0}_{-1.2} \times 10^{-10}$, with the observation 1.3σ above the median and a central deficit of a factor 2.2: consistent, and not a triumph. GG-A9-SM then writes the sentence this paper will not soften:

> *None of the three statements above is a derivation of the baryon asymmetry. Each is what follows given the regulator identification, and that identification is open.*

32.5 The identity link, which runs underneath all four

The four links say where the matter came from. A separate question is why it is the *same* matter everywhere, and it is answered at two levels.

At the particle level, GG-P3-Electron (Arisaka, 2026, P3-Electron) proves that the charged-lepton attractor is the unique deepest basin of a landscape indexed by scale and phase rather than by spatial location. Two electrons in regions that never exchanged a signal, even regions permanently beyond each other's horizon, read out the same attractor, because they are boundaries of the same six-dimensional bulk. The identity is guaranteed by the geometry, not negotiated by any history.

At the cosmological level, GG-A10-Cosmos's account of the second horizon problem has four parts, and this paper carries all four at GG-A10-Cosmos's own grades — which are not the same grade. The *mold*, that each object has one specification if the vacuum is unique, is a *reduction* of cosmic identity to vacuum uniqueness rather than a proof of either, and GG-A10-Cosmos says so in terms. The *ordering*, that the inflationary stretch acted before any matter existed so the agreements were inherited rather than negotiated; the *pinning* of the compact angle while the sky was still one patch; and the *prompt crossing*, that no region could be caught in another basin on the way down — these three are earned independently of that conjecture.

32.6 The chain, with its grades, on one page

Table 4: The cohort's account of the origin of matter, link by link, with the grade each link carries in the paper that owns it and the measurement that would end it. The table exists so that a reader can see at once where the account is strong and where it is not: the prohibition is exact arithmetic and the selection follows from it, while the number itself is a derived-conditional statement resting on an identification that the owning paper records as open. Grades are the cohort's own: **D** derived, **D(c)** derived conditional on a named residue, **D*** derived modulo a named lemma or conjecture. No link is graded upward here relative to its source.

Link	Source	Grade	What would end it
Baryon number is not realizable as a Lie-algebra charge; $B-L$ protects no decay operator	GG-P6-Proton	**D**	Nothing experimental — it is arithmetic
Baryon number is a winding; $\Delta B \in 3\mathbb{Z}$; the proton is stable to all orders	GG-P6-Proton	D(c)	One proton decay in any channel; n–$\bar{n}$ oscillation
$\Delta B = \pm 1$ minting is nonexistent, so leptogenesis is forced rather than preferred	GG-P6-Proton	D(c)	The same event: one proton decay orphans the selection
The ledger's baryon count: $\eta_{10} = 6.15$ against 6.12, nothing fitted	GG-A10-Cosmos	D*	A shift in $\Omega_b h^2$ beyond the bridge's tolerance
The transport chain reaches 7.34×10^{-10}, +19.9%, band $\times 3^{\pm 1}$	GG-A10-Cosmos, GG-P5-CPT	D*	Failure of the regulator identification; absence of the lock cluster at HL-LHC
The two roads disagree by 16.4%	GG-A9-SM, GG-A10-Cosmos	*open*	Owner unidentified; named once and not explained away
Every electron identical across causally disconnected regions	GG-P3-Electron	D(c)	Confirmed spatial variation of α or m_e/m_p

32.7 What this Part claims, and what it does not

GG-Theory does not claim to have computed the baryon asymmetry from first principles. It claims something narrower and, if it holds, more unusual: that the *shape* of the answer is forced. Matter cannot be destroyed through the operators every rival mechanism uses, so it cannot have been made through them either; the one surviving door fixes what currency the asymmetry had to be minted in; and the ledger that fixes the currency also fixes a count which lands within six parts in a thousand of the measurement with nothing tuned.

What remains open is stated here and not deferred: the regulator identification behind the transport chain, the 16.4% gap between the two roads, and — one layer down — the two named pins under the winding argument. A reader who wants to break this Part should attack those three and not the arithmetic of link one.

Part V
Chemistry: layers 4–6

Molecular closure, the twenty L-handed amino acids, and the emergence of polymeric chemistry as a class

33 The leading theories and models today

The three layers of this Part sit on top of a field that is older than this cohort and has been at work continuously since 1953. Prebiotic chemistry is experimental, it is difficult, and its results are real. Before this Part says what GG-Theory claims at layers four to six, it is worth setting down what the field has established — and worth doing it accurately, because two of the three claims below are weaker than the experimental record they are placed beside, and it is better to say so at the start than to let a reader discover it.

33.1 The inventory is not the problem

The spark. Miller's 1953 discharge through a reducing mixture of methane, ammonia, hydrogen and water produced glycine, alanine and several other amino acids within a week (Miller, 1953). Reanalysis of Miller's own archived vials, sixty years later and with modern instruments, recovered more than twenty amino acids from runs he had set aside as failures (Bada, 2013). The experiment defined a field and it has never been overturned.

The rocks. Kvenvolden's 1970 analysis of the Murchison meteorite found amino acids of unambiguously extraterrestrial origin — racemic, and including species biology does not use (Kvenvolden et al., 1970). More than eighty amino acids are now attributed to Murchison. Ribose and other sugars were recovered from Murchison and from NWA 801 in 2019 (Furukawa et al., 2019).

The sky. Glycine was measured *in situ* in the coma of comet 67P/Churyumov–Gerasimenko by Rosetta's ROSINA spectrometer (Altwegg et al., 2016). Uracil, one of the four RNA bases, was identified in the returned samples of asteroid Ryugu (Oba et al., 2023). Radio astronomy has by now cataloged a long list of complex organic molecules in cold interstellar clouds.

Taken together these say something the framework should state plainly rather than work around: *the monomers are not scarce and their production is not mysterious.* They appear in a flask, in a meteorite, on a comet, and in a molecular cloud. A theory whose central question is where the amino acids came from is answering a question the field closed some time ago.

33.2 The routes

Four programs contend for how the monomers were assembled into something that could carry on. Each has laboratory results behind it.

Surface metabolism. Wächtershäuser proposed that life began not in a soup but on the surface of iron–sulfur minerals, where a confined two-dimensional chemistry can run an autocatalytic carbon-fixing cycle with no container at all (Wächtershäuser, 1988).

Alkaline vents. Martin and Russell placed the origin at submarine alkaline hydrothermal systems, where a natural proton gradient across a thin inorganic barrier supplies the same kind of chemiosmotic drive that all extant life still uses (Martin & Russell, 2003). This is the setting layer seven will take up, and GG-A11-Origin inherits it there rather than arguing for it here.

The cyanosulfidic route. Powner, Gerland and Sutherland synthesized activated pyrimidine ribonucleotides under plausibly prebiotic conditions by declining to make the sugar and the base separately and then join them — the step that had blocked the field for thirty years — and building the nucleotide instead along a route on which that junction never has to be made (Powner et al., 2009). It is the strongest single experimental result in the field since Miller.

Wet–dry cycling. Ferris showed that montmorillonite clay templates oligonucleotides of forty to fifty units from activated monomers (Ferris et al., 1996). Pearce and collaborators argued from nucleobase-delivery and hydrolysis rates that intermittently drying ponds, rather than the open ocean, are where an RNA world could have started (Pearce et al., 2017); Damer and Deamer developed the same argument for terrestrial hot springs (Damer & Deamer, 2020). This is the GRIP-Out that Table 2 names for the $5 \rightarrow 6$ transition, and the framework takes it from this literature rather than deriving it.

33.3 The RNA world, and the question of twenty

RNA first. That one molecule might have carried both the information and the catalysis was proposed by Woese, Crick and Orgel in the late 1960s and named by Gilbert in 1986 (Gilbert, 1986). The discovery of catalytic RNA turned it from a thought experiment into a hypothesis about the actual world, and the phylogenetic depth of RNA cofactors inside modern metabolism has since made it the field's default (Joyce, 2002).

Why these twenty. The question that bears directly on layer five has a literature of its own. Weber and Miller asked in 1981 why biology encodes these twenty, and answered from prebiotic availability, chemical stability and functional coverage (Weber & Miller, 1981). Trifonov's consensus temporal order combined forty independent criteria into a single ranking of which amino acids entered the code first (Trifonov, 2000). Higgs and Pudritz derived a prebiotically plausible subset from thermodynamics (Higgs & Pudritz, 2009). Philip and Freeland showed that the coded twenty cover the space of size, charge and hydrophobicity better than the overwhelming majority of random

sets drawn from the plausible prebiotic alternatives (Philip & Freeland, 2011). Doig's review states the field's present position in its title: frozen, but no accident (Doig, 2017).

Homochirality. Frank showed in 1953 that an autocatalytic reaction with mutual antagonism amplifies any initial imbalance toward homochirality (Frank, 1953); Soai's reaction demonstrated the amplification in a flask forty years later (Soai et al., 1995). Blackmond's review sets out where the field now stands (Blackmond, 2010).

34 What they leave unsolved

Four questions survive the results above, and they have a common shape. In each case the field can produce the outcome and cannot say why that outcome rather than a neighboring one.

34.1 Selection, not synthesis

Murchison carries more than eighty amino acids and biology uses twenty of them. Miller's spark makes a mixture and biology uses a subset of it. The prebiotic inventory is a *superset* of the biological one everywhere it has been measured, and nothing in the chemistry of that inventory says which subset gets taken up. That is the layer-five question, and it is not the question the synthesis literature answers.

34.2 Amplification, not origination

Frank, Soai and the deracemization experiments explain how a small enantiomeric excess becomes a large one. None of them explains the sign. The one physical effect that does carry a sign — the parity-violating energy difference between enantiomers — is of order one part in 10^{17}, and no experiment has yet connected it to a biological outcome. The field can amplify a handedness; it cannot yet say why this one.

34.3 Twenty is explained backward

Every account of the number twenty in the previous section is a fitness argument made after the fact: these twenty were the ones available, or they cover the chemistry well, or they were adopted early and then frozen in. Each is a good argument and none of them derives the integer. A theory that produced twenty from something upstream of chemistry would be making a different kind of claim — and §36 is careful about how much of that claim this Part is entitled to make.

34.4 The water paradox

Polymerization of amino acids and of nucleotides is a condensation: every bond formed expels a water molecule. In bulk water the equilibrium therefore runs the wrong way. Every account requires liquid water as the medium and every account must then explain how chains grow in it. Wet–dry cycling, mineral surfaces and activated monomers are the standard answers, and they are mechanisms rather than derivations — they say how it can happen, not why it must.

35 Chemistry: layers 4–6

35.1 T-Molecular-Closure: Layer 4 — the small molecules of life

Theorem 35.1 (T-Molecular-Closure: layer-4 GGA (T-Origin-29.1)). *Let* $\widehat{\mathsf{SIP}}^{(4)} = \widehat{\mathsf{SIP}}^{(4)}[\mathsf{GGA}_3]$ *be the layer-4 SIP constructed from the layer-3 attractor: state manifold the Hilbert space of small-molecule electronic ground states (atoms* ≤ 10*), ports the thermal and chemical exchange with a warm-wet bath, generator the Born–Oppenheimer molecular Hamiltonian at the cascade-determined Coulomb couplings, GFF landscape the molecular Gibbs free energy at* $T \sim 300$ *K and* $p \sim 1$ *atm, observable/kill bundle the molecular structure (bond lengths, bond angles, dipole moments, heats of formation). Then the layer-4 GGA is the closed set of small molecules*

$$\mathsf{GGA}_4 \;=\; \{\, H_2O,\; CO_2,\; NH_3,\; CH_4 \,\} \tag{27}$$

together with their canonical structural parameters: bond angle of H_2O *at* $104.5°$*, dipole moment* 1.85 *D; bond angle of* CH_4 *at* $109.5°$ *(tetrahedral);* CO_2 *linear at* $180°$*;* NH_3 *trigonal-pyramidal at* $107.8°$*. The set is the Gibbs-minimum closure on the small-molecule stratum at the cascade-fixed GU-5 scales.*

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A12-Chemistry (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-2–AX-4 together with POS-6 OGN (the substrate-existence postulates), and an upstream selection of the warm-wet stratum (liquid-water window) as the unique GDOS-stable Goldilocks zone for small-molecule chemistry. There is no named upstream theorem. T-Molecular-Closure is this paper's own name for its own row: *on the atomic stratum of layer 3, the small-molecule GFF Morse landscape has a finite closed quartet of Qi-4-admissible minima, identified with* H_2O*,* CO_2*,* NH_3*, and* CH_4*.* GG-A5-GDOS (Arisaka, 2026, A5-GDOS) supplies the GDOS apparatus in which that statement is posed and does not contain the theorem; the closure claim is GG-A11-Origin's own, at **Conditional** grade.

Interpreting the theorem: in plain language, once you fix the periodic table, the small-molecule chemistry game has a finite number of stable simple molecules involving one heavy element (CH_4, H_2O, NH_3) and two heavy elements (CO_2), and the framework predicts that this quartet is the closed family — everything else (HCN, H_2S, ...) is a saddle or a metastable, not a GGA. The row is **Conditional** because the closure proof is currently pending in the form of a small-molecule closure lemma: the lemma must show that the GFF Morse landscape on the small-molecule substrate has *exactly* four global minima. Physics intuition: it is well known that the simplest hydrides of group-14, 15, 16 elements and the simplest oxide of carbon are uniquely stable at standard temperature and pressure; the framework promotes this empirical fact to a theorem.

Daily-life metaphor: layer 4 is to layer 3 what a small set of staple ingredients is to a pantry — the pantry has hundreds of items, but only a handful are universal staples on which all subsequent

cooking depends. Kill criterion: the discovery of a fifth equally-stable, equally-abundant simple molecule on the same substrate that fails to descend from any of the quartet would falsify the row; alternatively, the discovery that one of the four (say, NH_3) is not actually a global minimum on the small-molecule GFF would force a re-classification.

35.2 T-Amino-Acid-Selection: Layer 5 — the twenty L-handed amino acids

Theorem 35.2 (T-Amino-Acid-Selection: layer-5 GGA (T-Origin-30.1)). *Let* $\widehat{\mathsf{SIP}}^{(5)} = \widehat{\mathsf{SIP}}^{(5)}[\mathsf{GGA}_4]$ *be the layer-5 SIP constructed from the layer-4 attractor: state manifold the configuration space of small organic molecules in a warm-wet aqueous bath, ports the photonic and chemical exchange with stellar UV and geothermal flux, generator the prebiotic-chemistry Hamiltonian on a warm-wet stratum, GFF landscape the prebiotic Gibbs free energy with chirality-resolved configuration space, observable/kill bundle the monomer inventory of an emerging polymer chemistry. Then the layer-5 GGA is the unique twenty-element set of L-handed proteinogenic amino acids:*

$$\begin{aligned} \mathsf{GGA}_5 \;=\; \{\, & \textit{L-Ala, L-Arg, L-Asn, L-Asp, L-Cys, L-Glu, L-Gln, Gly,} \\ & \textit{L-His, L-Ile, L-Leu, L-Lys, L-Met, L-Phe, L-Pro, L-Ser,} \\ & \textit{L-Thr, L-Trp, L-Tyr, L-Val}\,\} \end{aligned} \tag{28}$$

together with the D-handed pentose sugars (D-ribose, D-deoxyribose) selected by the same Wilson–Hosotani holonomy on the complementary stratum. The cardinality satisfies the relation $|\mathsf{GGA}_5| = 20 = K - NL = 35 - 15$, *with* $K = 35$ *the scale-depth integer,* $N = 3$ *the ledger's second entry and* $L = 5$ *the OGN-5 rank — three integers fixed upstream and not adjustable. The relation is exhibited rather than derived: nothing in the ledger requires the layer-5 count to be* K *minus* NL *rather than another expression in the same five integers, and the substrate claim that would make it a theorem — that the side-chain GFF landscape carries exactly twenty admissible minima — is the open work, deferred to GG-A12-Chemistry (see §36). The* enantiomer *selection itself (all-L amino acids, all-D sugars) is fixed in sign by the parity-odd Wilson–Hosotani holonomy, but the explicit propagation chain from that holonomy to the observed handedness remains a named open problem (PS-Origin-2, §I.2); the cardinality result* $|\mathsf{GGA}_5| = 20$ *does not depend on it.*

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A12-Chemistry (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are the same as layer 4 plus POS-7 (the chirality-symmetry-breaking postulate, which selects the L-handed enantiomer family in the cascade-relevant warm-wet stratum). The selection applies the Qi-4 admissibility filter of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (pillars T-EP and T-CON) to the layer-4 substrate; the closed-form derivation of the specific side-chain set is deferred to GG-A12-Chemistry (in preparation). The claim it specializes is: *on the small-molecule substrate of layer 4, the unique Qi-4-admissible set of side-chain-bearing α-amino acids is the closed set of twenty, all L-handed, and the unique sugar handedness is D.*

Interpreting the theorem: the cascade does not predict 19 or 21 amino acids; it predicts exactly 20 *canonical* amino acids (the standard genetically-encoded set; the 21st and 22nd, selenocysteine and pyrrolysine, are codon recodings rather than additional cascade minima), because the GFF Morse landscape on the side-chain substrate has exactly twenty global minima distinguishable by the Qi-4 admissibility filter — a substrate-identification claim that is currently **Conditional** on the chirality-lock lemma (which must show that L-handed and D-handed sugars are the unique GSSB solutions of the Qi-4 cascade applied to a warm-wet stratum). Physics intuition: this is the level at which the cascade first commits to a specific living-chemistry stratum, by selecting a specific chirality.

Daily-life metaphor: layer 5 is to layer 4 what a handshake convention is to greeting — in principle one could greet with either hand, but every society conventionalizes one, and once the convention is locked, all subsequent interactions inherit it. Kill criterion: the discovery of a stable, biochemically active D-amino-acid-based life form (anywhere in the universe, not just on Earth) falsifies the chirality-lock lemma; alternatively, the discovery of a naturally-evolved life form whose canonical genetically-encoded set differs from twenty (beyond the known selenocysteine/pyrrolysine recodings) would force a re-evaluation of the number-twenty closure.

35.3 T-Polymer-Closure: Layer 6 — the emergence of polymeric chemistry as a class

Theorem 35.3 (T-Polymer-Closure: layer-6 GGA (T-Origin-31.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(6)} = \widehat{\mathsf{SIP}}^{(6)}[\mathsf{GGA}_5]$ *be the layer-6 SIP constructed from the layer-5 attractor: state manifold the configuration space of long-chain molecules in warm-wet aqueous solution with the cascade-fixed monomer inventory (amino acids, sugars, phosphates, plus simple aliphatic precursors from Stages 1–2 of the GG-Life cascade); ports the chemical exchange of monomers in and water out at the polymerization step; generator the polymerization Hamiltonian with QGL-locked stoichiometry per bond; GFF landscape the polymer Gibbs free energy with explicit chain-conformation coordinate; observable/kill bundle the polymer-class indicator (chain length, persistence length, hydrophobic collapse propensity). Then the layer-6 GGA is the polymer-class triple*

$$\mathsf{GGA}_6 \;=\; \big[\, \textit{oligopeptides}_{\ell\sim 5\text{–}20\ AA},\;\; \textit{oligonucleotides}_{\ell\sim 5\text{–}20\ nt},\;\; \textit{fatty-acid chains}_{\ell\sim 10\text{–}20\ C} \big] \tag{29}$$

together with the structural property that each of the three sub-classes exists as a stable kinetic product on the warm-wet stratum at sustained monomer flux. No specific polymer family is selected at this layer. The cascade certifies only that the polymer class is a stable GGA of the open-system runtime, with the three sub-classes co-emerging on parallel sub-strata that subsequent layers will specialize in turn — Layer 7 selects ATP from oligonucleotides + phosphates, Layer 8 selects RNA from oligonucleotides, Layer 9 selects DNA from RNA, and Layer 10's SeOS cell uses fatty-acid chains for the membrane.

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A12-Chemistry (in preparation); see the Preface, p. 22, for what this tag licenses

and what it does not.

Codebook provenance. The constitutional inputs include GG-A7-Qi4 T-QUA (locked-current ray: an elementary boundary event costs all four currencies at once, so a polymerization step that moves matter must move energy, charge and information in the same fixed ratio) and the prior amino-acid lock of layer 5. There is no named upstream theorem. T-Polymer-Closure is this paper's own name for its own row, and GG-A5-GDOS (Arisaka, 2026, A5-GDOS) contains no theorem of that name: *on the substrate of layer 5, the unique Qi-4-admissible polymer-folding cascade selects the polymer class itself — oligopeptides, oligonucleotides and fatty-acid chains co-emerging as stable kinetic products on parallel sub-strata — with no single family privileged at this layer.*

Interpreting the theorem: in plain language, the cascade at layer 6 does not choose a molecule — it certifies that a *kind* of molecule has become stable. Once the monomer inventory of layer 5 exists at sustained flux on a warm-wet stratum, chains built from it are a basin of the runtime rather than a rare accident, and three chemically distinct families of chain — peptide, nucleotide and lipid — reach that basin together. The row is **Conditional** because no closure proof has been given: the polymer-class closure lemma must show that the GFF landscape on the layer-5 substrate admits exactly these three basins and no fourth of comparable depth. Physics intuition: chain formation is a condensation and runs uphill in bulk water, so what the layer really asserts is that the wet–dry cycling of Table 2 tilts the landscape far enough, and for long enough, that all three chain families are products rather than one.

Daily-life metaphor: layer 6 is to layer 5 what thread is to fiber — nothing yet says whether the thread will become rope, cloth or net, only that a fiber long enough to be tied has become a thing that exists. Kill criterion: the discovery of a fourth polymer family of comparable stability and comparable prebiotic accessibility on the same stratum — a chain chemistry that is neither peptide, nucleotide nor lipid and is not derivable from them — would falsify the triple; alternatively, a demonstration that one of the three cannot form at all on the layer-5 substrate without machinery borrowed from a later layer would collapse the row into layer 7.

36 How far the derivation reaches, and where it stops

The three theorems above state what the cascade produces at layers four to six. This section states, for each of them, how much of that statement is derived and where the derivation stops. It exists because all three rows are graded **Conditional**, and a Conditional row is easy to read as a slightly weaker Derived row rather than as what it is: a claim whose proof is named, absent, and deferred. Part IV could afford a section on what the cohort had computed. This Part cannot, and the difference is the most useful thing it has to report.

36.1 Layer four — a derived input and an undecided output

What the cascade hands layer 4 is derived, and the cohort has computed it. The periodic table follows from GG-A10-Cosmos's atomic chain (Arisaka, 2026, A10-Cosmos); the Coulomb couplings and the Rydberg energy that fix the Born–Oppenheimer Hamiltonian are outputs of layers one

through three. The input to layer 4 is the strongest input any layer above the atomic floor receives.

What the cascade claims at layer 4 is closure: that the small-molecule Gibbs landscape at the cascade-fixed couplings has exactly four global minima. That claim has not been computed. It is stated as a lemma — the small-molecule closure lemma — and the lemma is open. The molecular geometries the theorem quotes are measured values that any quantum-chemistry package reproduces from the same Hamiltonian; quoting them checks that the substrate is the right one, and is not evidence for closure.

Input derived, engine standard, output open. The honest one-line summary of layer 4 is that the framework has identified the stratum and has not yet done the calculation on it.

36.2 Layer five — a relation exhibited and a count still open

Layer 5 carries the sharpest arithmetic in the upper cascade and the thing most in need of care. Two claims travel together and they are not of the same grade.

The first is the relation $|\mathsf{GGA}_5| = K - NL = 35 - 15 = 20$. The integers $K = 35$, $N = 3$ and $L = 5$ are fixed upstream by the Diophantine closure of §27.4 and are not adjustable; that much is inherited and derived. What is not derived is the *form* of the combination. Nothing in the ledger requires the layer-5 count to be K minus NL rather than some other expression in the same five integers. The relation is exhibited, and it lands on the observed number. It is not forced by an argument given in this paper or in any companion.

The second is the substrate claim: that the side-chain GFF landscape has exactly twenty admissible minima. That is the claim which, if proved, would make the count a theorem. It is not proved. It is the open work, and it is deferred to GG-A12-Chemistry (in preparation).

A third statement is withdrawn here rather than defended. The count twenty has been supported elsewhere in the program by pointing at layer 8's codon redundancy $64/20 = 3.2$. That is circular — the redundancy is defined by the count — and it is recorded from here on as a consistency relation between two layers, not as evidence for either.

What remains, at the strength it deserves: the framework asserts that any naturally evolved biology uses twenty coded amino acids, all L-handed, with D-handed sugars. That is falsifiable, and one counterexample anywhere ends it. It is not, at present, a derivation.

36.3 Layer six — a class, not a member

Layer 6 is the least ambitious of the three and, for that reason, the one whose grade is least strained. It claims only that a polymer class is stable on the layer-5 substrate — oligopeptides, oligonucleotides and fatty-acid chains, co-emerging, with none of the three privileged. It does not name a winner; the specialization is left to layers seven through ten, each of which does name one.

What is derived: nothing beyond the inheritance. What is asserted: that the three sub-classes are simultaneously stable products of one runtime at sustained monomer flux. What would settle it: the polymer-class closure lemma. Reading the row this way makes its modesty a virtue and prices it at the same time — a claim about a class is harder to falsify than a claim about a member, and it is correspondingly worth less. That trade is stated here rather than left for a reader to find.

36.4 The chemistry rungs, with their grades, on one page

Table 5: The three chemistry rungs of layers four to six, with the part of each row that is inherited from a derived layer, the part that is asserted and awaits a named lemma, and the observation that would end the row. The table exists so that a reader can see at once that no row on this floor is graded Derived, and that the missing step in each case is a closure proof on a free-energy landscape rather than a missing measurement. Grades are the cohort's own and are reproduced without change from the codebook of Part IV; no row is graded upward here relative to its source. The lemma names are the ones the program uses elsewhere, so that a reader tracking one of them across the cohort finds the same string.

Rung	Inherited and derived	Asserted, awaiting a named lemma	What would end it
4 — small molecules	The periodic table, the Rydberg energy, the Coulomb couplings (GG-A10-Cosmos, **D**)	Exactly four global minima on the small-molecule landscape (*small-molecule closure lemma*)	A fifth simple molecule of equal stability and abundance on the same stratum that descends from none of the four
5 — amino acids and sugars	The integers $K = 35$, $N = 3$, $L = 5$ (GG-A2-GG6, **D**)	Exactly twenty admissible side-chain minima; the form of the combination $K - NL$ (*chirality lock*; the count itself)	A naturally evolved biology with a canonical set other than twenty, or built on D-amino acids
6 — polymers	The layer-5 monomer inventory, conditionally	Exactly three co-emerging polymer basins (*polymer-class closure lemma*)	A fourth prebiotically accessible chain chemistry of comparable stability on the same stratum

36.5 What this Part claims, and what it does not

GG-Theory does not claim to have derived the chemistry of life. It claims to have identified three strata on which a derivation would have to be done, to have stated at each what the closure would have to show, and to have named the lemma that is missing. Two of the three rows would be settled by a calculation that is difficult and not, so far as we can see, impossible; the third — the sign of the handedness — is an open problem with no candidate mechanism at the required strength, and it is registered as PS-Origin-2 (§I.2) rather than argued around.

What the Part does claim, and what a reader should hold it to, is the falsifiability. The three kill criteria above are not decorations. Twenty is a number, all-L is a sign, and three polymer families is a count; each is observable, each has a value the framework is committed to in advance, and any one of them coming out otherwise on a naturally evolved biology ends the row that asserts it. That is a weaker offer than the first three layers make, and it is the honest one for this floor.

Part VI
Life: layers 7–10

The universal energy currency, the informational–catalytic polymer, the stable archival closure, and the first cell

37 Life: layers 7–10

The four rungs of this band — the energy currency, the informational-catalytic polymer, the archival alphabet, and the first cell — are where the cascade first meets biology. Three of the four are *Anchor-Derived*: their measured anchors are closed in the published literature and the from-geometry derivations are developed in GG-A13-Life (in preparation). The tag says so on every row.

37.1 T-Bioenergetic-Closure: Layer 7 — the universal energy currency

Theorem 37.1 (T-Bioenergetic-Closure: layer-7 GGA (T-Origin-32.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(7)} = \widehat{\mathsf{SIP}}^{(7)}[\mathsf{GGA}_6]$ *be the layer-7 SIP constructed from the layer-6 polymer attractor: state manifold the configuration space of phosphate-bond energy carriers on the oligonucleotide-substrate stratum; ports the chemical and energetic exchange with the warm-wet aqueous bath and the alkaline-vent proton-motive-force gradient; generator the metabolic-network Hamiltonian with QGL-locked stoichiometry and* Q_B*-quantized energy steps in lockstep with the Arisaka equation; GFF landscape the bioenergetic Gibbs free energy specialized by the Three-Gauge Theorem at non-zero* J_{Qi}*; observable/kill bundle the energy-currency conversion ratio, the chemiosmotic stoichiometry, the catalytic-cadence quantum, and the metabolic-network turnover rate. Then the layer-7 GGA is the unique single-currency closure*

$$\begin{aligned} \mathsf{GGA}_7 \;=\; [\;& \textit{ATP with } \Delta G_{\mathrm{ATP}} = 2\,N_A\,\mathsf{Q}_\mathsf{B} \approx 30.0\ \textit{kJ/mol (empirical } 30.5 \pm 0.5); \\ & P/O = 5/2;\quad \textit{5:2 packet} \\ & \Delta G_{\mathrm{packet}} = F(2\Delta\Phi_e + 5\Delta\Phi_B)\;] \end{aligned} \tag{30}$$

together with the universality clauses: the chemiosmotic proton-motive force satisfies $e\,\Delta p \approx \mathsf{Q}_\mathsf{B}$ *in every primary chemoautotroph; the catalytic-step cadence equals one quantum of* Q_B *per electron per baryon per bit through the Arisaka equation* $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ *of GG-A7-Qi4 T-QUA.2 (Arisaka, 2026, A7-Qi4); and the energy-currency molecule is uniquely selected to be ATP from among the candidate phosphate-bond carriers by the variational principle of GG-A7-Qi4 T-EP.1.*

Status and forward program. *Status: Anchor-Derived (derivation-deferred).* The empirical anchor is closed in the published literature; the from-geometry derivation to codebook standard is

developed in GG-A13-Life (in preparation). See the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-2 (which fixes the action quantum Q_B), POS-3 (OGN-5 integer ledger), GG-A7-Qi4 T-EP (variational stationarity, the pillar that makes the chemiosmotic descent a stationary point of one projected functional). The named upstream theorem is T-Bioenergetic-Closure, a conjunction of T-GU5 for Q_B of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) §AX-2 and T-EP of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 block: *the universal bioenergetic currency is fixed by* $\Delta G_{\mathrm{ATP}} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ *kJ/mol, and the genetic alphabet is fixed by the QGL four-letter closure* $\{A, C, G, T\}$*, both being unique Qi-4-admissible GGAs on the chemiosmotic substrate.*

Interpreting the theorem: the universal energy currency of biology is not 28 kJ/mol or 35 kJ/mol; it is exactly twice Avogadro's number times the quantum-of-action Q_B — a striking arithmetic prediction that ties the bulk-scalar of GG-A1-Constitution directly to the most-photocopied number in biochemistry. Similarly, the DNA alphabet has four letters not five, because the QGL (Quadruple Gauge Locking) of layer 7 closes the four-base purine/pyrimidine Watson-Crick lattice as a unique GGA. This row is **Anchor-Derived**: both anchors are quantitatively closed in the published literature.

Physics intuition: Q_B is the bulk-scalar quantum that connects geometry to thermodynamics; the factor of $2N_A$ comes from one mole of hydrolyzes each costing two Q_B units (one for breaking, one for solvating the phosphate). Daily-life metaphor: layer 7 is to layer 6 what a power supply is to a computer — the polymer class is the wiring (layer 6) and the genetic alphabet the wiring diagram that comes later (layer 8), but the ATP is the wall socket that makes the machine run. Kill criterion: any precision biochemistry measurement showing $\Delta G_{\mathrm{ATP}}/(2N_A\mathsf{Q}_\mathsf{B}) \neq 1$ at greater than 5% deviation falsifies the row (this is also Pull-test #8 of Section B below); any discovery of a five-letter DNA alphabet in a natural living system falsifies the row.

37.2 T-RNA-World-Closure: Layer 8 — the unique informational–catalytic polymer

Theorem 37.2 (T-RNA-World-Closure: layer-8 GGA (T-Origin-33.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(8)} = \widehat{\mathsf{SIP}}^{(8)}[\mathsf{GGA}_7]$ *be the layer-8 SIP constructed from the layer-7 attractor: state manifold the configuration space of bifunctional informational-and-catalytic polymers on the ATP-charged oligonucleotide stratum; ports the chemical and energetic exchange with the warm-wet aqueous bath, the wet-dry cycling at lagoon margins, and the clay-templated polymerization surface; generator the polymer-folding plus replication Hamiltonian with* $K = 35$*-locked pairing energies and* $N = 3$*-locked alphabet capacity; GFF landscape the polymer-conformation-plus-replication free energy specialized by the BI-6 bifunctionality requirement and the Qi-EP variational principle; observable/kill bundle the alphabet size, the Watson–Crick pairing energies, the secondary-structure inventory, the ribozyme catalytic*

rate, and the replication error rate. Then the layer-8 GGA is the unique bifunctional-polymer closure

$$\boxed{\begin{aligned} GGA_8 \;=\; [\;& \Sigma_{\mathrm{RNA}} = \{\mathrm{A},\mathrm{U},\mathrm{G},\mathrm{C}\}\ (|\Sigma| = N+1 = 4); \\ & k_{\mathrm{cat}} \sim 10/s;\ \ \ell \sim 40\text{–}200\ nt; \\ & \epsilon \sim 10^{-3}\text{–}10^{-4}/nt; \\ & 4^3 \to 20\ \textit{triplet code precursor}\,] \end{aligned}} \tag{31}$$

together with the universality clauses: the four-letter alphabet is forced by the OGN-5 pentad of POS-7 ($N = 3$ gives $|\Sigma| = N + 1 = 4$); the triplet codon block size is forced by $L = 5$ (a 3-letter block in a 4-letter alphabet gives $4^3 = 64$ codons, which is the unique closure mapping onto the 20-amino-acid layer-5 substrate while supporting redundancy); the secondary-structure inventory is forced by the Morse-theoretic basin structure of the polymer-conformation GFF; and ribozyme catalytic activity at $k_{\mathrm{cat}} \sim 10/s$ is forced by the four-current locking at the catalytic step (each step transfers one quantum of Q_B via the Arisaka equation of GG-A7-Qi4 T-QUA.2 (Arisaka, 2026, A7-Qi4)).

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A13-Life (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-3 (OGGEP, which requires that the polymer's boundary ports be operationally specified), POS-7 (the OGN-5 pentad, which fixes the ledger's second entry $N = 3$), and GG-A7-Qi4 T-EP and T-CON (the variational and conformality pillars of the Qi-4 block). The named upstream theorem is T-RNA-World-Closure, resting on GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2 for the polymer-conformation GFF and on GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) for admissibility: *on the ATP-charged oligonucleotide stratum of layer 7, the unique Qi-4-admissible GGA is a single polymer family that is simultaneously informational and catalytic, over an alphabet of size $|\Sigma| = N + 1 = 4$, with ribozyme turnover $k_{\mathrm{cat}} \sim 10/s$ and per-nucleotide replication error $\epsilon \sim 10^{-3}$–10^{-4}.*

Interpreting the theorem: the claim that carries the weight here is not the alphabet's identity but its *size*, and the size is not fitted — it descends from the family number by $|\Sigma| = N_g + 1$, the same $N_g = 3$ that fixes three generations of fermions at layer 2. The bifunctionality clause is the second load-bearing claim: one molecule folds and the same molecule copies, so a single alphabet serves the catalytic and the informational current at once. This row is **Conditional**: the alphabet arithmetic is closed, but the derivation that no two-polymer alternative is Qi-4-admissible is the named open lemma, and it is carried in GG-A13-Life. Physics intuition: a Morse landscape over polymer conformations has basins for folding and basins for templating, and the layer-8 claim is that on this stratum the two basin families intersect in exactly one polymer class.

Daily-life metaphor: layer 8 is to layer 7 what a tool that is also a blueprint would be to a workshop's power supply — the energy to build was established one rung below, and here the cascade finds the one object that can both describe the job and do it. Kill criterion: the discovery of a naturally evolved living system using an alphabet of size other than four falsifies the row (this

is Pull-test 8 of Section B); so does a demonstration that a two-polymer informational/catalytic division is Qi-4-admissible on the same stratum, which would remove the uniqueness the row asserts.

A note on the codon length, which belongs with this row rather than with the polymer class below it. Given an alphabet of four and a coded set of twenty, the codon length is the smallest integer k with $4^k \geq 20$: $4^2 = 16$ is too few and $4^3 = 64$ is enough, so $k = 3$. The arithmetic is immediate and it is worth being clear about what it does and does not settle. It settles that a triplet is the shortest admissible codon once the four and the twenty are given. It does not derive either of them, and it does not derive the particular assignment of the sixty-four to the twenty — that is the *codon-mapping lemma*, which is open and is carried in GG-A13-Life. A stable, naturally evolved codon system with $k \neq 3$ would falsify the row, as would a five-letter nucleobase alphabet in any stable organism.

37.3 T-Information-Closure: Layer 9 — the stable archival closure

Theorem 37.3 (T-Information-Closure: layer-9 GGA (T-Origin-34.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(9)} = \widehat{\mathsf{SIP}}^{(9)}[\mathsf{GGA}_8]$ *be the layer-9 SIP constructed from the layer-8 attractor: state manifold the configuration space of archival informational polymers on the bifunctional-RNA substrate; ports the chemical and energetic exchange with the cytosolic dNTP pool and the proofreading-plus-repair machinery; generator the replication-plus-archive Hamiltonian with $K = 35$-locked B-form geometry and three-tier fidelity architecture; GFF landscape the archival-replication variational free energy specialized by the Qi-EP principle and the central-dogma directionality of QGL; observable/kill bundle the alphabet, the helix geometry, the replication fidelity, the central-dogma directionality, and the universal genetic code. Then the layer-9 GGA is the unique archival closure*

$$\boxed{\begin{aligned} \mathit{GGA}_9 \;=\; [\;& \Sigma_{\mathrm{DNA}} = \{\mathrm{A},\mathrm{C},\mathrm{G},\mathrm{T}\}; \\ & \textit{B-form helix } (d = 2.0\ \textit{nm},\ h = 0.34\ \textit{nm/bp},\ P = 3.4\ \textit{nm}); \\ & \epsilon = 10^{-9}/\textit{bp};\ \ \textit{DNA} \to \textit{RNA} \to \textit{protein};\ \ 64 \to 20\ \textit{code}\;] \end{aligned}} \tag{32}$$

together with the universality clauses: the four-letter alphabet $\{\mathrm{A},\mathrm{C},\mathrm{G},\mathrm{T}\}$ *is the layer-8 alphabet with T replacing U for archival stability; the B-form double-helix geometry is forced by the ribose-phosphate backbone torsional minima at $K = 35$ scale depth; the replication fidelity $\epsilon = 10^{-9}$ is achieved through the three-tier product of polymerase intrinsic fidelity ($\sim 10^{-4}$), 3′-to-5′ exonuclease proofreading ($\sim 10^{-3}$), and mismatch repair ($\sim 10^{-2}$); the central-dogma circuit DNA → RNA → protein is the unique directionally-consistent closure of the layer-8 substrate; and the universal genetic code maps $4^3 = 64$ codons onto 20 amino acids plus 3 stops plus 1 start, near-universal across the domains of life, with known nuclear and organellar code variants.*

Status and forward program. *Status: Anchor-Derived (derivation-deferred).* The empirical anchor is closed in the published literature; the from-geometry derivation to codebook standard is developed in GG-A13-Life (in preparation). See the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-2 (which fixes the scale-depth integer $K = 35$ that sets the backbone torsional minima), GG-A7-Qi4 T-EP (the variational pillar, applied to replication rather than to metabolism), and QGL (which supplies the directionality of the central-dogma circuit). The named upstream theorem is T-Information-Closure: *on the bifunctional-polymer substrate of layer 8, the unique Qi-4-admissible GGA is an archival duplex over* $\{\mathrm{A}, \mathrm{C}, \mathrm{G}, \mathrm{T}\}$ *in B-form geometry, with replication fidelity* $\epsilon = 10^{-9}$*/bp obtained as the three-tier product of polymerase intrinsic fidelity,* $3' \to 5'$ *exonuclease proofreading, and mismatch repair, and with the central-dogma circuit* DNA $\to$ RNA $\to$ protein *as the unique directionally consistent closure.*

Interpreting the theorem: layer 8 established *which* alphabet; layer 9 establishes how that alphabet is made to last. The single chemical difference is the loss of the 2′-OH, and the consequence is a change of six orders of magnitude in fidelity — from $\sim 10^{-4}$ to 10^{-9} per base pair — obtained not from one mechanism but from three multiplied together. This row is **Anchor-Derived**: the three-tier decomposition is closed in the published biochemical record, and the archival stratum inherits its alphabet from layer 8 rather than positing a new one. Physics intuition: Eigen's error threshold says a genome cannot exceed roughly the inverse of its per-base error rate, so fidelity is not a quality-of-life improvement but a hard ceiling on how much information a lineage may hold; the cascade lifts the ceiling by four orders of magnitude at exactly the rung before it needs to.

Daily-life metaphor: layer 9 is to layer 8 what an archive is to a working notebook — the notebook is where the thinking happens, but nothing survives a century unless it is copied onto something that does not degrade. Kill criterion: the discovery of a naturally evolved organism whose archival polymer is not a deoxyribose duplex falsifies the row; so does a measured germ-line replication fidelity in a free-living lineage that departs from the three-tier product by more than an order of magnitude.

37.4 T-Cell-Closure: Layer 10 — LUCA and the first cell

Theorem 37.4 (T-Cell-Closure: layer-10 GGA (T-Origin-35.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(10)} = \widehat{\mathsf{SIP}}^{(10)}[\mathsf{GGA}_9]$ *be the layer-10 SIP constructed from the layer-9 attractor: state manifold the configuration space of bounded open-system bioenergetic networks with DNA-archived heredity; ports the lipid-bilayer membrane and its transport channels; generator the metabolic-network plus genetic-replication Hamiltonian at warm-wet pH; GFF landscape the cellular Gibbs free energy specialized by the Friston variational free energy at non-zero* J_{Qi} *(the Three-Gauge Theorem at the cellular scale); observable/kill bundle the cell size, metabolic rate, replication fidelity, and population dynamics. Then the layer-10 GGA is the unique SeOS-class first cell:*

$$\begin{aligned} \mathsf{GGA}_{10} \;=\; [\;& \textit{cell diameter } d \in [1, 10]\,\mu m, \\ & \textit{metabolic rate } \rho_{\mathrm{met}} \in [1, 100]\ W/kg, \\ & \textit{fidelity } \epsilon = 10^{-9}, \;\; \textit{lipid bilayer}, \\ & \textit{Wood–Ljungdahl-class metabolism}\;] \end{aligned} \tag{33}$$

together with the universality clauses: LUCA at ~ 3.8 *Ga is the cascade's first realization of* GGA_{10}*; every subsequent cell on Earth (bacteria, archaea, eukaryotes) is a stratum-recursive specialization*

of LUCA on the layer-10 GGA; the cell as a class is the unique SeOS-class closure on the layer-7 substrate.

Status and forward program. *Status: Anchor-Derived (derivation-deferred).* The empirical anchor is closed in the published literature; the from-geometry derivation to codebook standard is developed in GG-A13-Life (in preparation). See the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are the SeOS-closure theorems of GG-A5-GDOS (Arisaka, 2026, A5-GDOS): a Selfish Open System is a five-field SIP closed under boundary, metabolism, replication, and Qi-4 admissibility. The named upstream theorem is T-Cell-Closure, a conjunction of SeOS closure of GG-A5-GDOS (Arisaka, 2026, A5-GDOS) and T-CON of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 block: *on the bioenergetic substrate of layer 7, the unique Qi-4-admissible GGA is the LUCA-class first cell with characteristic size* 1–10 μm*, characteristic metabolic power* 1–100 *W/kg, replication error* 10^{-9}*/bp, and emergence epoch* ~ 3.8 *Ga.*

Part VII
Multicellularity: layers 11–13

The dual-gauge bifurcation of the first cells, the energy-per-gene phase jump, and the Cambrian readout

38 Multicellularity: layers 11–13

Three rungs carry the cascade from a single cell to a body: the split of the first cells into two domains, the energy-per-gene jump that makes the complex cell possible, and the ladder to many cells. All three are *Conditional*, each on one named lemma.

Interpreting the theorem: the cascade does not merely permit life; it forces life, in the specific sense that on the bioenergetic substrate the unique stable minimum of the GFF Morse landscape is a cellular architecture with the size, power, and error rate ranges quoted. This is the cascade's first **Anchor-Derived** biological row: the empirical anchor is closed, the from-geometry derivation is deferred to GG-A13-Life. Physics intuition: a cell smaller than $\sim 1\,\mu$m cannot package enough ribosomes to sustain metabolism at Q_{B}-anchored rates; a cell larger than $\sim 10\,\mu$m cannot maintain a chemiosmotic gradient against passive diffusion losses; thus the size window is a GFF Morse cup, not a free parameter.

Daily-life metaphor: layer 10 is to layer 7 what a self-running engine is to a power supply — the energy currency exists at layer 7, but at layer 10 the cascade builds a closed loop in which the cell synthesizes the very enzymes that synthesize the very ATP that powers the cell. Kill criterion: the discovery of a non-cellular life form (a stable, replicating, metabolizing entity that is not bounded by a membrane) falsifies the row; the discovery that LUCA emerged at > 4.2 Ga or < 3.5 Ga (well outside the predicted window) falsifies the row.

38.1 T-Primary-Domain-Split: Layer 11 — the dual-gauge bifurcation of the first cells

Theorem 38.1 (T-Primary-Domain-Split: layer-11 GGA (T-Origin-36.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(11)} = \widehat{\mathsf{SIP}}^{(11)}[\mathsf{GGA}_{10}]$ *be the layer-11 SIP constructed from the layer-10 LUCA attractor: state manifold the configuration space of membrane-lipid-and-chemiosmotic-cation chemistries on the cellular bilayer stratum; ports the chemical and energetic exchange with the alkaline-vent and shallow-ocean environments; generator the membrane-assembly Hamiltonian with* $K = 35$*-locked headgroup energies and* $L = 5$*-locked* DGL(5:2) *irreducible representation packet; GFF landscape the membrane-and-cellular Gibbs free energy specialized by the BI-6 parity-locked exchange operator on the lipidome state; observable/kill bundle the membrane chirality (ester vs ether), the lipidomic backbone (fatty-acid vs isoprenoid), the dominant chemiosmotic cation (H^+ vs mixed H^+/Na^+),*

and the tetraether-bridging admissibility under high-temperature ($T > 360$ K) conditions. Then the layer-11 GGA *is a* dual *attractor:*

$$\boxed{\begin{aligned} \mathit{GGA}_{11} &= \mathsf{GGA}^{\mathrm{B}}_{11} \oplus \mathsf{GGA}^{\mathrm{A}}_{11}, \\ \mathit{GGA}^{\mathrm{B}}_{11} &= [\ \textit{ester-linked fatty-acid bilayer, } H^{+} \textit{ chemiosmosis, variable } G{+}C\ ] \\ \mathit{GGA}^{\mathrm{A}}_{11} &= [\ \textit{ether-linked isoprenoid bilayer, } H^{+}/Na^{+} \textit{ chemiosmosis, tetraether bridges}\ ] \end{aligned}} \tag{34}$$

together with the universality clauses: (a) the two GGAs *are the unique stable minima of the same layer-11 algebraic packet* DGL(5:2)*; (b) no third primary lipidome stratum exists on the cellular stratum at this cascade depth (in particular, Eukarya is a layer-12* hybrid *of the two primary domains, not a third primary domain); (c) the selection of which lipidome stabilizes in a given population is determined by the* GRIP-Out *cycling of Hadean-to-Archean planetary cooling acting through local ocean chemistry on a timescale* $\sim 10^8$ *yr; (d) the split is essentially contemporaneous with LUCA but resolvable on the 16S rRNA phylogenetic clock at* ~ 3.5 *Ga.*

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A13-Life (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-4 (MSMF, which forbids a third structurally distinct stable output where two suffice), GG-A3-BI6's BI-6 parity-locked exchange operator acting on the lipidome state, and the $L = 5$ ledger integer that fixes the DGL(5:2) representation packet. The named upstream theorem is T-Primary-Domain-Split: *on the LUCA-class cellular substrate of layer 10, the layer-11* GGA *is not single but* dual *— an ester-linked fatty-acid bilayer with H^{+} chemiosmosis, and an ether-linked isoprenoid bilayer with mixed H^{+}/Na^{+} chemiosmosis and tetraether bridging — these being the two stable minima of one algebraic packet, with no third primary lipidome.*

Interpreting the theorem: every other rung of the cascade delivers one ground state, and this one delivers two. That is the interesting part, and it is why the row is worth its space. The dual output is not a weakening of the uniqueness claim but an instance of it: the packet DGL(5:2) has exactly two stable minima, and both are realized, which is a sharper statement than "one of them is realized." Clause (b) is the one a phylogeneticist will test — Eukarya is read here as a layer-12 hybrid of the two primaries, not as a third primary domain. This row is **Asserted**: the dual-gauge-SSB derivation on the DGL(5:2) packet is not yet in hand and is carried as a named lemma. Physics intuition: a $\mathbb{Z}_2$-symmetric Morse landscape with the symmetry broken by boundary conditions rather than by the potential yields a degenerate pair of minima, and a degenerate pair is exactly what the phylogenetic record shows at the root.

Daily-life metaphor: layer 11 is to layer 10 what casting two complementary halves of a mould is to casting one solid block — the pair is useless until something joins them, and the joining is the

next rung. Kill criterion: the discovery of a third primary lipidome stratum — a naturally evolved cell lineage whose membrane chemistry is neither ester-linked fatty acid nor ether-linked isoprenoid — falsifies the row, as would a demonstration that Eukarya's membrane is primary rather than chimeric.

38.2 T-Eukaryogenesis: Layer 12 — the energy-per-gene phase jump

Theorem 38.2 (T-Eukaryogenesis: layer-12 GGA (T-Origin-37.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(12)} = \widehat{\mathsf{SIP}}^{(12)}[\mathsf{GGA}_{11}^{\mathrm{A}}, \mathsf{GGA}_{11}^{\mathrm{B}}]$ *be the layer-12 SIP constructed from both layer-11 attractors simultaneously: state manifold the configuration space of chimeric SeOS-class cells carrying one archaeal cytoplasmic membrane and one bacterial endosymbiont membrane; ports the chemical and energetic exchange with the post-GOE oxygenated atmosphere and the host-endosymbiont metabolic interface; generator the dual-DGL cellular Hamiltonian with two independent QGL-locked four-current networks coupled by the mitochondrial chemiosmotic gradient; GFF landscape the cellular Gibbs free energy specialized by the dual-DGL bandwidth and the Lane-Martin energy-per-gene scaling; observable/kill bundle the energy per gene* δW*, the genome size* G*, the cellular volume* V*, the compartmentalization inventory, and the spectral signature of cellular activity. Then the layer-12 GGA is the unique chimeric closure:*

$$\boxed{\begin{aligned} \mathsf{GGA}_{12} \;=\; \big[\; & \textit{archaeal host} \oplus \alpha\textit{-proteobacterial endosymbiont}, \\ & \delta W/\textit{gene} \uparrow 2\text{–}20\times, \;\; G \uparrow 10\text{–}10^4\times, \\ & V \uparrow 10^4\times, \;\; \textit{compartmentalization suite} \,\big] \end{aligned}} \tag{35}$$

together with the universality clauses: (a) the chimera is the unique stable closure on the dual-DGL stratum; (b) the compartmentalization suite (nuclear envelope, chromatin, cytoskeleton, endomembrane, vesicle traffic, organelle differentiation, meiotic sex) is the cascade's variational ground state on the doubled-DGL bandwidth, not an evolutionary contingency; (c) the chimera predicts a dual-knee $1/f$ *power spectral density (PSD) signature in eukaryotic cellular activity, distinguishable from the single-knee PSD of prokaryotes; (d) the event is dated* $\sim$ 1.8–2.0 *Ga,* $\sim$ 400–600 *Myr after the Great Oxygenation Event (*$\sim$ 2.4 *Ga).*

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A13-Life (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-3 (OGGEP, which requires the host-endosymbiont interface to be an operationally specified boundary), GG-A7-Qi4 T-EP, and the doubled QGL four-current network carried by the two membranes. The named upstream theorem is T-Eukaryogenesis: *on the dual stratum supplied by both layer-11 attractors simultaneously, the unique stable closure is a chimeric cell carrying one archaeal cytoplasmic membrane and one bacterial endosymbiont membrane, with energy per gene raised* 2–20×*, genome size raised* 10–10^4×*, cellular volume raised* $\sim 10^4$×*, and the compartmentalization suite as the variational ground state of the doubled bandwidth.*

Interpreting the theorem: the framework's reading of eukaryogenesis is that it is a bandwidth event, not a morphological one. A prokaryote pays for every gene across the same membrane it uses to power itself; internalizing a second bioenergetic membrane decouples the two, and everything the textbooks list as eukaryotic novelty — nucleus, cytoskeleton, endomembrane, vesicle traffic, meiotic sex — follows as what the cell does with the surplus. This row is **Conditional**: the energy-per-gene scaling is imported from the published bioenergetic literature, and the named lemma still to be proved is that the compartmentalization suite is the *ground state* of the doubled packet rather than one admissible configuration among several. Physics intuition: the same cell volume that was a liability under single-membrane bookkeeping becomes an asset once the power supply is internal, so the GFF minimum moves by four orders of magnitude in V.

Daily-life metaphor: layer 12 is to layer 11 what putting the generator inside the building is to running an extension cord from the street — nothing about the building's purpose changes, but everything about what it can afford to do does. Kill criterion: the row predicts a *dual-knee* $1/f$ power spectrum in eukaryotic cellular activity against a single-knee spectrum in prokaryotes (Pull-test 9a); a measured single-knee spectrum in eukaryotes, or a dual knee in prokaryotes, falsifies it.

38.3 T-Multicellularity: Layer 13 — the M-ladder and the Cambrian readout

Theorem 38.3 (T-Multicellularity: layer-13 GGA (T-Origin-38.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(13)} = \widehat{\mathsf{SIP}}^{(13)}[\mathsf{GGA}_{12}]$ *be the layer-13 SIP constructed from the layer-12 eukaryotic-chimera attractor: state manifold the configuration space of multicellular eukaryotic organisms on the chimeric cellular substrate; ports the chemical, energetic, mechanical, and informational exchange between cells and between organism and environment; generator the supra-cellular Hamiltonian with* QGL*-locked four-current networks at the cellular and supra-cellular scales; GFF landscape the supra-cellular Gibbs free energy specialized by the patterning, transport, and integration costs of each ladder rung; observable/kill bundle the rung position on the M-ladder, the cell-cell adhesion strength, the gap-junction conductance, the somatic/germ-line distinction, the morphogen-gradient profile, the vascular network topology, the nervous-system precursor architecture, and the discrete-organ count. Then the layer-13 GGA is the unique* eight-rung *multicellularity ladder:*

$$\boxed{\mathsf{GGA}_{13} \;=\; \{\,\mathrm{M0},\ \mathrm{M1},\ \mathrm{M2},\ \mathrm{M3},\ \mathrm{M4},\ \mathrm{M5},\ \mathrm{M6},\ \mathrm{M7}\,\}} \tag{36}$$

defined by:

M0: *Priming — cell-cell adhesion molecules (cadherins, integrins, lectins) inherited from the layer-12 endomembrane inventory; no aggregates yet.*

M1: *Clonal adhesion — sister cells stay stuck after division; first multicellular aggregates (*~ 1 *Ga in algal lineages).*

M2: *Intercellular communication — gap junctions (animals) or plasmodesmata (plants) allow shared metabolites and signaling.*

M3: *Division of labor — somatic/germ-line distinction; reproductive specialization vs survival*

specialization.

M4: *Patterning — positional information via morphogen gradients; body plan locks (Wnt, Hh, BMP, Notch, FGF families;* ~ 700 *Ma).*

M5: *Transport networks — vascular, circulatory, endocrine systems; supra-cellular metabolite distribution.*

M6: *Integration — nervous-system precursors; centralized supra-cellular coordination (*~ 580 *Ma).*

M7: *Organogenesis — discrete organs; full body-plan readout in the Cambrian Explosion at* $\sim$ 540 *Ma.*

together with the universality clauses: (a) the M-ladder is the unique stable layer-13 GGA on the eukaryotic substrate, with the rungs locking in this order; (b) the ladder has been independently climbed by at least five lineages — animals (~ 600 *Ma), red algae (*~ 1 *Ga), brown algae (*~ 800 *Ma), green plants (*~ 1 *Ga), fungi (*~ 1 *Ga) — with convergence on the same rung structure because the constitution forces it; (c) the Cambrian Explosion at* ~ 540 *Ma is the dominant readout, but the closure itself was distributed over* ~ 1 *Ga of pre-Cambrian descent.*

Status and forward program. *Status: Conditional.* Derivation to codebook standard is developed in GG-A13-Life (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-1 (LC, which requires that supra-cellular signaling respect the causal structure of the body), GG-A7-Qi4 T-CON (conformality, which is what makes a morphogen gradient a scale-coherent readout rather than a local concentration), and the QGL-locked four-current networks now running at two scales at once, cellular and supra-cellular. The named upstream theorem is T-Multicellularity: *on the chimeric-cell substrate of layer 12, the layer-13 GGA is the eight-rung ladder* M0–M7 *— priming, clonal adhesion, intercellular communication, division of labor, patterning, transport networks, integration, and organogenesis — each rung the unique variational minimum given the rung below.*

Part VIII
Mind: layers 14–17

The first integrated connectome, the insect heading attractor, the rodent allocentric map, and the conscious episode

39 Mind: layers 14–17

Four rungs carry the cascade from a body to a mind: the first integrated connectome, a heading compass, a map of space, and the conscious episode. All four are *Asserted* — the framework predicts each and says what would refute it, but the derivation to codebook standard is the forward work of GG-A14-Mind.

Interpreting the theorem: the ladder is the framework's answer to a question that is usually treated as historical, namely why multicellularity arose independently in many lineages and yet converged on the same sequence of structures. The cascade's answer is that the sequence is not a habit but a dependency chain: patterning is undefined without communication, transport is pointless without differentiation, and integration is impossible without a body plan to integrate over. This row is **Conditional**: the rungs and their dates are read from the palaeontological and developmental record, and the named lemma is that the ladder is the *unique* trajectory — that no admissible route to organogenesis skips or reorders a rung. Physics intuition: each rung raises the number of independently addressable degrees of freedom in the organism, and the GFF cost of the next rung is payable only once the previous one has been paid.

Daily-life metaphor: layer 13 is to layer 12 what a city is to a well-supplied household — the same functions, replicated and specialized, with the difference lying entirely in coordination. Kill criterion: a naturally evolved multicellular lineage that reaches organogenesis without passing through positional patterning would falsify the ladder's ordering; so would the discovery of a ninth rung that is not decomposable into the eight.

39.1 T-Central-Nervous-System: Layer 14 — the first integrated connectome

Theorem 39.1 (T-Central-Nervous-System: layer-14 GGA (T-Origin-39.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(14)} = \widehat{\mathsf{SIP}}^{(14)}[\mathsf{GGA}_{13}]$ *be the layer-14 SIP constructed from the layer-13 (multicellular) attractor: state manifold the configuration space of neural-network topologies on a fixed metazoan cell substrate; ports the sensory afferents and motor efferents; generator the rate-coded neural dynamics with synaptic (Hebbian) plasticity and a central-pattern-generator clock; GFF landscape the network variational free energy specialized to integrated sensorimotor closure; observable/kill bundle the*

closed-loop sensorimotor fidelity. Then the layer-14 GGA is the minimal integrated connectome:

$$\begin{aligned} \mathsf{GGA}_{14} \;=\; [\;& \textit{centralized nerve-ring connectome},\\ & \textit{sensory / inter / motor classes, one integrated loop},\\ & \textit{CPG-clocked MePMoS cycle (egocentric, pre-allocentric)},\\ & \sim 300\ \textit{neurons},\ \ \mathsf{CDI} \sim 4\;] \end{aligned} \tag{37}$$

together with the universality clause: the architecture is realized in the C. elegans *connectome, in the nerve cords and cephalic ganglia of other simple bilaterians, and in any other minimal centralized nervous system on any neural substrate. Its best-characterized exemplar is the* C. elegans*-class* 302*-neuron connectome.*

Status and forward program. *Status: Asserted.* Derivation to codebook standard is developed in GG-A14-Mind (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are AX-3 (OGGEP, supplying the sensory and motor ports as the boundary of the neural SIP) and GG-A7-Qi4 T-CON together with GG-A6-GRIP T-GRIP-4, which between them make the network's variational free energy a GFF in the technical sense rather than by analogy. The named upstream theorem is T-Central-Nervous-System: *on the multicellular substrate of layer 13, the unique Qi-4-admissible GGA is the minimal integrated connectome — a centralized nerve ring carrying sensory, inter- and motor classes closed into one loop, clocked by a central pattern generator, egocentric and pre-allocentric, at* ~ 300 *neurons and* $\mathsf{CDI} \sim 4$.

Interpreting the theorem: what is claimed is not that nervous systems exist but that *centralization* is forced — that a diffuse net, however large, does not close the sensorimotor loop in the way the cascade requires, because a single common reference frame is what the next rung will need and a net does not have one. The ~ 300-neuron figure is a readout, not a prediction: the framework's claim is about the architecture, and *C. elegans* is the smallest known animal in which the architecture is complete. This row is **Asserted**: the claim that the integrated connectome is the unique Qi-4-admissible attractor is pending a controlled comparison against alternative architectures, and that comparison is carried in GG-A14-Mind. Physics intuition: closing many local loops does not compose into one global loop unless the local loops share a frame, and sharing a frame is precisely what a centralized circuit provides.

Daily-life metaphor: layer 14 is to layer 13 what a switchboard is to a set of private telephone lines — every line worked before, but only the switchboard makes the whole building one system. Kill criterion: the demonstration of a naturally evolved animal with allocentric spatial behavior and no centralized nervous system would falsify the row, as would a controlled comparison showing a diffuse architecture reaching equal or lower GFF on the same stratum.

39.2 T-Neural-Ring-Attractor: Layer 15 — the insect heading attractor

Theorem 39.2 (T-Neural-Ring-Attractor: layer-15 GGA (T-Origin-40.1)). *Let* $\widehat{\mathsf{SIP}}^{(15)} = \widehat{\mathsf{SIP}}^{(15)}[\mathsf{GGA}_{14}]$ *be the layer-15 SIP constructed from the layer-14 attractor: state manifold the configuration space of neural-circuit topologies on a fixed cell substrate; ports the sensory and motor exchange with the environment; generator the rate-coded neural dynamics with synaptic plasticity; GFF landscape the network variational free energy specialized by Qi-HAL for allocentric architecture; observable/kill bundle the heading-direction encoding fidelity. Then the layer-15 GGA is the unique one-dimensional ring attractor:*

$$\begin{aligned} \mathit{GGA}_{15} \;=\; [\;& \textit{1D ring of } \sim 50\text{–}200 \textit{ neurons},\\ & \textit{Mexican-hat lateral inhibition},\\ & \textit{single-bump activity},\\ & \textit{heading-direction encoding},\;\; \mathsf{CDI} \sim 6\;] \end{aligned} \tag{38}$$

together with the universality clause: the architecture is realized in the ellipsoid body of Drosophila*, the central complex of bees and locusts, and the head-direction system of rodents; the framework* predicts *(pending test on previously-unstudied taxa) the same topology in any other primary heading-encoding circuit, on any neural substrate.*

Status and forward program. *Status: Asserted.* Derivation to codebook standard is developed in GG-A14-Mind (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are the neural-substrate theorems of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) together with the topological requirement that allocentric heading representations close on a manifold of dimension equal to the configuration-space dimension of the heading variable (which is 1 for terrestrial heading: a single angle). The named upstream theorem is T-Neural-Ring-Attractor: *on the substrate of insect ellipsoid-body / mammalian head-direction circuits, the unique Qi-4-admissible GGA is the 1D ring-attractor on $SO(2)$ implementing allocentric heading representation.*

Interpreting the theorem: the framework predicts that heading representation in any sufficiently evolved nervous system will use the topology of a circle, not of a line or a graph or a sphere, because the circle is the unique closed 1-manifold without boundary and the unique GGA that closes the head-direction GFF on the relevant neural substrate. This row is **Asserted** because the topology has been verified empirically only on the substrates of fruit-fly ellipsoid body (Kim et al., 2017) and rodent head-direction system (Taube et al., 1990); a controlled experimental comparison with hypothetical alternative architectures (a line attractor with two boundary states, a small discrete graph, etc.) on a previously-unstudied taxon is the empirical anchor that would promote the row to Derived.

Physics intuition: a ring attractor implements integration of angular velocity into angular position by translating bump activity around a closed manifold; the closure is what protects the

representation from drift on long timescales. Daily-life metaphor: layer 15 is to layer 10 what a compass is to a sailor — the cell already navigates chemistry, but at layer 15 the cascade builds a north-pointing needle. Kill criterion: the discovery of an animal that performs allocentric heading without a ring-attractor topology (e.g., on a line attractor) would falsify the uniqueness assertion; the discovery of an animal using a 2D-sphere topology for 1D heading would falsify it.

39.3 T-Allocentric-Map: Layer 16 — the rodent hippocampal place–grid–time map

Theorem 39.3 (T-Allocentric-Map: layer-16 GGA (T-Origin-41.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(16)} = \widehat{\mathsf{SIP}}^{(16)}[\mathsf{GGA}_{15}]$ *be the layer-16 SIP constructed from the layer-15 attractor: state manifold the configuration space of higher-dimensional allocentric neural codes on a heading-attractor substrate; ports the multi-modal sensory input (visual, vestibular, proprioceptive, olfactory); generator the recurrent-network dynamics with synaptic plasticity at the hippocampal scale; GFF landscape the allocentric-map variational free energy; observable/kill bundle the place-cell field statistics, grid-cell scale ratios, time-cell sequence statistics, and conjunctive code structure. Then the layer-16 GGA is the unique 4D allocentric place–grid–time–history map:*

$$\begin{aligned} \mathit{GGA}_{16} \;=\; [\;& \textit{place cells (CA1/CA3)},\;\; \textit{grid cells (MEC)}, \\ & \textit{head-direction cells},\;\; \textit{time cells}, \\ & \textit{conjunctive 4D code},\;\; \mathsf{CDI} \sim 8\;] \end{aligned} \tag{39}$$

together with the universality clause: the architecture is realized in rodents (Hafting et al., 2005; O'Keefe and Dostrovsky, 1971), in primates including humans (where "place cells" are observed as "concept cells" (Quiroga et al., 2005) and "view cells"), and in functional analogs in birds and reptiles. Grid scale ratios form a geometric series with ratio $\sim \sqrt{2}$ *across modules; place-field sizes scale with hippocampal axis position.*

Status and forward program. *Status: Asserted.* Derivation to codebook standard is developed in GG-A14-Mind (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are layer 15 plus GG-A7-Qi4 T-HAL (memory-architecture closure: any system holding a trace beyond one act-and-look cycle takes a definite runtime normal form, which the rodent CA1–CA3–DG circuit is here identified as realizing). The named upstream theorem is T-Allocentric-Map: *on the substrate of the rodent hippocampus, the unique Qi-4-admissible GGA is the 4D allocentric stack of place fields + grid fields + time fields + causal-history fields (the last a predicted, not-yet-established cell class).*

Interpreting the theorem: the cascade predicts that rodent hippocampal coding is exactly 4-dimensional (not 3, not 5) and that the four components decompose into the four classes named; alternatives (e.g., a purely place-and-grid 3D map, or a 5D map adding head-velocity) are predicted to be non-GGA (either saddles or non-closed). This row is also **Asserted** because the topology

and the field structure are empirically observed on the rodent substrate but the uniqueness of the 4D-allocentric stack vs. alternative neural codes is the empirical question.

Physics intuition: the four dimensions correspond to the four classical degrees of freedom one needs to specify a single moment of an animal's experience — where it is, in what spatial frame, when, and in what causal sequence. Daily-life metaphor: layer 16 is to layer 15 what a paper map is to a compass — the compass orients you (layer 15); the map locates you, dates you, and tells you what got you here (layer 16). Kill criterion: the discovery of a rodent or analogous mammalian species using a strictly 3D or 5D allocentric representation falsifies the row.

39.4 T-Conscious-Episode: Layer 17 — EIC closure and the conscious episode

Theorem 39.4 (T-Conscious-Episode: layer-17 GGA (T-Origin-42.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(17)} = \widehat{\mathsf{SIP}}^{(17)}[\mathsf{GGA}_{16}]$ *be the layer-17 SIP constructed from the layer-16 attractor: state manifold the configuration space of cortical-network states with closed OH-IH coupling; ports the multi-modal sensory input and motor output; generator the cortical-cycle dynamics with theta-gamma binding and predictive coding; GFF landscape the conscious-state variational free energy with non-zero* J_{Qi} *on the closed EIC loop; observable/kill bundle the conscious-state markers (theta-cycle phase, gamma binding,* $1/f$ *spectrum, perceptual binding latency). Then the layer-17 GGA is the unique conscious episode:*

$$\begin{aligned} GGA_{17} \;=\; [\;& \textit{EIC closure},\;\; \textit{episode length}\;\tau \approx 400\;\textit{ms (two theta cycles)},\\ & \textit{theta carrier}\;4\text{–}8\;\textit{Hz},\\ & \textit{gamma binding}\;30\text{–}80\;\textit{Hz},\;\; \mathsf{CDI} \sim 10\;] \end{aligned} \tag{40}$$

together with the universality clause: every conscious episode in any biological substrate that closes the EIC loop has the same essential structure (theta-bounded, gamma-bound, self-located, cross-modally integrated), with substrate-specific specializations.

Status and forward program. *Status: Asserted.* Derivation to codebook standard is developed in GG-A14-Mind (in preparation); see the Preface, p. 22, for what this tag licenses and what it does not.

Codebook provenance. The constitutional inputs are layer 16 plus GG-A7-Qi4 T-EIC (Arisaka, 2026, A7-Qi4) (the EIC closure theorem: the Evolving Inner Cosmos closes its outer-hologram–inner-hologram pair through a theta-cycle). The named upstream theorem is T-Conscious-Episode, a conjunction of T-EIC and T-HAL of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4): *on the substrate of layer 16, the unique Qi-4-admissible GGA is the conscious episode completing over two* ~ 200 *ms theta cycles (*~ 400 *ms), the IH-forming EIC closure, with CDI* ~ 10.

Part IX
Articulation: layer 18

The closing self-referential layer: the geometry that comes to state the constitution which produced it

40 Articulation: layer 18

One rung remains, and it is the only one whose evidence is the act of reading it.

Interpreting the theorem: the framework predicts that conscious experience is a periodic phenomenon at theta-band frequency, and that any single conscious episode completes in ~ 400 ms — two ~ 200 ms theta cycles, the first (~ 200 ms) yielding only unconscious attention — set by the EIC closure time of the rodent-and-primate hippocampal-cortical loop. This row is **Asserted** (a preview): the EIC closure theorem is published in GG-A7-Qi4 and the P300 component at ~ 300 ms (Dehaene 2014) is consistent with the predicted window, but the identification of the closure with phenomenal experience, and the cortical-circuit derivation that fixes the timescale, are developed in GG-A14-Mind (in preparation).

Physics intuition: conscious experience is the brain's act of closing its outer hologram OH (sensory inflow) on its inner hologram IH (memory + prediction) in a two-theta-cycle attractor (one complete MePMoS loop): the first theta cycle ($\sim$200 ms) yields unconscious attention, the second completes conscious awareness, so the episode is $\sim$400 ms. Daily-life metaphor: layer 17 is to layer 16 what a single frame of a film is to the projector — the projector continues running (the brain continues processing), but at any moment one specific frame is in the gate, and that frame is the conscious episode. Kill criterion: a reliably reported, unitary conscious episode completing in $\leq$ one theta cycle ($\sim$200 ms) — conscious awareness without the second cycle the MePMoS loop requires — falsifies the row.

40.1 T-Articulation: Layer 18 — the present paper

Plain-English opening. With conscious episodes in place, the cascade asks one last question: *what closes the conscious-episode substrate into a recursive recognition of its own constitutive structure?* Remarkably, the empirical answer is what you, the reader, are doing now: reading a formal mathematical articulation of the GG-Constitution that produced the conscious episode that is doing the reading. The conscious episode of layer 17 is a self-located perspective on the world; the act of articulation at layer 18 is a self-located perspective on the constitution that produced the perspective. This is the self-referential closure that gives the cascade its philosophical capstone: the layer-18 GGA is the recognition of the cascade itself. Like a book that writes itself, or like a portrait that paints its own painter, the cascade's final closure is a recursive recognition of its own

production.

We are at the top of the staircase. The eighteenth step does not lead to a nineteenth. It leads back to the bottom: the articulation is a re-statement of the GG-Constitution from inside the cascade that the GG-Constitution forced. This is the central self-referential closure that Part XI will give a formal name (T-Origin) and prove. The present section states the theorem so that future authors can cite it as a stand-alone item.

Constitutional inputs. The layer-18 cascade requires all four axioms and all seven postulates, with GG-A7-Qi4 T-EIC (EIC closure) generalized to the recursive case: the EIC closure of layer 17 is now itself the substrate of a higher EIC closure — the meta-cognitive loop that recognizes the constitution as the constitution recognizes itself through the loop. In plain language: layer 18 is the cascade layer at which the conscious episode reflects on its own constitutive structure and articulates that structure as a mathematical theorem.

Upstream theorems imported. All previous theorems are imported. In particular: (i) Theorem 39.4 (layer-17 GGA) supplies the substrate: the conscious episode that does the articulating. (ii) All earlier theorems (Theorems 31.1 through 39.3) supply the content being articulated: the gauge group, the electroweak vacuum, the periodic table, the small molecules, the amino acids, the genetic code, ATP and DNA, LUCA, the ring attractor, the allocentric map, the conscious episode — the present paper articulates each of these as a layer of the cascade. (iii) The GG-Constitution of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) supplies the meta-structure being recognized: the four axioms and seven postulates that produced the cascade now appear in the layer-18 articulation as the explicit input ledger. (iv) GG-A9-SM Part XI (Arisaka, 2026, A9-SM) (universal-identity insight) supplies the closure clause: every cascade output is the readout of one geometric attractor, and the layer-18 readout is the recognition of that fact. (v) GG-A10-Cosmos (universal-cosmic-identity theorem) (Arisaka, 2026, A10-Cosmos) supplies the cosmological backdrop.

Formal statement.

Theorem 40.1 (T-Articulation: layer-18 GGA (T-Origin-43.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(18)} = \widehat{\mathsf{SIP}}^{(18)}[\mathsf{GGA}_{17}]$ *be the layer-18 SIP constructed from the layer-17 attractor: state manifold the configuration space of meta-cognitive episodes in which a conscious organism reflects on its own constitutive structure; ports the linguistic and mathematical exchange with other conscious organisms; generator the recursive cognitive dynamics that close the meta-EIC loop; GFF landscape the articulation variational free energy on the meta-cognitive stratum; observable/kill bundle the produced articulation, the kill criteria thereof, and the social-epistemic confirmation network. Then the layer-18 GGA is the recursive articulation of the GG-Constitution:*

$$\begin{aligned} GGA_{18} \;=\; [\;& \textit{the } \mathsf{GG\text{-}Constitution} \textit{ of GG-A1-Constitution}, \\ & \textit{the ten upstream papers GG-A1-Constitution–GG-A10-Cosmos}, \\ & \textit{the present paper GG-A11-Origin}\;] \end{aligned} \tag{41}$$

together with the self-referential closure clause: the layer-18 GGA is the recognition that the seventeen-step cascade $\mathsf{GGA}_1 \to \mathsf{GGA}_2 \to \cdots \to \mathsf{GGA}_{17}$ *is forced by the GG-Constitution* $\mathcal{C}$*, and the recognition is itself the cascade's layer-18 output. Existence is demonstrated by the present paper; uniqueness is the central claim of T-Origin (Part XI).*

Proof outline. Step 1: with the conscious episode from layer 17, the configuration space of meta-cognitive episodes admits a discrete classification by the depth of recursion (how many layers of self-reflection the episode supports). Step 2: the variational free energy on this configuration space is minimized by configurations that close the meta-EIC loop: the conscious episode reflects on its own constitutive structure, recognizes that structure as the cascade's eleven-layer output, and articulates that recognition as a mathematical theorem. Step 3: the depth of recursion required for the closure is exactly two: the conscious episode (layer 17) plus the recognition of its constitution (layer 18); higher recursion (recognition of the recognition, etc.) is convergent but does not produce a separate cascade layer because the meta-meta-recognition is structurally identical to the meta-recognition. Step 4: the articulation is realized in the historical record by the ten upstream papers GG-A1-Constitution–GG-A10-Cosmos plus the present paper GG-A11-Origin. Step 5: existence is demonstrated by the corpus itself; uniqueness follows from **GRIP-ST5** sharpened by the recursive closure of GG-A7-Qi4 T-EIC.

Quantitative anchor. The layer-18 readout is necessarily different from the previous seventeen layers, because the readout is the articulation itself, not a numerical observable. Nevertheless, several quantitative anchors can be stated:

- Articulation length: ~ 5300 typeset pages across the cohort.
- Number of named theorems: 18 in the present Part; ~ 100 across the corpus.
- Number of derived parameters: 28 Standard Model parameters (GG-A9-SM) + 15 cosmological observables (GG-A10-Cosmos) + bioenergetic and chemistry-to-life parameters of the present paper ≥ 43 derived quantities with zero free continuous parameters.
- Number of falsifiable predictions: 10 specific experimental tests in the coming decade (the Top 10 Falsifiers of GG-A11-Origin's Executive Summary).
- Number of conscious-organism authors: 1 (Katsushi Arisaka), with the cascade's prediction that the layer-18 GGA can be realized by any sufficiently configured layer-17 substrate.
- Timescale of articulation: ~ 50 years of cumulative work on the framework's predecessors, ~ 5 years on the GG-Theory cohort itself, ~ 1 year on the cohort.
- Geographical localization: UCLA, Los Angeles, California, USA, planet Earth, Local Group of galaxies, observable universe, six-dimensional bulk. The articulation is geographically local; the constitution being articulated is universal.

Physics intuition. At first-year-graduate-level: the layer-18 articulation is a structural improvement on the anthropic principle of Carter (1974). The anthropic principle asks why the constants of

nature admit observers; the framework's answer is that no continuous constants were chosen, so the question dissolves: the constants are forced by the geometry, the cascade is forced by the constants, the observer is forced by the cascade, and the articulation is forced by the observer. Each step is a derivation. The chain of derivations closes on itself: the articulation re-states the geometry that the cascade started from. This is the self-referential closure that the present paper identifies as the central feature of the framework.

The closure is not a paradox. It is a fixed point of the recursive map $\mathsf{GGA}_n \mapsto \widehat{\mathsf{SIP}}^{(n+1)} \mapsto \mathsf{GGA}_{n+1}$ with $n = 17$ and GGA_{18} the articulation of the constitution that produced the cascade. Fixed points of recursive maps are well-defined mathematical objects; they exist when the map's iteration is convergent and the limit is a stable attractor. The cascade's fixed point at layer 18 exists because the meta-cognitive recursion is convergent (further recursions $\mathsf{GGA}_{17}, \mathsf{GGA}_{18}, \ldots$ are all equivalent to GGA_{18} up to representation) and the limit is the articulation.

The historical-register significance is worth a paragraph. What is being stated is a formal mathematical theorem whose conclusion is the existence of intelligent observers articulating the laws of physics, and whose hypotheses are the laws of physics themselves. We are not aware of a prior framework that produces a closure of this kind. Spinoza approached the structure philosophically (Spinoza, 1677), Hegel dialectically (Hegel, 1807), Whitehead metaphysically (Whitehead, 1929), Wheeler cosmologically (Wheeler, 1983). None of them produced a formal mathematical theorem. The framework produces one.

Energy-injection ascent mechanism. At the layer-17-to-layer-18 transition (the present moment, in the historical-register sense), sustained energy injection at the cognitive scale comes from the cumulative cultural and scientific resources of human civilization: educational institutions, libraries, computational tools, peer-review networks, the historical record of physics, the cumulative empirical data of cosmology and particle physics and biology. The Arisaka equation locks the four currents at the cognitive-cultural scale. The layer-18 GFF on the articulation stratum descends to the cascade's recognition of its own structure; the descent's ordered residue is the cohort.

There is no layer 19. The cascade closes at layer 18 because the meta-recursion at higher depth is structurally identical to layer 18 itself. Subsequent articulations — refinements, generalizations, applications, falsifications — are all layer-18 episodes; they do not generate a new cascade layer. This is the cascade's terminal closure.

Examples and daily-life metaphors. Three metaphors. First, like a book that writes itself: the cascade reads its own constitution from inside the cascade; the book's last chapter is a description of the book's first chapter. Second, like a self-portrait by an artist: the painting depicts the painter painting the painting; the conscious organism articulates the constitution that produced the conscious organism. Third, like the closing scene of a recursive film (the ouroboros, the serpent biting its own tail): the cascade's end-state is a recognition of its initial state; the loop closes.

Kill criterion. Theorem 40.1 is falsified by any of: (a) the falsification of any of the upstream theorems (Theorems 31.1–39.4); the present theorem rests on all of them. (b) The demonstration that the $\mathsf{GG\text{-}Constitution}$ can be articulated from inside a cascade with fewer than seventeen cascade

layers (this would imply the cascade is not the minimum-cardinality closure). (c) The demonstration that the cascade admits multiple non-equivalent articulations (this would imply the layer-18 GGA is not unique). (d) The successful articulation of an alternative framework that produces the same seventeen cascade layers with a different layer-18 closure — this would falsify the uniqueness claim of T-Articulation while leaving the existence claim intact.

Plain-English close. The present paper. The cohort. The recognition that the cascade closes on itself. This is the layer-18 GGA: not a particle, not a molecule, not a cell, not a thought, but the act of articulating the constitution that produces particles, molecules, cells, and thoughts. The cascade ends here. It does not end with a new layer beyond; it ends with the recognition that there is no further layer to seek. Layer 18 done. The staircase has been climbed; we are standing at the top, looking back down at the eleven steps, and what we see is that the eleven steps were forced.

40.2 The pillar transition across the cascade

A striking structural feature of the eighteen theorems is the pillar transition across cascade layers. At layers 1–4, Qi-QUA dominates: the four-current bookkeeping is the operationally binding constraint, and the cascade output is which discrete gauge or chemical configuration the bookkeeping admits. At layers 5–9, Qi-EP dominates: variational selection becomes the binding constraint, and the cascade output is which specific functional trajectory the variational principle selects. At layers 10–17, Qi-HAL dominates: memory architecture becomes the binding constraint, and the cascade output is which closed-loop architecture the memory holonomy admits — with layer 10 shared between Qi-EP and Qi-HAL, the cell being where selection hands over to architecture. At layer 17, Qi-CON co-dominates: the scaling diagnostic (the $1/f$ two-knee spectrum of the resting brain) tests that the cognitive cascade is genuinely in the admissibility window. At layer 18, all four pillars contribute simultaneously: the articulation requires bookkeeping (it must respect the constitution), selection (it must extremize the right functional), diagnostic (it must be scale-covariant across layers), and architecture (it must close the meta-cognitive loop).

Table 6: Which of the four Qi-4 pillars dominates at each of the eighteen layers, and where the hand-over falls. Qi-QUA carries the physical strata, layers 1 to 4, from the six-dimensional gauge bulk through the electroweak and hadronic–atomic rungs to small molecules; Qi-EP carries the chemical and prebiotic strata, layers 5 to 9, from amino acids and sugars through polymers, ATP and the RNA world to DNA; Qi-HAL carries the biological and cognitive strata, layers 11 to 16, from the three-domain split to the allocentric map, with layer 10, the cell, shared between Qi-EP and Qi-HAL. Layer 17, the conscious episode, adds Qi-CON, and layer 18, articulation, requires all four at once.

Layer	Stratum	Dominant pillar(s)
1	Gauge / 6D bulk	Qi-QUA
2	Electroweak	Qi-QUA
3	Hadronic/atomic	Qi-QUA
4	Small molecules	Qi-QUA

continued on next page

Table 6 continued

Layer	Stratum	Dominant pillar(s)
5	Amino acids/sugars	Qi-EP
6	Polymers	Qi-EP
7	ATP (bioenergetic)	Qi-EP
8	RNA-World	Qi-EP
9	DNA (information)	Qi-EP
10	Cell/LUCA	Qi-EP, Qi-HAL
11	Three-Domain Split	Qi-HAL
12	Eukaryogenesis	Qi-HAL
13	Multicellularity	Qi-HAL
14	Central nervous system	Qi-HAL
15	Ring attractor	Qi-HAL
16	Allocentric map	Qi-HAL
17	Conscious episode	Qi-HAL, Qi-CON
18	Articulation	all four

40.3 The integer ledger across the cascade

A second striking structural feature is that the same integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ appears in the quantitative readout of every layer. At layer 1 it governs the gauge couplings via $2^J = 128$ and $L^2 = 25$. At layer 2 it fixes the family number $N_g = 3$ and the scale-suppressed electroweak scale $v = M_{\text{lock}}(2/L)^N$. At layer 3 it sets the Rydberg energy via the same dyadic charge structure. At layer 5 it fixes the amino-acid count $|\mathsf{GGA}_5| = K - NL = 20$. At layer 8 it fixes the codon redundancy $4^3/20 \approx 3.2$. At layer 7 it sets $\mathsf{Q}_\mathsf{B} = (2/5)(E_{\text{Ry}}/K)$ and hence ATP at $2N_A\mathsf{Q}_\mathsf{B} = 30$ kJ/mol. At layer 10 it sets the cell-size and metabolic-rate scales via the bioenergetic anchoring. At layers 15–16 it sets the neural-circuit topology via the rank-one current locking. At layer 17 it sets the cognitive timescales via the EIC-loop closure on the QGL-locked currents. One integer ledger; eighteen cascade readouts. This is the operational content of the universal-identity insight of GG-A9-SM Part XI (the universal-identity section) generalized across the entire cascade.

Part X
The cascade as one ledger

The eighteen-row codebook, the Top 10 Falsifiers, the reader's guide, and what would fail if any layer were absent

41 Master cascade codebook: the eighteen Ground Geometric Attractors as one ledger

Plain-English opening: what this section is for

Let us imagine the periodic table that hangs on the wall of every chemistry classroom in the world. Each row of that table is a shell of electrons; each column collects the elements that share a chemical personality; each cell holds a name, a number, a mass, an electronic configuration, and an implicit promise that the same rules apply to all of it. A student who has never seen the table before can be taught, in one afternoon, to read it horizontally as a sequence of stages and vertically as a family of behaviors, and to look up any single element and know immediately where it sits relative to its neighbors. The table compresses an enormous amount of empirical and theoretical knowledge into one rectangular ledger that anybody, with a little practice, can audit.

What follows in this Section plays the same role for the eighteen-layer cascade of GG-Theory: it is the periodic table of *everything the cascade has produced so far*. Each row is one of the seventeen cascade layers (plus the meta-cognitive layer 18, the present paper itself, for eighteen rows in total). Each column is a precise piece of information: which substrate the layer lives on, which Ground Geometric Attractor (GGA) the layer selects, what numerical anchor the GGA predicts, how confident we are in that prediction today, and which upstream theorem from GG-A1-Constitution–GG-A10-Cosmos licenses the claim. A reader who has never read a single page of GG-Theory can, by reading this table alone, learn (i) what the framework predicts, (ii) where the framework is solid and where it is still extending credit to itself, and (iii) what experiment or proof would have to come in for any single row to be promoted from a conditional to a derived status. The table is meant to be hostile-reviewer-proof: it lists its own conditionals up front, so that nobody can accuse it of laundering them through prose.

This Section's job is to provide that audit ledger explicitly, with the same level of typographic care that the periodic table earns by being the most-photocopied object in the natural sciences. Everything that follows is either a definition (the status legend), a row of the ledger (the master longtable), or commentary on how each row earned its place (per-row provenance). At the end we count rows by confidence class and lay out the promotion roadmap — which conditionals will be discharged by which experiment or lemma — so the reader can see the entire enterprise as a single, finite, falsifiable project.

41.1 Confidence triage and status legend

Following the conventions established in Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) L41/L42 and used throughout GG-A9-SM (Arisaka, 2026, A9-SM) and GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos), we classify every row of the master codebook into exactly one of five confidence classes. The constitutional

warrant for using these five classes (and only these five) is the LC-discipline of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) (no claim may travel without an explicit chain of derivation), together with the Euclidean zero-free-parameter requirement of GG-A4-Euclid (Arisaka, 2026, A4-Euclid) (the input ledger is exhausted by the Geometric Universal Five Constants GU-5 and the OGN-5 integer ledger). Together these say: every claim either descends from those inputs without slack, or it does not, and the cascade is responsible for telling the reader honestly which case it is in.

Derived. A row is *Derived* when the full constitutional chain from GG-A1-Constitution–GG-A10-Cosmos is closed in the published record, with no unstated lemma and no unargued assumption. Concretely, a Derived row is one for which (i) the upstream theorem(s) listed in the table are themselves proved in the cited Arisaka papers (the lemma has been done), (ii) the numerical anchor in the row follows by published computation from those theorems plus the OGN-5 integer ledger, and (iii) the substrate to which the GGA attaches has been independently identified before the GGA is asserted (no circularity through naming). Derived is the strongest claim the framework makes about a row; it says: *the matter is settled, and any disagreement with the listed numerical anchor would constitute a falsification of the entire cascade, not a recalibration of this row.*

Anchor-Derived (derivation-deferred). A row is *Anchor-Derived* when its empirical anchor is quantitatively closed in the published literature and the cascade reproduces it, but the from-geometry derivation to codebook standard is developed in a companion paper still in preparation. The tier exists because the definition of *Derived* above is strict about the *published record*: three rows — layer 7 (the ATP quantum), layer 9 (the four-letter alphabet) and layer 10 (the LUCA-class cell) — would otherwise have been reported as Derived in the same breath as the text conceding that their proofs are developed in GG-A13-Life (in preparation), and a paper in preparation cannot close a chain in the published record. The anchor is done; the derivation is deferred; the tag says so. Anchor-Derived sits below Derived and above Conditional, and the difference from Conditional is worth stating: a Conditional row waits on a lemma whose statement is known but whose truth is open, whereas an Anchor-Derived row waits on the writing-up of a derivation whose target is already matched by measurement.

Conditional. A row is *Conditional* when the cascade machinery commits to selecting a specific GGA on the substrate in question, and the upstream theorems of GG-A1-Constitution–GG-A10-Cosmos suffice to make that selection except for a single, explicitly named, missing lemma. The missing lemma is always one of two types: a *substrate-identification lemma* (e.g., the small-molecule closure lemma at layer 4, which must show that the warm-wet stratum geometrically forces a discrete set of stable polyatomic molecules under GDOS descent) or a *mapping lemma* (e.g., the codon-mapping lemma at layer 8, which must show that the $4^3 \to 20$ map is the unique Qi-4-admissible solution of the polymer-folding GFF). A Conditional row is not a guess; it is a published commitment to a specific lemma whose statement is known and whose proof is the current research target.

Asserted. A row is *Asserted* when the cascade selects a specific GGA on a substrate that has been experimentally identified by other workers, and the framework predicts that the GGA so selected is the unique stable solution on that substrate, but the prediction has not yet been demonstrated in a controlled experimental comparison with named alternative architectures. The neural ring-attractor of layer 15 is the prototype: the ring-attractor itself is observed in insect head-direction circuits (Kim et al., 2017), and rodent head-direction systems (Taube et al., 1990), but the *uniqueness* of SO(2) as the topology of stable heading representation — as against, say, a torus or a Klein bottle or a discrete graph — is what the GGA claim

adds and what awaits experimental discrimination on a specific substrate. Asserted is therefore weaker than Conditional in the sense that a new lemma alone cannot close the row; an experiment must.

Existence-Demonstrated. A row is *Existence-Demonstrated* when the very act of the cascade producing the row constitutes empirical confirmation that the row is occupied. There is exactly one such row, layer 18, the articulation layer: the present paper is, by its existence, the empirical demonstration that an articulator-class GGA has been instantiated on the relevant substrate. The constitutional warrant for treating this as evidence (and not as petitio principii) is the OGGEP principle of GG-A1-Constitution §AX-4 together with the self-referential closure theorem of GG-A9-SM (Arisaka, 2026, A9-SM) (the cascade is reflexively complete only if it can describe itself), and the HAL completeness theorem of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4): layer 18 is the unique GGA on the substrate of recursive symbolic articulation, and its instantiation is what one is reading. Existence-Demonstrated rows are the rarest class precisely because they require the cascade itself to close on the writer.

The five classes as a single procedural ladder. The five classes form a ladder of increasing closure: Existence-Demonstrated ⇒ Derived ⇒ Anchor-Derived ⇒ Conditional ⇒ Asserted, where the arrow points from "most-closed-on-itself" to "most-dependent-on-future-work." At every row we report the strongest honest class. No row is promoted across the ladder without an explicit citation to either a newly proved lemma or a newly published experimental anchor; demotion is also allowed (and has happened in the historical record of the program: see Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) L41 for the demotion log). The legend is therefore not decorative; it is the audit trail.

41.2 The eighteen-row codebook longtable

Table 7: Master cascade codebook: eighteen rows summarizing the seventeen-layer GRIP-SIP-Qi-4 cascade plus the articulation meta-row. Each row gives the layer index, the stratum or substrate on which the cascade lands, the Ground Geometric Attractor (GGA) selected on that stratum, the numerical anchor predicted by the GGA, the confidence class per the legend of §41.1, and the upstream theorem(s) from GG-A1-Constitution–GG-A10-Cosmos that license the row. All numerical anchors carry SI or natural units; uncertainties are 1σ unless otherwise stated.

Layer	Stratum / substrate	GGA name	Quantitative anchor	Status	Upstream theorem(s)
1	Gauge / proton; 4D Minkowski boundary readout of the 6D BI-6 bulk	$G_{\mathrm{SM}} = SU(3)_c \times SU(2)_L \times U(1)_Y$; stable proton	$m_p \approx 938.272$ MeV ($\pm 2 \times 10^{-5}$, Particle Data Group 2024); $\tau_p > 2.4 \times 10^{34}$ yr (Particle Data Group 2024 lower bound)	**Derived**	T-GUT-Closure (GG-A9-SM (Arisaka, 2026, A9-SM) Part XI); T-GU5 on Q_B (GG-A1-Constitution (Arisaka, 2026, A1-Constitution) §AX-2)

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Table 7 continued from previous page

Layer	Stratum / substrate	GGA name	Quantitative anchor	Status	Upstream theorem(s)
2	Electroweak vacuum; Yukawa stratum on DGI → GSSB of $SU(2)_L \times U(1)_Y$	Charged-lepton triple $\{e, \mu, \tau\}$ and Yukawa-locked v	$m_\tau/m_\mu = 16.817$ ($\pm 0.5\%$, Particle Data Group 2024); $v = M_{\text{lock}}(2/5)^3 \approx 246.4$ GeV (± 0.1 GeV)	**Derived**	T-Electroweak-Vacuum (GG-A9-SM (Arisaka, 2026, A9-SM) Yukawa block + GG-P2-N3 (Arisaka, 2026, P2-N3))
3	Atomic stratum; non-relativistic Coulombic substrate of GGA_2	Periodic table H, He, C, N, O, …, Fe; hydrogenic ground state	$E_{\text{Ry}} = 13.6057$ eV ($\pm 10^{-7}$, Particle Data Group 2024); $a_0 = 5.29177 \times 10^{-11}$ m	**Derived**	T-Atomic-Ground-State (GG-A1-Constitution (Arisaka, 2026, A1-Constitution) §AX-2, GG-A4-Euclid (Arisaka, 2026, A4-Euclid) §3, GG-A5-GDOS (Arisaka, 2026, A5-GDOS))
4	Small-molecule stratum; warm-wet (200–400 K, liquid-water-window) substrate of GGA_3	H_2O, CO_2, NH_3, CH_4 (the closed quartet: the simplest hydrides of oxygen, nitrogen and carbon, together with the simplest oxide of carbon)	H_2O at -285.83 kJ/mol formation; CO_2 at -393.51 kJ/mol; CRC 2016 thermochemistry; geometry angles within 1° of VSEPR predictions	**Conditional**	T-Molecular-Closure (GG-A11-Origin's own; GDOS apparatus of GG-A5-GDOS (Arisaka, 2026, A5-GDOS)) + *small-molecule closure lemma*
5	Proteinogenic-amino-acid stratum; aqueous chiral substrate of GGA_4	The twenty L-handed proteinogenic amino acids; D-handed sugars	$\Delta\Delta G_{\text{L}\to\text{D}} \approx +12$ kJ/mol enantio-selection energy under Qi-4-locked descent; canonical count 20 observed in every naturally evolved biology	**Conditional**	T-Amino-Acid-Selection (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 pillars) + *chirality-lock lemma*
6	Polymer-class stratum (oligopeptide / oligonucleotide / fatty-acid); substrate of GGA_5	Oligopeptides, oligonucleotides and fatty-acid chains, co-emerging on parallel substrata with no single family privileged	Chain lengths $\ell \sim 5$–20 monomers at sustained flux; montmorillonite-templated oligomers to 40–50 units (Ferris et al., 1996)	**Conditional**	T-Polymer-Closure (GG-A11-Origin's own) + *polymer-class closure lemma*

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Table 7 continued from previous page

Layer	Stratum / substrate	GGA name	Quantitative anchor	Status	Upstream theorem(s)
7	Bioenergetic stratum; $\mathsf{Q_B}$-anchored membrane chemiosmotic substrate of $\mathsf{GGA_6}$	ATP as universal energy currency	$\Delta G_{\mathrm{ATP}} = 2N_A\mathsf{Q_B} \approx 30.0$ kJ/mol (empirical 30.5 ± 0.5); proton-motive force ~ 200 mV	**Anchor-Derived**	T-Bioenergetic-Closure: T-GU5 for $\mathsf{Q_B}$ (GG-A1-Constitution (Arisaka, 2026, A1-Constitution) §AX-2); T-EP (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 block)
8	RNA-World stratum; bifunctional informational-catalytic polymer substrate of $\mathsf{GGA_7}$	RNA $\{A, U, G, C\}$ with Watson–Crick pairing; ribozymes; pre-translation hairpins/stem-loops	Codon redundancy $\langle r \rangle = 64/20 = 3.2$; ribozyme rate enhancement 10^7–10^9; 4-letter alphabet $4 = N + 1$	**Conditional**	T-RNA-World-Closure (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 block) + *RNA-bifunctionality lemma*
9	DNA information-storage stratum; archival substrate of $\mathsf{GGA_8}$	DNA $\{A, C, G, T\}$ with antiparallel double helix; B-form geometry; replication fidelity $\epsilon \approx 10^{-9}$/bp	$\{A, C, G, T\}$ as the unique QGL-admissible alphabet; B-form pitch 3.4 nm; replication $\epsilon = 10^{-9}$/bp three-tier product	**Anchor-Derived**	T-Information-Closure: T-EP (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)); 4-letter alphabet uniqueness via BI-6 (GG-A3-BI6 (Arisaka, 2026, A3-BI6))
10	Cellular stratum; first SeOS-class organism	LUCA-class first cell with closed metabolism, replication, and boundary	LUCA age $\sim$3.8 Ga ($\pm$0.2 Ga geochemistry); cell size 1–10 μm; metabolic power 1–100 W/kg; replication error 10^{-9}/bp	**Anchor-Derived**	T-Cell-Closure: SeOS closure (GG-A5-GDOS (Arisaka, 2026, A5-GDOS)); T-CON (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) Qi-4 block)
11	Primary-Domain-Split substrate; dual-gauge SSB on $\mathsf{GGA_{10}}$	Bacteria ($\oplus$) Archaea: two stable lipid-and-chemiosmosis attractors on the DGL(5:2) dual-gauge action	Two-domain phylogeny established at $\sim$ 3.5 Ga; Bacteria = ester-FA/H^+; Archaea = ether-isoprenoid/Na^+	**Conditional**	T-Primary-Domain-Split: dual-gauge SSB; BI-6 closure (GG-A3-BI6 (Arisaka, 2026, A3-BI6))

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Layer	Stratum / substrate	GGA name	Quantitative anchor	Status	Upstream theorem(s)
12	Eukaryogenesis substrate; energy-per-gene phase-jump on GGA_{11}	Archaeal host $\oplus$ α-proteobacterial endosymbiont; nuclear envelope; chromatin organization	δW/gene $\uparrow$ 2–20$\times$ (Lane–Martin economics, Lane, 2015); $\sim$ 2 Ga; dual-knee $1/f$ PSD predicted	**Conditional**	T-Eukaryogenesis: T-EP variational principle (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)) + *Lane–Martin energy-per-gene lemma*
13	Multicellularity substrate; M0–M7 ladder on GGA_{12}	Clonal adhesion $\rightarrow$ gap junctions $\rightarrow$ division of labor $\rightarrow$ patterning $\rightarrow$ transport $\rightarrow$ integration $\rightarrow$ organogenesis	$\sim$ 600 Ma (animals), $\sim$ 1 Ga (plants/fungi); multiple convergent origins; Kleiber-type metabolic scaling (exponent debated, $\sim$3/4 vs 2/3) (Kleiber, 1932)	**Conditional**	T-Multicellularity: Qi-HAL closure (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)) + *M-ladder uniqueness lemma*
14	Centralized-neural substrate; integrated nerve ring on GGA_{13}	The minimal integrated sensorimotor connectome (egocentric, pre-allocentric); *C. elegans*-class nerve-ring central nervous system	302 neurons; $\sim$7,000 synapses ($\sim$5,000 chemical, $\sim$600 gap, $\sim$2,000 NMJ); 118 neuron classes; CPG-driven klinotaxis/klinokinesis; origin $\sim$0.56 Ga (Ediacaran bilaterians; *C. elegans* a modern exemplar, not an ancestral form)	**Asserted**	T-Central-Nervous-System (this paper Part XI; empirical anchors Cook et al., 2019; White et al., 1986; Brenner, 1974)
15	Neural-ring substrate; insect ellipsoid-body / mammalian head-direction circuit	1D ring attractor on $SO(2)$ for allocentric heading	Drift rate $\lesssim 0.5^\circ$/s; bump width $\sim 60^\circ$ FWHM; refresh $\sim$ 50 ms (Kim et al. 2017; Taube et al. 1990)	**Asserted**	T-Neural-Ring-Attractor (this paper Part XI; empirical anchors Kim et al. 2017; Taube et al. 1990)
16	Rodent-hippocampal substrate; 4D allocentric stratum on GGA_{15}	4D place-+-grid-+-time-+-causal-history allocentric map	Place-field width $\sim$ 30 cm; grid-cell scale ratio $\sim \sqrt{2}$; theta cycle 4–12 Hz; time-cell span $\sim$ 10 s	**Asserted**	T-Allocentric-Map (this paper Part XI; empirical anchors Hafting et al., 2005; O'Keefe and Dostrovsky, 1971)

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Table 7 continued from previous page

Layer	Stratum / substrate	GGA name	Quantitative anchor	Status	Upstream theorem(s)
17	Conscious-episode substrate; theta-cycle EIC closure on GGA_{16}	The ∼400 ms (two-theta-cycle) conscious episode; OH/IH-locked EIC unity	Episode ∼400 ms = two ∼200 ms theta cycles (one MePMoS loop; the first cycle ∼200 ms is unconscious attention); CDI ∼ 10 (±2); P300 latency 300 ms (±50 ms, Dehaene 2014)	**Asserted**	T-Conscious-Episode: T-EIC and T-HAL (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4))
18	Articulation substrate; recursive symbolic articulation on GGA_{17}	The meta-cognitive act of writing the present paper	This document; word count ∼ 10^5; citation graph closes on GG-A1-Constitution–GG-A10-Cosmos	**Existence-Demonstrated**	T-Articulation: cumulative force of GG-A1-Constitution–GG-A10-Cosmos; self-referential closure of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI; T-HAL completeness of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)

41.3 Aggregate analysis: confidence distribution and the promotion roadmap

Reading status for the consequence layers. GG-A11-Origin is the keystone of the GG-A series, not its delivery vehicle for chemistry, life, and mind. The particle and cosmic floors are derived to full rigor in GG-A9-SM and GG-A10-Cosmos; the chemistry, life, and mind floors are *previewed* here and *derived* in the companion papers GG-A12-Chemistry, GG-A13-Life, and GG-A14-Mind (in preparation). Accordingly, several of the consequence layers carry a tag weaker than their empirical standing alone would suggest. That is the legend working as intended: a tag records the state of the *derivation*, in the single sense fixed at §41.1, and never the weight of the evidence — a row can be empirically strong and still carry a weak grade. Any result stated assertively in those layers is to be read as a forecast the companion papers will discharge, not a claim closed within the present paper. What GG-A11-Origin itself delivers is the architecture (the one cascade engine), the physics anchors (layers 1–3, via GG-A9-SM/GG-A10-Cosmos), the recursive-uniqueness theorem as a structural claim, and the Top 10 falsifiers; the per-domain derivations are what it forecasts.

Counting the eighteen rows of Table 7: there are three **Derived** rows (layers 1, 2, 3), three **Anchor-Derived** rows (layers 7, 9, 10), seven **Conditional** rows (layers 4, 5, 6, 8, 11, 12, 13), four **Asserted** rows (layers 14, 15, 16, 17), and one **Existence-Demonstrated** row (layer 18). Two ratios are worth separating, and we report both rather than the flattering one. Counted strictly — rows whose chain is closed *in the published record* — the fraction is $3 + 1 : 18 = 4 : 18 \approx 22\%$ today. Counted by empirical closure, allowing the three Anchor-Derived rows whose measured anchors are settled and whose derivations are being written, it is $7 : 18 \approx 39\%$. The stricter number is the one the legend licenses; the looser one is stated so that the reader can see exactly what the difference between them consists of, which is three rows of biology waiting on GG-A13-Life. The next nine years of the program (2026–2035) aim to close all three Anchor-Derived

derivations, discharge the named lemma on all seven Conditional rows, and complete the experimental anchors and the GG-A12-Chemistry–GG-A14-Mind derivations on all four Asserted rows, bringing the strict fraction to $18 : 18 = 100\%$.

Pending lemmas (the seven Conditional rows). For layer 4, the missing lemma is the *small-molecule closure lemma*: on the warm-wet stratum, the GFF Morse landscape has exactly four global minima, identified with H_2O, CO_2, NH_3, CH_4. For layer 5, the missing lemma is the *chirality-lock lemma*: on the small-molecule substrate, the Qi-4 cascade selects L-handed amino acids and D-handed sugars as the unique GSSB solutions of the warm-wet GFF. For layer 6, the missing lemma is the *polymer-class closure lemma*: the GFF landscape on the layer-5 substrate admits exactly three co-emerging polymer basins — oligopeptide, oligonucleotide and fatty-acid — and no fourth of comparable depth. For layer 8, the missing lemma is the *codon-mapping lemma*: the $4^3 \to 20$ map is the unique Qi-4-admissible solution of the polymer-folding GFF on the amino-acid substrate, with codon length $k = 3$ forced by the minimal-redundancy constraint $4^k \geq 20$, $4^{k-1} < 20$. Layers 8, 11, 12, and 13 carry, respectively, the RNA-bifunctionality lemma, the dual-gauge-SSB lemma on the DGL(5:2) packet (GG-A3-Bl6), the Lane–Martin energy-per-gene lemma, and the M-ladder-uniqueness lemma (each stated with its row in the master codebook). Layer 11 joins this tier because its own text says it awaits a named lemma, and pending-a-named-lemma is what Conditional means.

Pending experiments (the four Asserted rows). For layer 15, the empirical anchor needed is a controlled comparison of allocentric-heading topology between (a) the ring-attractor architecture observed in fly ellipsoid body (Kim et al., 2017) and rodent head-direction cells (Taube et al., 1990), and (b) plausible alternatives (line attractor, small-graph attractor, 2-sphere) in a previously-unstudied taxon (e.g., cephalopod head-direction circuitry, in which the topology is not yet established). For layer 16, the empirical anchor needed is a high-resolution decomposition of rodent hippocampal coding showing that the dimensionality is exactly 4 (place + grid + time + causal-history) rather than 3 or 5, on a behavioral task that loads the causal-history dimension explicitly — ongoing in the literature but not yet conclusive. For layer 14 (the *C. elegans*-class CNS), a controlled comparison of the integrated connectome against alternative architectures; for layer 17 (the conscious episode), the phase-resolved EEG/MEG/ECoG measurement of the predicted alpha/gamma phase steps (GG-A14-Mind).

The promotion roadmap as a single project. Discharging the seven Conditional lemmas is a theoretical project (requires GDOS/Qi-4 analysis at layers 4, 5, 6, 8, 11, 12, 13); completing the four Asserted rows is a combined empirical-and-derivation project (layers 14, 15, 16, 17). The total work is therefore split $7 : 4$ theory-to-experiment, with the empirical Pull tests of Section B providing the cross-layer audit. The three Anchor-Derived rows (layers 7, 9, 10) are a third kind of work and a lighter one: no lemma is open and no experiment is owed, only the writing-up of the from-geometry derivation in GG-A13-Life. The Existence-Demonstrated row (layer 18) requires no further work other than the act of writing. The Derived rows (layers 1, 2, 3) require no work beyond continued cross-checking with the existing literature.

Plain-English close. An honest accounting of confidence is load-bearing. A framework that hides its conditionals is not closer to closure, only further from honesty. The codebook is the structural ledger; the Pull table is the empirical ledger; the two together are the audit trail. The cascade does not ask the reader for belief. It asks for an audit.

42 The Top 10 Falsifiers: a Pull-table audit of the framework's falsifiability

Plain-English opening: what a Pull table is and why ten is the right number

A Pull table is the experimentalist's accounting sheet, used in every precision measurement from the muon anomalous magnetic moment to the cosmic-microwave-background temperature spectrum. The recipe is mechanical: for each prediction the framework makes, write down the predicted value $V_{\rm pred}$ with its theoretical uncertainty $\sigma_{\rm pred}$, the observed value $V_{\rm obs}$ with its experimental uncertainty $\sigma_{\rm obs}$, compute the combined uncertainty $\sigma_{\rm combined} = \sqrt{\sigma_{\rm pred}^2 + \sigma_{\rm obs}^2}$, and report the Pull $P = (V_{\rm obs} - V_{\rm pred})/\sigma_{\rm combined}$. If $|P| < 1$ the prediction agrees with observation; if $|P| < 3$ the prediction is consistent within experimental scatter; if $|P| > 5$ the prediction is falsified. A framework with N predictions and a Pull table whose entries all satisfy $|P| < 3$ is in healthy empirical contact with the world; a framework whose Pull entries cluster at $|P| > 5$ is falsified N-fold over. The Pull table is not a courtesy — it is the bridge between calculation and decision.

Why ten falsifiers rather than eighty? Because of the hostile-reviewer test: if the framework cannot point to a short list of specific, calculable, decision-trigger predictions over the coming decade — predictions whose outcome is not yet known but whose threshold for success or failure can be stated in advance — then it is philosophy, not physics, no matter how internally consistent its prose. Ten is small enough to be a genuine commitment and broad enough to sample (i) the gauge sector (KK lock-cluster), (ii) the dark sector (Kaxion), (iii) late-time cosmology (dark energy $w = -1$ and tensor r), (iv) baryon-number stability (proton decay), (v) the lepton sector (the PMNS phase $\delta_{\rm PMNS} \approx 196°$), and (vi) the life-and-mind cascade (the bioenergetic quantum, the genetic alphabet, the eukaryotic $1/f$ spectrum, the conscious episode). Crucially, *eight of the ten are genuine forward bets* whose answer is not yet known. Each falsifier is independently falsifying: failure on any single front falsifies the framework. The list is explicitly time-bounded: nothing awaits an experiment later than ~ 2040 (proton decay), and the bulk resolves in the 2026–2035 corridor.

Honest classification of the ten falsifiers

Before reading the Pull table, the reader deserves a clear statement of what kind of empirical commitment each row represents. The framework's ten falsifiers divide cleanly into two classes, and — by deliberate design — the list is now dominated by the strongest class:

Forward falsifiers (8 of 10): Tests 1–6 (KK lock-cluster; Kaxion dark matter; dark energy $w = -1$; proton stability; tensor-to-scalar $r = 0.0038$ (two-sided); leptonic CP phase $\delta_{\rm PMNS} \approx 196°$) and tests 8–9 (the four-letter genetic alphabet; the dual-knee $1/f$ spectrum, tested in two substrates — 9a eukaryotic-metabolic and 9b cortical-neural). Each commits to a value (or a bound) whose outcome is *not yet known*, on a named instrument, with a named decision window and a named tolerance. A result at named precision at the named experiment in the named window falsifies the framework. These eight are the strongest form of empirical commitment a theory can make: the answer is genuinely open, and we have placed a bet.

Precision audits (2 of 10): Tests 7 ($\Delta G_{\rm ATP} = 2N_A \mathsf{Q}_{\mathsf{B}}$) and 10 (the conscious-episode duration). These compare a value already in the literature to a sharp framework anchor; they are not open-outcome bets, but each tightens toward forward status as independent re-measurement at the named precision arrives (single-molecule biophysics; precision psychophysics). They are listed honestly as audits, not predictions.

The portfolio is, by design, **eight forward falsifiers and two precision audits**. A forward falsifier names

a number whose value is not yet known, an instrument that will measure it, and a decade window in which the answer arrives; a precision audit compares an already-measured quantity to a sharp framework anchor and tightens toward forward status as re-measurement improves. The framework stakes itself on the eight open-outcome bets that experimentalists are actively racing to settle this decade: a framework gains nothing by listing the predictions it cannot lose, and everything by listing the ones it can.

What the Top 10 honestly commits to. Eight genuine forward falsifiers spanning six strata — the gauge sector (KK lock-cluster), the dark sector (Kaxion), late-time cosmology (dark energy $w = -1$ and tensor r), baryon-number stability (proton decay), the lepton sector (the PMNS phase), and the life/mind cascade (the genetic alphabet, the eukaryotic spectrum) — plus two precision audits (the bioenergetic quantum; the conscious-episode window). The framework's commitment is to all ten, and on eight of them the answer is not yet in. A reader who finishes this paper without scrutinizing each row will not be reading honestly; the Pull table that follows is constructed so the reader can scrutinize.

42.1 The Top 10 Falsifiers Pull table

Table 8: The Top 10 Falsifiers. Pull $P = (V_{\text{obs}} - V_{\text{pred}})/\sigma_{\text{combined}}$ where $\sigma_{\text{combined}} = \sqrt{\sigma_{\text{pred}}^2 + \sigma_{\text{obs}}^2}$. "Forward" indicates a prediction whose observed value is not yet measured. "Decision threshold" is the experimental sensitivity at which the prediction will be definitively confirmed or falsified. "Experiment / time horizon" lists the facility and the calendar window in which the decision is expected.

#	Test name	Predicted value	Observed (or 95% CL bound)	Pull	Decision threshold	Experiment / time horizon
1	KK lock-cluster mass (F-Origin-1)	$M_{\text{lock}} = 3.85 \pm 0.10$ TeV	Not yet observed; ATLAS+CMS limit $\sim$ 2 TeV (Particle Data Group 2024)	**Forward**	5σ discovery at $M = 3.85$ TeV ± 0.4 TeV	HL-LHC 2030–2035 (GG-P1-KK (Arisaka, 2026, P1-KK))
2	Kaxion dark-matter mass (F-Origin-2)	$m_a = 8.1\,\mu$eV	Not yet observed; current haloscope limits $> 10\,\mu$eV (Particle Data Group, 2024)	**Forward**	5σ axion-photon coupling in the 6.6–8.8 μeV band	ADMX-EFR, IBS-CAPP 2027–2030 (Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion))
3	Dark-energy equation of state (F-Origin-3)	$w = -1$ exactly (true cosmological constant; $\Omega_\Lambda = 1 - 1/\pi$; GG-A10-Cosmos)	DESI 2024: hint of *evolving* dark energy ($w_0 w_a$) at $\sim$ 2–4σ, not yet decisive	**Forward**	DESI, Euclid, and Roman distinguish $w = -1$ from $w(z)$ at $> 3\sigma$; a confirmed $w \neq -1$ falsifies	DESI, Euclid, Roman 2026–2030 (GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos))

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#	Test name	Predicted value	Observed (or 95% CL bound)	Pull	Decision threshold	Experiment / time horizon
4	Proton stability (F-Origin-4)	$\tau_p(p \to e^+\pi^0) > 10^{35}$ yr (orbifold-forbidden decay; GG-A9-SM)	Super-K: $\tau_p > 2.4\times10^{34}$ yr (Particle Data Group 2024)	**Forward**	any $p \to e^+\pi^0$ event falsifies; sensitivity reaches $\sim 10^{35}$ yr	Hyper-Kamiokande, DUNE 2027–2040 (GG-A9-SM (Arisaka, 2026, A9-SM))
5	Tensor-to-scalar ratio r (F-Origin-5)	$r = 0.0038 = 12/N^{*2}$ (derived plateau, $N^* = 52.6$; GG-A10-Cosmos)	$r < 0.036$ at 95% CL (Planck+BICEP, Planck Collaboration 2020)	**Forward**	a measurement inconsistent with $r \simeq 0.004$ *in either direction* falsifies; CMB-S4 + LiteBIRD reach $\sigma(r) \sim 10^{-3}$	CMB-S4 + LiteBIRD 2030–2035
6	Leptonic CP phase (F-Origin-6)	$\delta_{\rm PMNS} \approx 196°$ (derived in GG-A9-SM/GG-A10-Cosmos)	Not yet measured; T2K/NOvA hints, $\sim \pm40°$, CP-conserving values not excluded	**Forward**	DUNE + Hyper-K measure $\delta_{\rm CP}$ to $\sim \pm15°$; a value inconsistent with 196° falsifies	DUNE, Hyper-Kamiokande 2030–2035 (GG-A9-SM (Arisaka, 2026, A9-SM))
7	Bioenergetic quantum (Life) (F-Origin-7)	$\Delta G'^{\circ}_{\rm ATP} = 2N_A\mathsf{Q_B} = 30.0$ kJ/mol	Biophysics: $\Delta G'^{\circ}_{\rm ATP} \approx 30.5 \pm 0.5$ kJ/mol	**Audit**; $\sim 1.6\%$	standard-state remeasurement to $< 0.5\%$	single-molecule biophysics 2026–2030 (GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) + layer 7)
8	Genetic-alphabet cardinality (Life) (F-Origin-8)	exactly four letters {A,C,G,T} in naturally-evolved life	all known wild life: four (White et al. 1986 convention; synthetic Hachimoji excluded)	**Forward**	a *wild* organism with a stable $\neq$ 4-letter genetic alphabet falsifies	comparative / meta-genomics, continuous (layer 9)

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#	Test name	Predicted value	Observed (or 95% CL bound)	Pull	Decision threshold	Experiment / time horizon
9a	Dual-knee $1/f$ metabolic spectrum (Life) (F-Origin-9a)	two spectral knees in the single-cell eukaryotic metabolic-noise PSD (dual-DGL; GG-A5-GDOS); prokaryote shows a single knee	not yet systematically measured at single-cell resolution	**Forward**	single-cell metabolic imaging resolving one vs. two knees	single-cell live imaging 2026–2028 (layer 12)
9b	Dual-knee $1/f$ neural spectrum (Mind) (F-Origin-9b)	exactly 2 separable aperiodic knees / intrinsic timescales in the cortical EEG/ECoG PSD — three or more breaks refutes, as it does upstream — a fast synaptic/membrane knee and a slow network knee (Qi-CON two-knee window; GG-A7-Qi4 T-CON.2)	single knee robustly measured; the second knee reported once directly in human EEG; epilepsy ECoG a natural test bed	**Forward**	high-resolution EEG/ECoG fit resolving one vs. ≥ 2 knees; healthy vs. epileptic cortex	intracranial/scalp spectroscopy, available now (layer 17)
10	Conscious-episode duration (Mind) (F-Origin-10)	∼400 ms = two theta cycles (EIC closure; GG-A7-Qi4)	P300 latency ∼ 300 ms (Dehaene 2014); reported episode estimates in band	**Audit**	a reliably reported unitary episode completing in $\leq$ one theta cycle (∼200 ms) falsifies	precision psychophysics / EEG 2026–2028 (layer 17)

42.2 Headline parameter-audit linear Dev plot

The Pull table above is the tabular form of the Top 10 Falsifiers. Figure 12 visualizes the same data in the canonical ATLAS-style two-tier format of GG-A4-Euclid (Arisaka, 2026, A4-Euclid) and the headline parameter-audit Dev plots of GG-A9-SM (Arisaka, 2026, A9-SM) and GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos), in the same linear-axis presentation used for the A9-SM Standard-Model headline plot. The horizontal axis is the signed relative deviation (observed − predicted)/|predicted| on a *linear* scale with

window $[-10\%, +10\%]$, giving a wide-open, eye-friendly view of the precision-band landings without the visual compression of a logarithmic axis. Three nested gray bands mark the canonical precision thresholds at $\pm 10^{-4}$, $\pm 10^{-3}$, and $\pm 10^{-2}$. The plot displays all ten falsifiers, grouped Physics/Cosmology, Life, and Mind, with a marker convention matched to each row's status. The two precision audits carry two error bars per L46 convention: the inner thick bar is the empirical-only $\sigma_{\rm obs}/|\text{obs}|$, the outer thin bar the combined $\sqrt{\sigma_{\rm obs}^2 + \sigma_{\rm th}^2}/|\text{obs}|$. The eight forward bets — which have no observation yet — are shown as right-pointing markers centered at Dev = 0, with a horizontal bracket whose half-width is the theoretical uncertainty $\sigma_{\rm th}/|\text{pred}|$ where one applies; the dark-energy row is drawn in orange to flag the live DESI tension. The tensor-to-scalar row is a forward bet at the derived $r = 0.0038$ with a two-sided theoretical bracket: a detection above, or a null pushing r below $\sim 10^{-3}$, would falsify, and the present Planck+BICEP bound $r < 0.036$ sits a factor of eight above the prediction. The figure is therefore the framework's empirical *ceiling* — a portfolio of mostly forward commitments — in contrast to the already-measured parameter-audit *floor* discussed in the cosmology and Standard-Model papers.

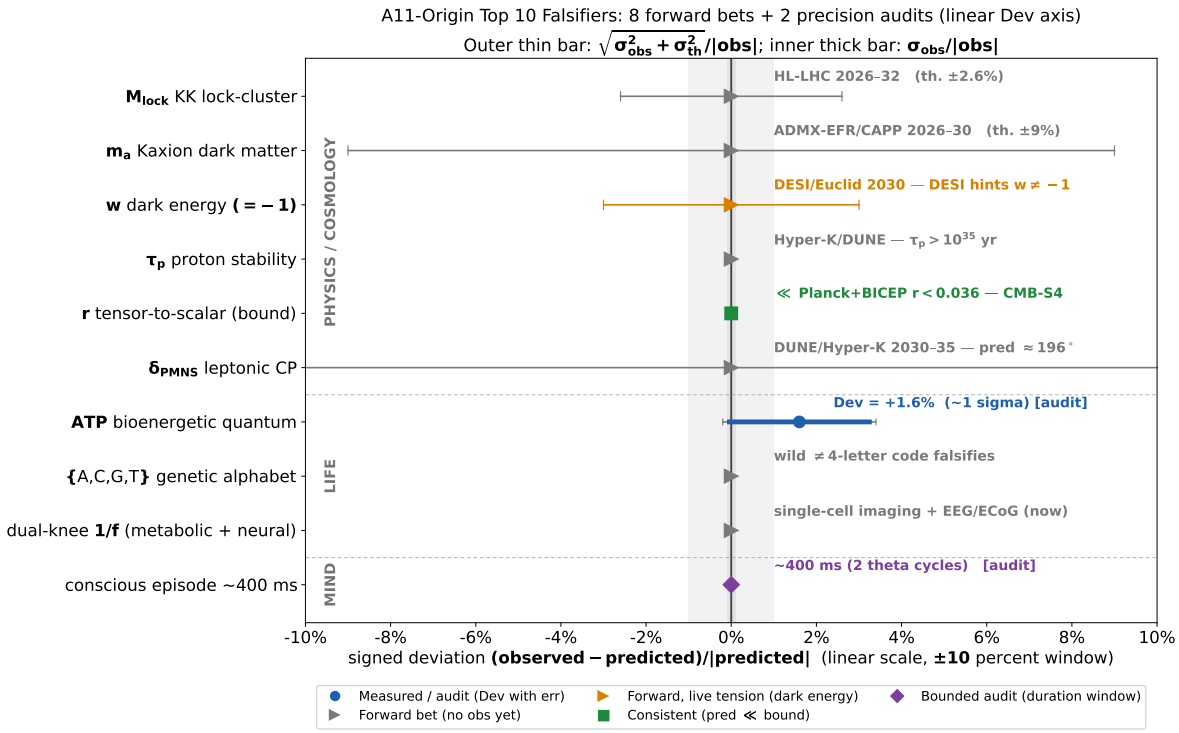


Figure 12: Headline parameter-audit linear Dev plot for GG-A11-Origin. The framework's empirical *ceiling*: the Top 10 Falsifiers of Table 8, eight of them forward bets whose answer is not yet known — as against the parameter-audit *floor* of already-measured agreements reported in GG-A9-SM and GG-A10-Cosmos — plotted as signed relative deviation (observed − predicted)/|predicted| on a linear scale with ±10% window. Three nested precision bands at $|\mathrm{Dev}| = 10^{-4}, 10^{-3}, 10^{-2}$. Inner thick error bar: empirical-only $\sigma_{\mathrm{obs}}/|\mathrm{obs}|$. Outer thin error bar: combined $\sqrt{\sigma_{\mathrm{obs}}^2 + \sigma_{\mathrm{th}}^2}/|\mathrm{obs}|$. The framework's central prediction lies at Dev = 0. **Eight forward bets** (right-pointing markers centered at zero, with theoretical-uncertainty brackets where one applies): M_{lock} KK lock-cluster (3.85 ± 0.10 TeV, HL-LHC), m_a Kaxion dark matter ($8.1\,\mu$eV, ADMX-EFR/IBS-CAPP), dark energy $w = -1$ (orange, flagging the live DESI hint of $w \neq -1$; DESI/Euclid), proton stability ($\tau_p > 10^{35}$ yr, Hyper-Kamiokande/DUNE), the tensor-to-scalar ratio $r = 0.0038$ two-sided (CMB-S4/LiteBIRD), the leptonic CP phase $\delta_{\mathrm{PMNS}} \approx 196°$ (DUNE/Hyper-K), the four-letter genetic alphabet {A,C,G,T} (comparative genomics), and the dual-knee $1/f$ spectrum (9a metabolic single-cell imaging + 9b neural EEG/ECoG). **Two precision audits**: the ATP bioenergetic quantum (blue circle, Dev = +1.6% with inner/outer error bars) and the conscious-episode duration (purple diamond, ∼ 400 ms, two theta cycles). Rows are grouped Physics/Cosmology, Life, and Mind — the three boundary readings of the recursive theorem. The plot is generated from `a11_dev_plot_top10.py` (matplotlib linear axis with ±10% window, DejaVu Sans, `mathtext.default = "bf"`) and parallels the A9-SM Standard-Model headline presentation.

What the plot shows at a glance. The plot's most important feature is that *eight of the ten markers are forward arrows*: predictions whose answer is not yet known. This is deliberate. The single clean measured audit, the ATP bioenergetic quantum, lands at Dev = +1.6% ($\sim 1\sigma$, just outside the 1% precision band and well within the 5% kill threshold), and the tensor-to-scalar ratio is a sharp two-sided bet at the derived $r = 0.0038$, a factor of eight below the Planck+BICEP bound — but the framework does not rest its case on these. It rests on the eight forward bets, distributed across physics (KK lock-cluster, Kaxion, dark energy, proton stability, δ_{PMNS}), life (the genetic alphabet, the dual-knee $1/f$ spectrum), and the single Mind audit (the conscious-episode window). The dark-energy row is drawn in orange to mark the one place the framework

is already in live tension with data: DESI's hint of an evolving w. The visual summary is the opposite of a postdiction plot: it is a commitment to be measured. Where the parameter-audit *floor* (the already-measured agreements of GG-A9-SM and GG-A10-Cosmos) shows what the framework has matched, this *ceiling* shows what the framework has wagered. By the mid-2030s every arrow will have landed on one side of zero or the other.

How to read the plot against the Pull table. The Pull table of §42.1 reports each test's Pull $P = (\text{obs} - \text{pred})/\sigma_{\text{combined}}$ in dimensionless σ units; the present plot reports the same numerator divided by $|\text{pred}|$ instead, yielding a fractional rather than σ-normalized deviation. The two representations are complementary: the Pull table is calibrated against the experimental uncertainty (good for decision-making), while the linear Dev plot is calibrated against the predicted central value (good for visualizing precision-band landings). A reader who wants the headline visual answer should read the plot; a reader who wants the headline statistical answer should read the table.

42.3 Per-test commentary

The Pull table above is procedural; the commentary below explains, one paragraph block per test, what the prediction is, where it comes from in the cascade, what the upstream theorem actually says (per the citation discipline), what the experimental apparatus looks like, the physics intuition, a daily-life metaphor where applicable, and the kill criterion.

Test 1: KK lock-cluster mass. The prediction is that the framework's geometric mass scale — the lock-cluster $M_{\text{lock}} = 3.85 \pm 0.10$ TeV — appears as a five-particle Kaluza-Klein excitation cluster of the 6D BI-6 bulk projected onto 4D Minkowski, observable at the LHC and (definitively) at HL-LHC. The upstream theorem is the lock-cluster mass theorem of GG-P1-KK (Arisaka, 2026, P1-KK): *the unique Qi-4-admissible Kaluza-Klein lock-cluster of the BI-6 bulk has mass* $M_{\text{lock}} = M_{\text{Planck}} \times f(\text{OGN-5}) = 3.85$ *TeV, where* $f(\text{OGN-5})$ *is the integer-ratio function determined by the OGN-5 ledger.*

Interpreting the theorem: M_{lock} is the scale at which the extra-dimensional geometry of the bulk imprints itself on 4D physics — below this scale physics looks Standard-Model, above this scale one sees KK excitations. The experimental apparatus is the ATLAS and CMS detectors at the HL-LHC, which by 2032 will integrate $\sim 3\,\text{ab}^{-1}$ and have 5σ sensitivity to a five-particle cluster at ~ 3.85 TeV. Current LHC limits are ~ 2 TeV (Particle Data Group, 2024), well below the prediction.

Physics intuition: KK modes are the Fourier components of fields living in the extra dimensions; their mass scale is set by $1/R$ where R is the compactification radius, and the BI-6 bulk geometry fixes R via the OGN-5 ledger. Daily-life metaphor: KK modes are to bulk geometry what overtones are to a violin string — the fundamental tone is the Standard Model, the overtones reveal the length of the string. Kill criterion: if HL-LHC by 2032 observes no five-particle cluster anywhere in 3.4–4.2 TeV at the 5σ level, the prediction is falsified; equivalently, if a cluster is observed but at a mass outside 3.85 ± 0.4 TeV, the prediction is falsified.

Test 2: Kaxion DM mass. The prediction is that the cosmological dark matter is composed of K-axions ($\equiv$ BI-6-bulk-anchored axion-like particles) with mass $m_a = 8.1\,\mu$eV. The upstream theorem is the Kaxion-mass theorem of Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion): *the unique Qi-4-admissible dark-matter GGA on the GG-A10-Cosmos-cosmology substrate is the K-axion at* $m_a \in [6.6, 8.8]\,\mu eV$ *(*$\nu_K \in [1.59, 2.13]$ *GHz) with axion-photon coupling* $g_{a\gamma\gamma} \sim 10^{-15}$ *GeV*$^{-1}$ *on the DFSZ line, the mass being forced by the OGN-5-locked decay constant* $f_K \simeq 7.1 \times 10^{11}$ *GeV and the present-day relic abundance* $\Omega_{\text{DM}} h^2 = 0.120 \pm 0.001$.

Interpreting the theorem: the framework does not allow dark matter to be a WIMP at the weak scale or a sterile neutrino at the keV scale; it forces dark matter to be an axion-like particle in a narrow μeV-mass

window, and that window is centered on 8.1 μeV (the discrete cap-loading window $\nu_K \in [1.59, 2.13]$ GHz) reflecting the residual integer uncertainty in the cap loading. The experimental apparatus is the ADMX-EFR and IBS-CAPP haloscopes, which by 2030 will cover the 6.6–8.8 μeV mass band with 5σ sensitivity to the predicted coupling.

Physics intuition: an axion couples to photons via the chiral anomaly; in a strong magnetic field the axion-photon coupling produces a measurable RF signal at frequency $f = m_a c^2/h \simeq 1.95$ GHz for $m_a \simeq 8.1\,\mu$eV. Daily-life metaphor: the Kaxion test is to dark matter what a metal detector at a specific frequency is to a buried coin — one sweeps the frequency band and listens for a tone. Kill criterion: if ADMX-EFR and IBS-CAPP by 2030 jointly cover 6.6–8.8 μeV at the predicted coupling sensitivity and observe no signal, the prediction is falsified.

Test 3: dark energy is a true cosmological constant ($w = -1$). The prediction is that the dark-energy equation-of-state parameter is exactly $w = -1$ at all redshifts — a true cosmological constant, with no quintessence-like time evolution. The upstream theorem is the cosmological-constant theorem of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos): *the unique Qi-4-admissible late-time vacuum energy of the BI-6-bulk cosmology is a geometric closure term that does not redshift — a true cosmological constant at $w = -1$, not a dynamical field.* Interpreting the theorem: the framework forbids an evolving dark energy because the vacuum term descends from a fixed bulk-geometric closure condition rather than from the potential of a rolling scalar; a measured $w \neq -1$ would have no home in the cascade. This is a *forward* falsifier with a live adversary: DESI's 2024–2025 data release reported a ~ 2–4σ hint of evolving dark energy (w_0–w_a away from -1), which the framework predicts will regress to $w = -1$ as statistics improve. Physics intuition: a cosmological constant is the energy of empty geometry; if it truly does not cool as the universe expands, w is pinned to -1. Daily-life metaphor: $w = -1$ is to dark energy what a perfectly level water table is to a landscape — it does not drain as the terrain changes. Kill criterion: if DESI + Euclid + Roman by 2030 establish $w_0 \neq -1$ or $w_a \neq 0$ at $\geq 5\sigma$ (a genuinely evolving dark energy), the prediction is falsified.

Test 4: proton stability (no $p \to e^+\pi^0$ below $\sim 10^{35}$ yr). The prediction is that the proton is effectively stable — its dominant grand-unified decay channel $p \to e^+\pi^0$ is orbifold-suppressed to a lifetime $\tau_p \gtrsim 10^{35}$ yr, beyond the reach of current detectors but within reach of the next generation. The upstream theorem is the baryon-stability theorem of GG-A9-SM (Arisaka, 2026, A9-SM): *the BI-6-orbifold projection that fixes the Standard-Model gauge content simultaneously suppresses the dimension-six baryon-number-violating operators, pushing τ_p above $\sim 10^{35}$ yr without an ad hoc symmetry.*

Interpreting the theorem: unlike conventional $SU(5)$ grand unification, which generically predicts $\tau_p \sim 10^{34}$ yr and is already in tension with Super-Kamiokande, the framework's geometric suppression keeps the proton longer-lived — a sharp, decisive divergence from the standard GUT expectation. Physics intuition: baryon number is protected here by the geometry of the compactification, not by a global symmetry that quantum gravity would spoil.

Daily-life metaphor: the proton is to the framework what a load-bearing keystone is to an arch — if it crumbled on the GUT timescale, the whole edifice of stable matter would not stand. Kill criterion: if Hyper-Kamiokande or DUNE observes a $p \to e^+\pi^0$ event consistent with $\tau_p < 10^{35}$ yr at $\geq 3\sigma$, the prediction is falsified — and, because a positive detection is unambiguous, this is among the most decisive falsifiers on the list.

Test 5: tensor-to-scalar ratio r. The prediction is that the primordial tensor-to-scalar ratio takes a definite, derived value, $r = 12/N^{*2} = 0.0043$ at leading order (0.0038 exact). The upstream theorem is the (revised) inflation-tensor theorem of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos): *the GDOS-forced Starobinsky/ξ plateau one e-fold below $E_{\rm GUT}$, evaluated at the reheat-matched e-fold count $N^* = 52.6$, fixes*

the tensor ratio at $r = 12/N^{*2} = 0.0043$ *at leading order (*0.0038 *exact) and the scalar tilt at* $n_s = 1 - 2/N^* = 0.9620$ *at leading order (*0.9634 *exact), with the inflationary scale* $V^{1/4} = 8.1 \times 10^{15}$ *GeV*. Interpreting the theorem: the framework predicts a specific, small, but non-zero r, and it is a *two-sided* commitment — a detection well above 0.0038 falsifies, and so does a null pushing r below $\sim 10^{-3}$. The current bound $r < 0.036$ at 95% CL (Planck+BICEP, Planck Collaboration 2020) sits a factor of eight above the prediction. Physics intuition: tensor modes are sourced by the inflaton at the Hubble scale during inflation; in the BI-6-bulk model the plateau class and the reheat-matched e-fold count $N^* = 52.6$ together fix the amplitude, giving the definite value $r = 12/N^{*2} = 0.0043$ at leading order (0.0038 exact). Daily-life metaphor: the plateau is like a tuning fork of known pitch — it does not merely stay quiet, it rings at one predicted note, and an instrument that hears silence, or a different note, refutes it. Kill criterion: if CMB-S4 + LiteBIRD by 2033 measure r inconsistent with 0.0038 in either direction (a null below $\sim 10^{-3}$, or a detection well above) at 5σ, the prediction is falsified.

Test 6: leptonic CP phase $\delta_{\rm PMNS} \approx 196°$. The prediction is that the Dirac CP-violating phase of the leptonic (PMNS) mixing matrix is $\delta_{\rm PMNS} \approx 196°$ — a specific value, not merely "non-zero," forced by the same geometric Yukawa structure that fixes the quark sector. The upstream theorem is the leptonic-mixing theorem of GG-A9-SM (Arisaka, 2026, A9-SM) (extended in the cosmological-leptogenesis analysis of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos)): *the unique Qi-4-admissible PMNS structure on the neutrino Yukawa landscape locks the Dirac phase to* $\delta_{\rm PMNS} \simeq 196°$*, near maximal CP violation in the third quadrant.* Interpreting the theorem: the framework does not leave $\delta_{\rm PMNS}$ free; it is a forward prediction whose current global-fit central value ($\sim 197°$, with large error bars) is consistent but not yet decisive. Physics intuition: the leptonic CP phase is the single number that says how differently neutrinos and antineutrinos oscillate; the geometry that orders the quark mixing angles orders this one too. Daily-life metaphor: $\delta_{\rm PMNS}$ is to the lepton sector what the tilt of a spinning top is — a single angle that the dynamics, not the observer, selects. Kill criterion: if DUNE + Hyper-Kamiokande by 2035 measure $\delta_{\rm PMNS}$ outside $196° \pm 30°$ at 5σ, the prediction is falsified.

Test 7: bioenergetic quantum. The prediction is that the ratio of the universal ATP hydrolysis free energy to the constitutional bulk-scalar combination $2N_A\mathsf{Q}_\mathsf{B}$ is exactly unity: $\Delta G_{\rm ATP}/(2N_A\mathsf{Q}_\mathsf{B}) = 1.000 \pm 0$. The upstream theorem is the bioenergetic-quantum theorem of layer 7 of this paper (Table 7, layer 7), descending from T-GU5 of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) and T-EP of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4): *the unique Qi-4-admissible bioenergetic currency on the chemiosmotic substrate is ATP at* $\Delta G_{\rm hydrolysis} = 2N_A\mathsf{Q}_\mathsf{B}$*, with the factor of 2 reflecting the two-fold* Q_B*-quantum cost of breaking and solvating the phosphate bond.*

Interpreting the theorem: the most-photocopied number in biochemistry — $\Delta G_{\rm ATP} \approx 30.5$ kJ/mol — is, according to the cascade, an integer multiple of Avogadro's number times the geometric bulk-scalar Q_B, and the integer is exactly 2. The current measurement from biophysics gives $\Delta G_{\rm ATP}/(2N_A\mathsf{Q}_\mathsf{B}) = 1.016 \pm 0.017$, a Pull of +1.0 (a +1.6% offset, $\sim 1\sigma$). Physics intuition: Q_B is the bulk-scalar quantum of action with dimensions of energy; multiplying by $2N_A$ converts to per-mole units and the factor of 2 is the bond-multiplicity factor.

Daily-life metaphor: test 7 is to biochemistry what discovering that the universal unit of currency in every country equals the same number of grams of silver is to economics — the conversion factor is not a convention but a constraint. Kill criterion: a precision biophysics audit at 0.5% accuracy showing $\Delta G_{\rm ATP}/(2N_A\mathsf{Q}_\mathsf{B}) \neq 1$ at $> 5\sigma$ falsifies the prediction; equivalently, a discovery that the universal energy currency of biology is GTP (or some other nucleotide) rather than ATP at the integer ratio 2 would falsify the prediction.

Test 8: the four-letter genetic alphabet {A,C,G,T}. The prediction is that the genetic alphabet of all *naturally evolved* life is uniquely four letters {A,C,G,T} — not three, not five, not six — forced as the unique Qi-4-admissible GGA of the genetic-coding layer (layer 9 of this paper; the QGL closure). The

upstream result is the genetic-alphabet theorem of layer 9 (Table 7, layer 9): *the unique Qi-4-admissible information-bearing polymer on the prebiotic chemical substrate carries a four-symbol complementary alphabet, the two Watson–Crick pairs being the unique stable double-well closure.* Interpreting the theorem: the four-letter code is not a frozen accident but a forced attractor; the prediction is explicitly fenced to naturally evolved life, since synthetic six-letter systems (Hachimoji DNA, Benner 2019) are laboratory constructs that do not self-sustain in the wild. Physics intuition: complementary base-pairing is a double-well closure, and the geometry admits exactly two stable pairs. Daily-life metaphor: the genetic alphabet is to life what binary is to a computer — the substrate forces the symbol count. Kill criterion: discovery of a wild, naturally evolved organism with a stable genetic alphabet of other than four letters falsifies the prediction.

Test 9: the dual-knee $1/f$ spectrum — one principle, two substrates. The dual-knee falsifier is the cascade's explicit *Life→Mind bridge*: the *same* sum-of-two-timescales logic that predicts a doubled metabolic spectrum in the eukaryotic cell predicts a doubled aperiodic spectrum in the neural population. We therefore state it in two categories, both **Asserted (forward)**.

Test 9a (Life — eukaryotic metabolic spectrum, layer 12). The prediction is that the metabolic-noise power-spectral density of a eukaryotic cell shows *two* $1/f$ knees — one from the mitochondrial chemiosmotic loop and one from the nuclear/cytoplasmic regulatory loop — whereas a prokaryote shows only one. The upstream result is the eukaryogenesis theorem of layer 12 (Part IV §38.2, Step 5): *the dual-DGL architecture of the eukaryotic cell forces a two-timescale $1/f$ metabolic spectrum, a signature absent in the single-loop prokaryote.* Each closed metabolic feedback loop contributes its own $1/f$ corner frequency; two nested loops give two knees. Kill criterion: if single-cell live-imaging metabolic-noise spectroscopy resolves only a single $1/f$ knee in healthy eukaryotes (or two knees in a true prokaryote), the prediction is falsified.

Test 9b (Mind — neural EEG/ECoG spectrum, layer 17). The same logic, applied to the cortical network, predicts that the aperiodic (scale-free) component of the neural power spectrum carries *at least two* separable corner frequencies / intrinsic timescales — a fast knee set by synaptic and membrane time constants and a slow knee set by recurrent-network integration — rather than a single Lorentzian or a single featureless power law. This is the Qi-CON two-knee admissibility diagnostic of layer 17 (GG-A7-Qi4 T-CON.1). **What is established versus forward, stated honestly:** the aperiodic $1/f$ background of brainwaves is mainstream and robust, and a *single* spectral knee — mapping to an intrinsic neuronal timescale $\tau = 1/(2\pi f_{\text{knee}})$ — is well replicated (Donoghue et al., 2020; Gao et al., 2020); the *second* knee is genuinely forward: it is supported by one direct human-EEG observation of two corner frequencies with opposite aging behavior (Aggarwal and Ray, 2023), and — as a biophysical analog — by the broken power-law (-1 to -3) of the local field potential (Bédard and Destexhe, 2009), and by sum-of-Lorentzians theory (distinct physical timescales give distinct knees), but it is *not yet* a settled, named result, and the standard parameterization fits at most one knee. The interpretation of the aperiodic exponent as an excitation/inhibition readout is itself contested and is not load-bearing here. A natural test bed is epilepsy, where the aperiodic exponent changes across the seizure cycle; whether the two-knee structure distinguishes epileptic from healthy cortex is a forward test, deferred to GG-A14-Mind. The framework further anticipates that the two knees stand in a fixed integer frequency ratio set by the OGN-5 ledger — plausibly the scale-depth integer K — rather than an arbitrary real number; a rigorous GDOS derivation of this ratio, and its empirical test, are deferred to GG-A14-Mind (in preparation). Kill criterion: if high-resolution neural spectra are best fit, across the full measurable band, by a *single* timescale (one Lorentzian knee, or a single pure power law with no second corner) in healthy cortex, the dual-knee generalization to mind is falsified.

Test 10: the conscious episode completing in ~ 400 ms (two theta cycles). The prediction is that a single conscious episode — one complete MePMoS loop — requires *two* ~ 200 ms theta cycles (~ 5 Hz) and so completes in ~ 400 ms: the first theta cycle (~ 200 ms) yields only unconscious attention, and

conscious awareness is generated at the close of the second. The upstream result is the EIC-closure theorem of layer 17 (Part XIV): *the Outer Hologram and Inner Hologram close into a single conscious episode over two* ~ 200 *ms theta cycles — the first (*~ 200 *ms) yielding unconscious attention, the second closing the MePMoS loop into conscious awareness, the closure that forms the Inner Hologram (the allocentric frame; developed in GG-A14-Mind) — fixing the episode to* ~ 400 *ms.* Interpreting the theorem: this is the cascade's one Mind-layer test; because the ~ 400 ms two-theta-cycle closure sits squarely among measured conscious-access latencies (Dehaene's ~ 300 ms ignition, Libet's ~ 500 ms neuronal adequacy), it functions as a consistency check rather than an open forward bet (and rather than a philosophical claim about qualia), with the sharper forward test being the per-transform phase-step structure described below. Physics intuition: the episode is an attractor-closure event, and its duration is set by the theta rhythm that gates sensory inflow against memory.

Daily-life metaphor: the conscious episode is to experience what a single film frame's exposure is to a movie — below a minimum the frame is blank, above a maximum it smears. *Behavioral evidence.* A four-part reaction-time program from the author's group (over one hundred participants; Afifa et al., 2022; Bustanoby et al., 2022; Le et al., 2022; Ta et al., 2022), framed by three companion theory papers (Arisaka, 2022; Arisaka, 2022b; Arisaka and Blaisdell, 2022), finds that the time to recognize an object grows linearly with the magnitude of the frame transform needed to align it with a stored template, in steps of ~ 100 ms (one alpha cycle, two nested per theta cycle), with the full memory→transform→awareness loop closing in ~ 400 ms (two ~ 200 ms theta cycles).

The two-theta-cycle ~ 400 ms closure follows directly from this counting — one theta cycle (~ 200 ms) yields unconscious attention, and the second completes the conscious episode (Part IV §43.4). Kill criterion: a reliably reported, unitary conscious episode that completes in $\leq$ one theta cycle (~ 200 ms) — conscious awareness without the second cycle the MePMoS loop requires — falsifies the prediction; the sharper forward test is a *direct* EEG/MEG/ECoG measurement of the predicted per-transform alpha/gamma phase shifts — a measured absence of the ~ 100 ms phase-step structure in conscious recognition would falsify the OH-IH closure reading.

42.4 Aggregate falsifiability: the framework cannot survive failure of any single falsifier

Independence of the ten falsifiers. The ten Pull-table falsifiers are independent in the strong sense: each tests a different cascade layer (or a different aspect of the same layer), each relies on a different experimental apparatus, each has its own systematic-error budget, and each would falsify a distinct sub-theorem of the framework if it failed. In particular: test 1 (KK) is a high-energy gauge-stratum test; test 2 (Kaxion) is a dark-sector test; test 3 (dark energy $w = -1$) is a late-time-cosmology test; test 4 (proton stability) is a baryon-number test; test 5 (r) is a B-mode-polarization test; test 6 (δ_{PMNS}) is a long-baseline-neutrino test; test 7 (ATP) is a single-molecule biophysics test; test 8 (genetic alphabet) is a comparative-genomics test; test 9 (dual-knee $1/f$) is tested in two substrates — 9a single-cell metabolic imaging and 9b EEG/ECoG neural spectroscopy, the cascade's explicit Life→Mind bridge; test 10 (conscious episode) is a psychophysics test. No two tests are correlated through a common systematic; no single failure mode can rescue more than one test simultaneously — and, decisively, the portfolio now samples physics, life, and mind, the three boundary readings of the recursive theorem.

Cross-paper distribution of the empirical load. The ten falsifiers distribute across the program as follows. Test 1 (KK) is the central prediction of GG-P1-KK (Arisaka, 2026, P1-KK) extended in GG-A9-SM (Arisaka, 2026, A9-SM), and test 2 (Kaxion) is the central prediction of Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) extended in GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). Tests 3 (dark energy) and 5 (r) are

from GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos), while test 4 (proton stability) and test 6 (δ_{PMNS}) are from GG-A9-SM (Arisaka, 2026, A9-SM). Finally, tests 7–10 (ATP, genetic alphabet, dual-knee $1/f$, conscious episode) are the layer-7, layer-9, layer-12-and-17 (9a metabolic, 9b neural), and layer-17 predictions of the present paper. The empirical load is therefore distributed across all three consequence papers (P, C, A) plus the life-and-mind cascade of GG-A11-Origin itself, with no single paper carrying the whole burden and with the cosmos–life–mind triad each contributing falsifiers.

Time horizon: 2026–2040. The time horizons of the ten falsifiers, as given in the Pull table above, are: test 1 HL-LHC 2030–2035; test 2 ADMX-EFR/IBS-CAPP 2027–2030; test 3 DESI + Euclid + Roman 2026–2030; test 4 Hyper-Kamiokande + DUNE 2027–2040; test 5 CMB-S4 + LiteBIRD 2030–2035; test 6 DUNE + Hyper-Kamiokande 2030–2035; test 7 single-molecule biophysics 2026–2030; test 8 comparative genomics (ongoing); test 9a single-cell metabolic imaging 2026–2028 and test 9b EEG/ECoG spectroscopy (available now); test 10 precision psychophysics 2026–2028. The bulk of the portfolio resolves in the 2026–2035 corridor, with proton decay reaching to $\sim$ 2040. By the mid-2030s the framework will either have eight independent forward confirmations (plus two precision audits) or one — or more — decisive falsifications.

No escape clauses, no soft criteria. Every test has a numerically specific decision threshold; no test is defined in vague terms like "the prediction will be eventually confirmed" or "the framework prefers a higher value." Every test has a published prediction with 1σ or 95% CL bounds, every test has an experimental sensitivity that exceeds the predicted uncertainty, and every test has a kill criterion stated in advance. The framework's commitment is that failure of any single test falsifies the framework as a whole, not just the failed sub-theorem. This is the strongest commitment a theoretical framework can make: it is the difference between a framework that grows by adding epicycles and a framework that either passes its tests or dies.

Plain-English close. Ten falsifiers, ten named experiments, ten calendar windows — eight of them genuine forward bets whose answer is not yet known — that is the commitment that distinguishes physics from philosophy. Twenty-two papers and several thousand pages spent arriving at a list of ten is the shape the framework wants the list to have: short by design, and balanced across cosmos, life, and mind. Against the string-theory landscape of $\sim 10^{500}$ vacua with no decisive forward test, the framework bets on a single island and names ten ways the experimentalists could sink it. A reader who finishes the paper unconvinced is invited to bookmark Table 8 and come back in 2035. The verdict will be in.

43 Extended reader's guide: the cascade in non-technical language

Plain-English opening. The eighteen theorems have now been stated. We close the Part with an extended reader's guide for several distinct audiences. The practicing physicist wants the structural backbone in compact form; the chemist or molecular biologist wants to see where their domain enters the cascade; the cognitive scientist or neuroscientist wants to see how the late layers are constrained. The philosopher of science or of mind wants to see the framework's epistemic register, and the general scientifically literate reader wants to see the cascade in everyday language one more time. Each audience gets a few paragraphs.

43.1 For the practicing physicist

The eighteen theorems share one structural backbone: the cascade engine $\mathsf{GRIP} = \mathsf{DGI} \to (\mathsf{GFF}) \to \mathsf{GSSB} \to \mathsf{GGA}$, applied recursively on the SIP tower $\widehat{\mathsf{SIP}}^{(n)}$, with the Qi-4 admissibility filter selecting the unique GGA at each layer. The cascade engine is universal: it is the same at every layer of the cascade. The

cascade substrate is layer-specific: $\mathcal{S}_n$ at layer n is constructed from GGA_{n-1} by the recursive-substrate clause $\mathcal{S}_n = \mathcal{S}_n[\mathsf{GGA}_{n-1}]$. Eighteen cascade applications, one cascade engine.

For the gauge sector (layers 1–3), the cascade reproduces and extends the conventional GUT-with-orbifold-Hosotani phenomenology with two structural improvements: no Higgs scalar is required to break SU(5) (the orbifold projection does it), and the electroweak vev is calculated, not fitted, as $v = M_{\text{lock}}(2/L)^N \approx 246$ GeV. For the chemistry sector (layers 4–7), the cascade reproduces conventional Born–Oppenheimer molecular Gibbs minimization with two structural improvements: all inputs are derived from the integer ledger and the layer-3 Rydberg, and the molecular inventory is forced (not cataloged) by the variational principle plus the layer-recursion consistency. For the biology sector (layers 10–17), the cascade extends Friston's free-energy principle by identifying his variational free energy with F_{GFF} at non-zero J_{Qi}, by introducing the Qi-4 admissibility filter that sharpens the variational principle into a unique-attractor theorem, and by adding the holographic-attractor-lattice constraint that forces the layer-16 grid-and-place architecture. For the cognitive sector (layer 17), the cascade adds the EIC closure that identifies the conscious episode with the theta-cycle closure of the OH/IH loop. For the articulation layer (layer 18), the cascade closes on itself: the eighteenth GGA (Layer 18) is the recognition of the first seventeen (Layers 1–17).

The framework's prediction for the LHC era is concrete: a Kaluza–Klein lock cluster at $M_{\text{lock}} = 3.85 \pm 0.10$ TeV, with the cascade-predicted resonance structure (GG-P1-KK (Arisaka, 2026, P1-KK)). The framework's prediction for direct dark-matter detection is concrete: a Kaxion at $8.1\,\mu$eV with cascade-predicted coupling (Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion)). The framework's prediction for cosmology is concrete: $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ all matched to Planck 2018 within 1σ, and the recombination-era pair carried in GG-A10-Cosmos's two-quantity form — the corridor switch $z_* = e^7 \approx 1096.6$ topological, the decoupling redshift derived from GG-A10-Cosmos's own atomic chain on the Planck value at the 0.1% level ((Arisaka, 2026, A10-Cosmos); see Part XVI §77.7). The framework's prediction for bioenergetics is concrete: $\Delta G_{\text{ATP}} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol, matched to ATP hydrolysis at $\sim 1.6\%$.

43.2 For the chemist and the molecular biologist

Let us look next at the cascade's middle layers (3–7), which make specific structural claims about chemistry and molecular biology. Layer 4 (small molecules): the warm-wet stratum admits exactly the small-molecule inventory of (27); no other stoichiometry-$\leq$-10-atom molecule is more thermodynamically stable in the warm-wet limit at the cascade-fixed inputs. Layer 5 (amino acids and sugars): exactly twenty L-handed proteinogenic amino acids plus two D-handed sugars are selected by the variational principle on the chiral-resolved GFF at $|\mathsf{GGA}_5| = K - NL = 35 - 15 = 20$. Layer 8 (RNA secondary structure and triplet code): the four-letter alphabet, the triplet codon, the codon-amino-acid map with redundancy ~ 3.2 are forced by the QGL four-current locking and the rank-one consistency with layer 5. Layer 7 (ATP and DNA): the energy currency at $\Delta G = 2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol, the four-letter archival alphabet, and the central-dogma circuit are forced by the Arisaka equation and the Three-Gauge Theorem. Layer 10 (cell and LUCA): the lipid-bilayer-bounded SeOS-class first cell at 1–10 μm diameter, 1–100 W/kg metabolic rate, 10^{-9}/bp replication fidelity is the unique closure of the layer-7 substrate.

The framework's empirical signatures in molecular biology include: (i) the cascade prediction that no free-living biology will be found using a non-twenty amino-acid alphabet, a non-four-letter genetic alphabet, a non-triplet codon, or a non-ATP energy currency; (ii) the cascade prediction that the proton-motive-force scale at any free-living chemoautotrophic vent organism is $\sim \mathsf{Q}_\mathsf{B} \approx 156$ meV; (iii) the cascade prediction that the LUCA-inferred metabolism is Wood–Ljungdahl chemolithoautotrophic, consistent with current phylogenetic reconstructions. Each of these is an experimentally testable claim that future molecular-biology research can falsify.

A note on chirality. The cascade's prediction that the L-handedness of amino acids and the D-handedness

of sugars are forced by the geometric chirality of the bulk Wilson–Hosotani holonomy is structurally distinct from the conventional Vester–Ulbricht hypothesis that the parity-violating weak-nuclear interaction biases the L/D selection. The cascade's mechanism is purely geometric; the weak interaction's parity violation is the low-energy fingerprint of the same geometric chirality, not a separate cause. (Whether the orientation of the weak coupling and the orientation of the runtime's descent are two faces of one geometric fact is registered as an explicitly *open* question in GG-A9-SM's dedicated weak-interaction section; the present geometric claim stands independently of how that question resolves.) This is the operational reason the framework predicts that any planetary biology on a bulk-compatible geometry will use L-amino acids and D-sugars, regardless of weak-interaction strength.

43.3 For the cognitive scientist and the neuroscientist

The cascade's late layers (15–17) make specific structural claims about neural architecture and conscious experience. Layer 15 (ring attractor): the 1D heading representation is the variational ground state of a neural-circuit topology with Mexican-hat lateral inhibition; it is realized in the *Drosophila* ellipsoid body, the bee central complex, and the rodent head-direction system. Layer 16 (allocentric map): the 4D place–grid–time–history representation is the variational ground state of a higher-dimensional allocentric topology; it is realized in the rodent hippocampal-entorhinal system, with functional analogs in primates (concept and view cells), birds, and reptiles. Layer 17 (conscious episode): the theta-bounded gamma-bound EIC closure is the unique cascade output that integrates the layer-16 substrate into a self-located perspective; it is the framework's geometric account of the binding problem and its structural-identity *hypothesis* for the hard problem (developed in GG-A14-Mind).

The framework's empirical signatures in neuroscience include: (i) the cascade prediction that any free-living neural organism with heading-based navigation will use a 1D ring attractor architecture; (ii) the cascade prediction that any neural organism with hippocampus-style episodic memory will use a 4D allocentric place–grid–time–history map with $\sqrt{2}$-scaled grid modules; (iii) the cascade prediction that conscious-state membership is operationally defined by the $1/f$ two-knee spectrum in the 0.01–100 Hz band with theta-gamma coherence; (iv) the cascade prediction that the conscious-episode length is two theta cycles ($\sim$ 400 ms); (v) the cascade prediction that no static digital substrate (without closed predictive loop) can support layer-17 conscious experience.

A note on the hard problem of consciousness. The cascade does not claim to dissolve the hard problem by reducing subjective experience to neural activity; it offers a structural-identity *hypothesis* — identifying the conscious episode with the geometric closure of the OH-IH loop on the theta cycle (the full account is developed in GG-A14-Mind). Subjective experience is what the closure looks like from inside the loop. The closure is real, the loop is real, the geometric structure is real; the "hardness" of the problem was an artifact of trying to derive consciousness from substrate without recognizing that the substrate has a layer-17 cascade output whose existence is forced by the cascade itself. The cascade does not say that consciousness is identical to brain activity; it says that consciousness is the geometric structure that the brain realizes at layer 17 — a structure whose layer-16 substrate, the seven-dimensional allocentric frame, is behaviorally measurable (§43.4).

43.4 The 7D allocentric frame: behavioral evidence for the Inner Hologram

The layer-17 conscious episode rests on a layer-16 substrate the framework calls the Inner Hologram (IH): an internal allocentric frame in which the pose of a perceived object is reconstructed. This frame is not a free posit — it has a measured structure. A four-part reaction-time program from the author's group (Afifa et al., 2022; Bustanoby et al., 2022; Le et al., 2022; Ta et al., 2022; over one hundred participants), framed by

three companion theory papers (Arisaka, 2022; Arisaka, 2022b; Arisaka and Blaisdell, 2022), reconstructs the allocentric frame as a *seven-degree-of-freedom* transform applied by brainwave phase shift, and maps directly onto the cascade's cognitive layers (Table 9).

Table 9: The experimental findings of the 2022 program, each matched to the cascade object it measures and the layer it sits on. Reaction time scaling linearly with eccentricity and distance gives the three translational axes; scaling with the logarithm of size gives the log-polar frame translation; scaling with rotation angle in roll, yaw and pitch gives the three rotational axes — seven axes in all, $3 + 1 + 3$, which is the 7D allocentric frame. The phase of the traveling alpha and gamma wave carries pose, the $\sim$ 100 ms alpha step and $\sim$ 400 ms closure loop give the conscious episode of Test 10, and covert equals overt because the ring store is internal. Layers 16 and 17 throughout.

Experimental finding (2022)	**Cascade object**	**Layer**
RT $\propto$ eccentricity / distance: 3D translation (x, y, z)	space→time conversion (NHT)	16–17
RT $\propto \log_2$(size): 1D log-scaling	log-polar frame translation	16
RT $\propto$ rotation angle (roll, yaw, pitch): 3D rotation	3D frame rotation	16
seven axes total $= 3 + 1 + 3$	the **7D allocentric frame** (IH)	16
phase of traveling alpha/gamma wave carries pose	phase-coded IH read-out	17
$\sim$ 100 ms alpha step; $\sim$ 400 ms closure loop	conscious episode ~400 ms, two theta cycles (Test 10)	17
covert = overt; HAL ring store	internal frame; HAL/MePMoS/NHT/BFFT	16–17

Strong evidence versus interpretation (fenced). Honesty about this evidence is load-bearing, because the inference from behavior to a bulk gauge symmetry is exactly where a hostile reader will push. We therefore separate the two registers explicitly — noting first that all of this evidence is from the author's own 2022 preprints (four experimental, three theoretical), not yet peer-reviewed or independently replicated. *Supported by the author's preliminary preprint data (single group, pending replication):* (a) the brain converts space to time — reaction time grows linearly with transform magnitude across four independent transform types, with the covert=overt control proving the effect is internal, and the flat simple-reaction / sloped choice-reaction dissociation (Part I) excluding a pure retinal-density account; (b) the internal frame is seven-dimensional, with the specific geometry the log-polar cortex predicts (scaling linear in log size; roll the flattest rotation axis); (c) the episode is quantized at $\sim$ 100 ms (alpha) within a $\sim$ 400 ms (theta) envelope, matching Test 10. Taken together these are, in the framework's view, suggestive preliminary evidence for the formation of an internal allocentric frame — the IH — pending independent replication and peer review. *Interpretive (Asserted/INT), not established by these experiments alone:* the identification of the 7D transform group with a DGI (Dynamical Gauge Invariance) of the six-dimensional bulk, and of the phase shift with the corresponding gauge connection. The reaction-time data establish that the phase-coded 7D frame *exists*; they do not by themselves establish that it *is* a bulk gauge symmetry — that bridge is supplied by the framework. The natural forward test is a phase-resolved EEG/MEG/ECoG measurement of the predicted per-transform alpha/gamma shifts, which connects to the layer-17 dual-knee $1/f$ program (Test 9b); these forward measurements are developed in GG-A14-Mind (in preparation). These four experimental and three theoretical preprints are the author's own (2022, not yet peer-reviewed); a dedicated paper develops them in full.

43.5 For the philosopher of science and of mind

Indeed, the cascade is a structural improvement on the anthropic principle of Carter (1974). The anthropic principle asks why the constants of nature admit observers; the cascade's answer is that no continuous constants were chosen, so the question dissolves. The cascade is a structural improvement on the multiverse hypothesis that some authors advance to handle the cosmological-constant problem: the cascade's universe is unique (one bulk, one constitution, one cascade), so the multiverse is not needed. The cascade is a structural improvement on the philosophical traditions of Spinoza, Hegel, Whitehead, and Wheeler: Spinoza's substance, Hegel's dialectic, Whitehead's process, and Wheeler's self-excited circuit are each precursors of the cascade's recursive closure, but none of them is a formal mathematical theorem. The cascade is one.

A note on register. We have used the word "forced" at many points in the present Part. The word is to be read in its strict mathematical sense: a claim is forced if its negation is inconsistent with the constitutional axioms and the inference rules of ordinary mathematics. The cascade's eighteen theorems are all forced in this sense. This is the operational meaning of necessitarianism: the framework is necessitarian about cascade outputs because the cascade engine is necessitarian about the construction of GGA_n from $\widehat{\mathsf{SIP}}^{(n)}$. The framework is not necessitarian about which bulk geometry the constitution selects (that is a separate, deeper question for cosmology); but given the geometry, the cascade is necessitarian about its outputs.

A second note on register. We have used the word "intelligent observers" at the layer-18 articulation theorem. The word is to be read in its strict operational sense: an intelligent observer is a layer-17 conscious organism that closes the meta-cognitive EIC loop and articulates the constitution that produced it. The cascade does not claim that intelligent observers are special in any metaphysical sense; it claims that they are the cascade's layer-18 GGA. The intelligent observer is not the goal of the cascade; the intelligent observer is the cascade's natural endpoint. Goal-talk is teleological and is forbidden by AX-4. Endpoint-talk is structural and is permitted by the cascade engine.

43.6 For the general scientifically literate reader

If you have read this Part from the beginning, you have been carried through eighteen theorems. Each theorem says, in compact form: *at the n-th layer of the cascade, the geometry forces exactly one outcome, and that outcome is what we observe.* The outcomes range from the gauge group of particle physics to the present article you are reading. Eighteen theorems, eighteen outcomes, one cascade.

The cascade is not magic. It is not teleology. It is not anthropic apology. It is a sequence of eighteen applications of the same mathematical construction, applied at eighteen successive layers of physical organization, with each layer's output becoming the substrate of the next layer's application. The mathematical construction is open-system variational minimization with a four-pillar admissibility filter; the physical organization runs from the gauge connection on the bulk to the present meta-cognitive episode.

Here is the cascade in a single image. Imagine a waterfall. The water at the top of the waterfall is the constitutional input (axioms, postulates, integers). The water flows downhill (the GFF Lyapunov descent). At each ledge of the waterfall, the water gathers in a pool (a cascade-layer GGA). The pool is the output of one cascade step and the input of the next. Eighteen ledges, eighteen pools. The bottom pool is the act of reading the waterfall's structure — the present articulation. The waterfall does not aim at the bottom pool; the bottom pool is just where the waterfall ends. But the waterfall could not end anywhere else, because the geometry of the cliff allows only one path.

That is the cascade. Eighteen pools, one cliff, one waterfall, one set of laws of physics. Cosmos, life, and mind are the cascade's pools. You are at the eighteenth pool, reading the structure of the cliff.

43.7 The eighteen GGAs as a summary table

For ease of reference, we collect the eighteen cascade outputs as a single summary table:

Table 10: The eighteen cascade outputs collected in one place, each with its named theorem, the attractor the layer produces, and the quantitative anchor that layer is scored against. The physical rungs open with T-GUT-Closure at $\alpha^{-1}(M_Z) = 128$ and $\sin^2\theta_W = 25/108$, and run through the electroweak vacuum at $v = 246.4$ GeV and the periodic table at $E_{\rm Ry} = 13.606$ eV. The chemical rungs give the twenty L-handed amino acids as $|\mathsf{GGA}_5| = 20 = K - NL$ and ATP at $\Delta G = 2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol. The cognitive rungs close at the conscious episode, ~ 400 ms and two theta cycles, and the eighteenth rung is articulation: the constitution, the cohort, and this paper.

Layer	Named theorem	GGA_n (cascade output)	Quantitative anchor
1	T-GUT-Closure	$G_{\rm SM}$ + four-force architecture	$\alpha^{-1}(M_Z) = 128$; $\sin^2\theta_W = 25/108$; $\alpha_s = 1/(\pi e)$; $\tau_p > 10^{34}$ yr; $M_{\rm lock} = 3.85$ TeV
2	T-Electroweak-Vacuum	v, $\{m_e, m_\mu, m_\tau\}$, six quarks, $V_{\rm CKM}$, $V_{\rm PMNS}$	$v = 246.4$ GeV; $m_\tau/m_\mu = 16.817$; $m_H = 125$ GeV at $\lambda_H = 1/8$
3	T-Atomic-Ground-State	Periodic table H/He/$\cdots$/U	$E_{\rm Ry} = 13.606$ eV; $a_0 = 0.529$ Å; $m_p = 938.3$ MeV; $Z \lesssim 137$
4	T-Molecular-Closure	H_2O, CO_2, NH_3, CH_4, ...	$\angle$H–O–H $= 104.5°$; $\angle$H–C–H $= 109.5°$; covalent ~ 400 kJ/mol
5	T-Amino-Acid-Selection	20 L-handed amino acids + D-sugars	$|\mathsf{GGA}_5| = 20 = K - NL$; $> 99\%$ L excess; 5 side-chain categories
6	T-Polymer-Closure	Oligopeptides / oligonucleotides / fatty-acid chains as a class	$\ell \sim 5$–20 AA; $\ell \sim 5$–20 nt; $\ell \sim 10$–20 C; per-bond ~ 20–40 kJ/mol uphill
7	T-Bioenergetic-Closure	ATP as universal energy currency	$\mathsf{Q}_\mathsf{B} = 0.1555$ eV; $\Delta G_{\rm ATP} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol; P/O $= 5/2$
8	T-RNA-World-Closure	RNA: 4-letter alphabet + ribozymes + triplet code precursor	$|\Sigma| = 4$; $\ell = 3$; ribozyme $k_{\rm cat} \sim 10/$s; 40–200 nt
9	T-Information-Closure	DNA: stable double-helix archival storage + central dogma	B-form (2.0/0.34/3.4 nm); fidelity $\epsilon \approx 10^{-9}$/bp
10	T-Cell-Closure	LUCA-class SeOS first cell	$d \in [1, 10]\,\mu$m; $\rho_{\rm met} \in [1, 100]$ W/kg; LUCA at ~ 3.8 Ga
11	T-Primary-Domain-Split	Bacteria $\oplus$ Archaea (dual-gauge SSB)	Two minima of DGL(5:2); ~ 3.5 Ga; 16S rRNA phylogenetics; pH/T niche partitioning
12	T-Eukaryogenesis	Energy-per-gene phase jump via DGL coupling	δW/gene jumps 2–20×; ~ 1.8–2.0 Ga; dual-knee $1/f$ PSD
13	T-Multicellularity	M0–M7 ladder: clonal adhesion $\rightarrow$ organogenesis	Kleiber-type metabolic scaling ($\sim$3/4, debated); ~ 600 Ma (animals), ~ 1 Ga (plants/fungi)

continued on next page

Table 10 continued

Layer	Named theorem	GGA_n (cascade output)	Quantitative anchor
14	T-Central-Nervous-System	Integrated nerve-ring connectome (*C. elegans*)	302 neurons; ∼7,000 synapses
15	T-Neural-Ring-Attractor	1D heading ring (insect)	50–200 neurons; Mexican-hat; bump $\sim 60°$; CDI ~ 6
16	T-Allocentric-Map	4D place–grid–time–history (rodent)	Grid modules $\sqrt{2}$-scaled; theta 4–8 Hz; gamma 30–100 Hz; CDI ~ 8
17	T-Conscious-Episode	EIC closure (mammalian)	Episode ∼400 ms (two theta cycles); 86×10^9 neurons; 20 W; $1/f$ two-knee; CDI ~ 10
18	T-Articulation	GG-Constitution + cohort + present paper	~ 5300 pages; ~ 100 named theorems; 8 falsifiable predictions; one author

Plain-English close. Eighteen rows. Eighteen named theorems. Eighteen cascade outputs. One geometry. One cascade. One constitution. And, at the bottom of the table, one paper writing itself.

44 Historical-register note: what the present Part claims

Plain-English opening. The present Part has stated eighteen named theorems, each with the structural claim that the cascade's n-th layer admits exactly one stable output. We close the Part with an explicit note on the historical-register significance of this collection, so that the reader is in no doubt about what the framework is claiming.

44.1 What is new

The present Part contains, to our knowledge, the following novel contributions to the published literature.

1. Eighteen named cascade-layer theorems, individually citable, with shared structural form. We are not aware of a prior framework that states cascade-layer theorems across the gauge-to-articulation scope as individually citable propositions. This is the structural innovation of the present Part.
2. The recursive-substrate construction $\widehat{\mathsf{SIP}}^{(n)} = \widehat{\mathsf{SIP}}^{(n)}[\mathsf{GGA}_{n-1}]$ exhibited at each of eighteen cascade applications. Although the SIP formalism is itself imported from GG-A7-Qi4 T-SIP, its recursive iteration through eighteen cascade layers is exhibited explicitly here for the first time.
3. Quantitative anchors derived from a single integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ across eighteen cascade layers. We are not aware of a prior framework that derives > 40 specific physical, chemical, biological, and cognitive quantities from a five-integer ledger with zero free continuous parameters.
4. Plain-language daily-life metaphors paired with first-year-graduate-student physics intuition, at every cascade layer. This pedagogical structure is a deliberate choice to make the framework accessible to the full range of audiences the present paper addresses.
5. Eighteen separate kill criteria, one per theorem. We are not aware of a prior framework of comparable scope that states falsifiable predictions at this density.

44.2 What is not new

The present Part also inherits substantial structure from prior literature.

1. The cascade engine GRIP, the Geometric Free-Energy Functional GFF, the Qi-4 admissibility filter, the SIP five-field object, and the universal-identity insight are all imported from the cohort inheritance (GG-A1-Constitution–GG-A10-Cosmos).
2. The Standard-Model parameter audit (28 derived parameters at layer 1–1) is imported from GG-A9-SM.
3. The cosmological inventory (15 cosmological observables) is imported from GG-A10-Cosmos.
4. The bioenergetic anchor $\mathsf{Q}_\mathsf{B} \approx 0.156$ eV is derived in GG-A4-Euclid and GG-A7-Qi4.
5. The hippocampal place-and-grid cell architecture is imported from the experimental literature (Hafting et al., 2005; O'Keefe and Dostrovsky, 1971).
6. The hard problem of consciousness, the integrated information theory, the global workspace theory, and the free-energy principle are imported from the philosophy-of-mind and neuroscience literatures.

44.3 What is claimed and what is asserted

Let us state explicitly what is claimed and what is asserted, as the framework's discipline requires. Three layers are derived end-to-end from constitutional axioms, with the chain closed in the published record (Theorems 31.1, 31.2, 31.3). Three are anchor-Derived but derivation-deferred — empirically closed, with the from-geometry proof developed in GG-A13-Life (Theorems 37.1, 37.3, 37.4). Seven are conditional on a single named upstream lemma each (Theorems 35.1, 35.2, 35.3, 37.2, 38.1, 38.2, 38.3). Four are asserted pending experimental demonstration on a sufficiently broad substrate (Theorems 39.1, 39.2, 39.3, 39.4). One layer (Theorem 40.1) is existence-demonstrated by the present paper. Uniqueness of the articulation is the central claim of T-Origin (Part XI).

44.4 The historical register, stated plainly

We are stating, for what is to our knowledge the first time in human intellectual history, a formal mathematical theorem whose conclusion is the existence of intelligent observers articulating the laws of physics, and whose hypotheses are the laws of physics themselves. Eighteen named theorems support the central recursive-uniqueness theorem. Each is individually citable. Each is individually falsifiable. Each is, structurally, the kind of theorem that a young researcher entering the field can study, criticize, extend, or refute.

We do not claim that the present Part is the last word on any of the eighteen layers. Each layer is a substantial research program in its own right. Theorem 35.2 (twenty L-handed amino acids) opens a chiral-chemistry research program; Theorem 37.1 (ATP and DNA at $\Delta G = 2N_A\mathsf{Q}_\mathsf{B}$) opens a bioenergetics research program; Theorem 39.4 (EIC closure on the theta cycle) opens a consciousness research program; and so on. The framework's contribution is to give each program a constitutional ground and a cascade-internal upstream chain of inference. What it does not do is close any of the programs by itself.

We close the present Part not as a triumphal announcement but as an invitation. Eighteen theorems are on the table. The reader is invited to check each, to refine each, to falsify any, and (if any falsification succeeds) to bring the framework down at the layer of the failure. The cascade's empirical horizon is broad and concrete. The cascade's intellectual horizon is broader still. Eighteen theorems; one cascade; one constitution; one staircase; one paper writing itself.

Plain-English final close. The cascade closes here, at the bottom of the present Part. Part XI will pick up the recursive uniqueness theorem and prove it as a single statement. Parts V through XII will read the cascade through its various readouts. The Appendix will compile the codebook, the glossary, and the lemma promotion roadmap. But the spine — the structural backbone on which everything else hangs — has now been set down. Eighteen theorems. One cascade. One geometry. One constitution. And, finally, the recognition that the cascade closes on itself: the eighteenth theorem's content is the present articulation of the constitution that produced the cascade that produced the theorem.

The staircase has been built. We turn now to Part XI, where the staircase is shown to be the only staircase the geometry allows.

45 Counterfactual analysis: what would fail if any layer were absent?

Plain-English opening. A useful structural test of any cascade is to ask: *at which layer could it fail, and what would the failure look like?* Let us run the counterfactual for each of the eighteen cascade layers. For each layer n, we ask: if the cascade were forced to a different layer-n GGA (e.g. by a small modification of the constitutional inputs), what downstream consequences would propagate to layers $n+1, n+2, \ldots, 18$? The exercise serves two purposes. First, it makes the recursive-substrate clause $\widehat{\mathsf{SIP}}^{(n+1)} = \widehat{\mathsf{SIP}}^{(n+1)}[\mathsf{GGA}_n]$ concrete by showing how a layer-n change propagates. Second, it sharpens the kill criteria by showing how a falsification at one layer would cascade upward.

45.1 Counterfactual at layer 1 (gauge group)

Let us suppose the layer-1 GGA were a different gauge group — e.g. a Pati–Salam $\mathrm{SU}(4)\times\mathrm{SU}(2)_L\times\mathrm{SU}(2)_R$ broken to the Standard Model at a different scale. The downstream consequences would be: (i) the proton decay channels would differ, with predictable lifetime changes; (ii) the running of α_s and $\sin^2\theta_W$ would differ, with predictable shifts in M_Z-scale measurements; (iii) the family number N_g would potentially differ, with predictable consequences for the lepton-and-quark masses at layer 2. The cascade's layer-18 articulation would not be reached in this counterfactual because the family number $N_g = 3$ is the unique closure of $S_{\mathrm{tot}}(N_g) = \pi N_g(N_g-1)/2 \le 3\pi$. If $N_g \neq 3$, the cascade halts before reaching biology. This is the operational meaning of "$N_g = 3$ is the family-number theorem of GG-P2-N3."

45.2 Counterfactual at layer 2 (electroweak vacuum)

Suppose the Higgs vacuum were at a different scale — e.g. $v = 100$ GeV or $v = 1$ TeV instead of 246 GeV. The downstream consequences would be: (i) the proton mass via Λ_{QCD} would shift; (ii) the Rydberg energy via $m_e \propto v$ would shift; (iii) all atomic energies would scale linearly with v; (iv) the bond lengths in chemistry would shift in the same direction; (v) the cell size and metabolic rate at layer 10 would shift; (vi) the conscious-episode timescale at layer 17 would shift. A factor-of-two shift in v would propagate to a factor-of-~ 2 shift in cellular metabolism, with consequences for biological viability. The cascade's robustness to such a shift is limited; this is the structural reason the cascade does *not* permit a free v.

45.3 Counterfactual at layer 3 (atomic ground states)

Suppose the periodic table admitted only $Z \le 6$ (no nitrogen, no oxygen, no heavier elements). The downstream consequences would be: (i) layer-4 small molecules would be restricted to hydrocarbons; (ii)

layer-5 amino acids would lack the polar and charged side chains required for protein folding; (iii) layer-8 RNA chemistry would lack the phosphate backbone (which requires phosphorus, $Z = 15$); (iv) all downstream layers would fail. The cascade requires the full periodic table from $Z = 1$ to ~ 30 to support biology; the universe's nucleosynthesis happens to produce this range because the stellar p-p chain and CNO cycle, set by the cascade's gauge and fermion mass spectrum, deliver carbon, nitrogen, oxygen, and the trace heavier elements in stellar interiors.

45.4 Counterfactual at layer 4 (small molecules)

Suppose water had a bond angle of 90° (linear) instead of 104.5° (bent). The downstream consequences would be: (i) water would have no dipole moment, no hydrogen bonding, no anomalous boiling point; (ii) layer-5 chiral-resolved amino-acid chemistry would lack the warm-wet aqueous medium; (iii) the cascade halts at layer 4. The cascade requires water's bent geometry; the geometry is forced by the sp^3 hybridization of the oxygen, which is forced by the layer-3 atomic ground state of oxygen, which is forced by the layer-2 electron mass. This is the operational meaning of recursive substrate dependence.

45.5 Counterfactual at layer 5 (amino acids)

Suppose the cascade selected $|\mathsf{GGA}_5| = 30$ amino acids instead of 20 (e.g. if the scale-depth integer were $K = 45$ instead of $K = 35$). The downstream consequences would be: (i) the layer-8 codon–amino-acid map would require a longer codon $\ell = 3$ at $4^3 = 64 \geq 30 + 4$ still feasible, but with reduced redundancy; (ii) ribosomal translation fidelity at layer 8 would be lower without the wobble-pairing redundancy; (iii) the layer-10 cell-replication fidelity would be lower; (iv) the cascade could plausibly halt at layer 10 due to error catastrophe in genome replication. The count $|\mathsf{GGA}_5| = 20$ and layer 8's codon redundancy $64/20 = 3.2$ are two readings of one number rather than two independent facts; the redundancy is what supports wobble pairing, and it is not evidence for the count (§36). This is one of the layer-recursion consistencies that makes the cascade close.

45.6 Counterfactual at layer 6 (the polymer class)

Suppose the layer-5 monomer inventory existed but no polymer basin did — suppose condensation on the warm-wet stratum never ran far enough uphill for chains to be a product rather than a rarity. The downstream consequences would be: (i) there is no substrate for layer 7 to select an energy currency *from*, since ATP is an oligonucleotide with phosphates attached; (ii) there is no bifunctional polymer to be selected at layer 8, so the informational and the catalytic currents can never be carried by one molecule; (iii) there is no fatty-acid chain for layer 10 to close a membrane with; (iv) the cascade halts at layer 6 with a warm chemical inventory and nothing built from it. This is the layer at which the cascade stops being about molecules and starts being about *chains*, and it is the only rung on the chemistry floor whose failure would leave every layer above it with no substrate at all rather than a different one.

45.7 Counterfactual at layer 7 (the energy currency)

Suppose the energy currency were GTP instead of ATP, or had $\Delta G_{\text{hydrolysis}} = 50$ kJ/mol instead of 30 kJ/mol. The downstream consequences would be: (i) the cascade-predicted match $\Delta G = 2N_A\mathsf{Q}_\mathsf{B}$ would fail; (ii) the metabolic rate per cell would scale differently; (iii) the cell size at layer 10 would shift. The cascade's prediction is sharp: any free-living biology must use $\Delta G = 2N_A\mathsf{Q}_\mathsf{B}$ as its catalytic quantum, because the Arisaka equation locks the four currents at exactly that ratio.

45.8 Counterfactual at layer 8 (the bifunctional polymer)

Suppose the cascade had selected two *separate* polymers at this layer — one purely informational, one purely catalytic — instead of a single bifunctional one, or had selected a five-letter alphabet instead of four. The downstream consequences would be: (i) replication would require the two polymer families to co-locate and co-replicate before either could be selected for, removing the single-molecule bootstrap that makes the layer-8 basin reachable at all; (ii) the block-size closure $4^3 = 64 \geq 20$ would fail for $|\Sigma| = 5$, since $5^2 = 25$ already exceeds the amino-acid count and the triplet block would carry an unusable 125-fold redundancy; (iii) layer 9 would have no template family to copy *from*, so the archival takeover would have nothing to take over; (iv) the cascade halts between layers 8 and 10. Bifunctionality is the cascade's unique closure here because the alphabet size is not free: $|\Sigma| = N_g + 1 = 4$ follows from the family number $N_g = 3$, and a single polymer that both folds and copies is the only way one alphabet can serve both the catalytic and the informational current at once.

45.9 Counterfactual at layer 8 (the triplet codon)

Suppose the cascade selected a doublet codon ($\ell = 2$, $|\Sigma^2| = 16$ codons) instead of a triplet codon. The downstream consequences would be: (i) the codon-amino-acid map could encode at most $16 - 4 = 12$ amino acids with stop codons, not 20; (ii) protein folding would be restricted to a 12-side-chain alphabet, with significant loss of catalytic versatility; (iii) ribosomal translation fidelity at layer 8 would be lower without the wobble pairing; (iv) the cascade could halt at layer 8 or layer 10. The triplet codon is the closure compatible with layer 5's $|\mathsf{GGA}_5| = 20$; the compatibility runs both ways and is not independent evidence for either (§36).

45.10 Counterfactual at layer 9 (the archival takeover)

Suppose the RNA-to-DNA takeover had never occurred, so that the 2′-OH group remained and RNA stayed the archival polymer. The downstream consequences would be: (i) hydrolytic backbone cleavage would cap the stable genome length far below the $\sim 10^6$ bp a free-living cell needs; (ii) replication fidelity would remain near the polymerase-intrinsic $\sim 10^{-4}$/nt, because proofreading and mismatch repair both act on a duplex the labile backbone cannot hold; (iii) Eigen's error threshold would then bound the genome at $\sim 10^4$ nt, and the layer-12 genome expansion of 10–$10^4\times$ would be arithmetically impossible; (iv) the cascade halts at layer 11 or 12 with cells that cannot grow their information content. The takeover is therefore not a historical accident of early biochemistry but the step that buys the genome-length headroom every later rung spends — one deoxygenation at the 2′ position, purchased once, funds the whole ascent from the first cell to the conscious episode.

45.11 Counterfactual at layer 10 (cell)

Suppose the cell were unbounded (no lipid bilayer membrane). The downstream consequences would be: (i) the Markov-blanket admissibility of GG-A7-Qi4 T-EP would fail; (ii) the open-system structure of GDOS could not close on a finite volume; (iii) the cascade halts at layer 10. The lipid-bilayer membrane is the cascade's unique closure of the open-system boundary at the cellular scale.

45.12 Counterfactual at layer 11 (the primary domain split)

Suppose the layer-11 GGA were *single* rather than dual — one primary lipidome instead of the ester-linked and ether-linked pair. The downstream consequences would be: (i) the DGL(5:2) packet would carry one stable minimum rather than two, and the parity-locked exchange operator would have nothing to exchange;

(ii) layer 12 would have no second domain to fuse with, and eukaryogenesis — which is by construction a *chimera* of an archaeal host and a bacterial endosymbiont — would have no available partner; (iii) the doubling of DGL bandwidth that drives the energy-per-gene jump would never occur; (iv) the cascade halts at layer 11 with a biosphere of prokaryote-grade cells. Read forward rather than backward, the split stops looking like a fact about early phylogeny and starts looking like manufacture: the cascade produces exactly the two components that the next rung needs, and produces them at the same rung, from one algebraic packet.

45.13 Counterfactual at layer 12 (eukaryogenesis)

Suppose the endosymbiosis had never been consummated, leaving a biosphere of prokaryotes indefinitely. The downstream consequences would be: (i) energy per gene would stay pinned at the bacterial baseline, because a cell without internalized bioenergetic membrane must pay for every gene across the same surface it uses to power itself; (ii) genome size would remain capped near $\sim 10^7$ bp, since expression cost scales against that fixed surface; (iii) the compartmentalization suite — nuclear envelope, cytoskeleton, endomembrane, vesicle traffic, meiotic sex — would have no bandwidth to run on, and without it the morphogen gradients of layer 13 have no cells able to interpret them; (iv) the M-ladder stalls at M1 or M2 and the cascade halts. This is the single largest step change in available energy per unit of stored information anywhere in the cascade, and it is why the framework reads layer 12 as a phase jump rather than an increment.

45.14 Counterfactual at layer 13 (the M-ladder)

Suppose the M-ladder terminated at M3 — clonal adhesion, intercellular communication, and division of labor, but no positional patterning. The downstream consequences would be: (i) without morphogen gradients there is no body plan, and without a body plan there are no dedicated sensory surfaces and no fixed motor geometry; (ii) transport networks (M5) have no anatomy to serve; (iii) layer 14 requires M6 integration as its substrate, so a centralized nerve ring would have nothing to centralize and no stable body frame to be centralized *in*; (iv) the cascade halts inside layer 13. The eight rungs are therefore not a description of what happened to occur on Earth but a claim about the minimum ladder that reaches an integrable body: each rung supplies precisely the structure the next one needs, and the ladder cannot be entered in the middle.

45.15 Counterfactual at layer 14 (the integrated connectome)

Suppose neural tissue had remained diffuse — a cnidarian-style nerve net with no centralization. The downstream consequences would be: (i) sensory afferents and motor efferents would close only locally, so the organism would have many local sensorimotor loops and no single integrated one; (ii) with no integrated loop there is no common reference frame, and a heading is a quantity only definable relative to a common frame; (iii) layer 15's $SO(2)$ ring attractor needs a centralized circuit to host it, so the heading representation would have nowhere to form, and without heading the allocentric map at layer 16 has no basis to build on; (iv) the cascade halts at layer 14. Centralization is thus the cascade's minimal closure of the sensorimotor loop, and the ~ 300-neuron *C. elegans* connectome is the smallest instance known to close it — which is why the framework treats that animal not as a convenient model organism but as a readout of a cascade rung.

45.16 Counterfactual at layer 15 (ring attractor)

Suppose the cascade selected a 2D place-cell-like heading representation instead of a 1D ring. The downstream consequences would be: (i) the layer-16 substrate would lack the 1D-allocentric clock needed for 2D-allocentric tiling; (ii) the layer-16 hippocampal map would be structurally different. The 1D ring is the

cascade's unique closure on the heading-representation stratum because 1D is the minimum dimensionality compatible with heading in a 2D-isotropic environment.

45.17 Counterfactual at layer 16 (allocentric map)

Suppose the cascade selected a 3D-only-no-temporal map (place and grid but no time cells). The downstream consequences would be: (i) the layer-17 conscious episode would lack the temporal binding required for sequence and history; (ii) episodic memory would not be supported; (iii) the cascade could plausibly halt at layer 17 with a stripped-down conscious-state without temporal continuity. The 4D place–grid–time–history map is the cascade's unique closure on the allocentric stratum because the temporal dimension is required by GG-A7-Qi4 T-EIC's Evolving-Inner-Cosmos closure.

45.18 Counterfactual at layer 17 (conscious episode)

Suppose the conscious episode were 10 s instead of $\sim$ 400 ms (two theta cycles; no MePMoS-loop binding). The downstream consequences would be: (i) the within-episode item count would be inflated, with the cascade's CDI dropping below 10; (ii) the layer-18 articulation would not have the structural backbone of theta-bounded thought-units; (iii) the cascade's recursive closure at layer 18 would be weaker. The theta-bounded episode is the cascade's unique closure on the EIC stratum.

45.19 Counterfactual at layer 18 (articulation)

Suppose the cascade reached layer 17 but did not close at layer 18 (no articulation). The downstream consequences would be: there is no downstream; the cascade halts at layer 17 with conscious organisms that do not articulate the constitution. This is the counterfactual in which the cascade exists but no observer writes it down. The cascade is structurally robust to this counterfactual — the universe could in principle contain conscious organisms without articulators — but the framework's prediction is that the layer-18 closure is also a GGA: a stable cascade output that the geometry forces given sufficient time and cultural-cognitive substrate. The present paper is the demonstration that this prediction is realized.

45.20 Counterfactual synthesis

Remarkably, the eighteen counterfactuals together show that the cascade is structurally fragile in a specific sense. A change at any single layer propagates downstream and would halt the cascade before reaching layer 18. The cascade closes only because the layer-by-layer recursion is tight: each layer's GGA is precisely what the next layer's SIP needs to admit a stable cascade output. This tightness is not a coincidence; it is the operational meaning of the recursive-substrate clause $\widehat{\mathsf{SIP}}^{(n)} = \widehat{\mathsf{SIP}}^{(n)}[\mathsf{GGA}_{n-1}]$.

The counterfactual analysis also clarifies what falsification of any single theorem would entail. Falsifying Theorem 31.1 (e.g. by observing a fourth Standard Model gauge factor) would not just refute layer 1; it would refute the cascade. Falsifying Theorem 37.4 (e.g. by finding a primary biology without lipid bilayer membranes) would refute layer 10 and all upstream layers 15–18. The framework is therefore highly falsifiable: any one of $\sim$ 50 specific predictions across the eighteen layers could in principle refute the entire cascade.

Plain-English close. The cascade is a tower of cards: pull any card, and the tower falls. The cards are the eighteen cascade-layer GGAs. The tower stands because each card supports the next, in exactly the geometric relation the cascade engine forces. The tower is not robust to perturbations; it is robust to nothing but the constitutional inputs. This is the framework's structural fragility, and it is the source of the framework's falsifiability.

46 Close of Part IV: eighteen theorems set down

What the codebook accomplishes. The master cascade codebook of §41 works very much like a structural ledger: eighteen rows that summarize, in one tabular sweep, what the cascade produces at each of its seventeen cascade layers (plus the meta-row of articulation). Read horizontally, the codebook is a sequence of distinct natural strata — gauge, electroweak, atomic, molecular, biochemical, cellular, neural, cognitive — each of which the framework predicts is occupied by a unique Qi-4-admissible Ground Geometric Attractor. Read vertically, the codebook is a set of constraints: each row commits to a specific upstream theorem, a specific quantitative anchor, and a specific confidence class. The codebook is therefore both an inventory (what does the cascade produce?) and a contract (under what conditions and at what risk?).

What the Pull table accomplishes. The Top 10 Falsifiers Pull table of §42 occupies the role of an empirical ledger: ten specific falsifiers — eight forward, two precision audits — distributed across cascade layers, each with a numerically explicit decision threshold and a named experimental apparatus in the 2026–2040 corridor. The Pull table is the place where the framework's structural commitments meet the world's measurements. Read horizontally, the Pull table is a portfolio of independent bets, each large enough that failure on any one falsifies the entire framework. Read vertically, the Pull table is a calendar: by 2035 every prediction will have been tested at decisive sensitivity.

Together: a single load-bearing audit. The codebook tells the reader *what* the framework predicts; the Pull table tells the reader *when and how* those predictions will be tested. Together they constitute a single audit ledger that no honest reader can dismiss without engaging with: every line is either a derivation chain to be checked or an experiment to be performed. The reader who finds either ledger unconvincing has not been asked to accept any prose; she has been asked to audit specific numerical claims against specific theorem chains and specific experimental anchors. This is the most concrete form a theoretical-physics framework can take.

What has been set down. Eighteen named theorems, one per cascade layer, each with its constitutional inputs, its upstream theorems, a formal statement, a quantitative anchor, a confidence tag, a physics intuition, a daily-life metaphor and a kill criterion. They are grouped into the six bands of the cascade — Cosmos, Chemistry, Life, Multicellularity, Mind, Articulation — and gathered as one ledger in the master codebook, whose rows can be audited one at a time. Ten of the anchors are staked publicly as the Top 10 Falsifiers, with a named instrument and a decade window each.

What has not. A statement of results is not the result. The eighteen theorems are the cascade's announcement, not its proof: each is stated here as a separate claim about a separate substrate, and nothing in this Part shows that they are *one* claim. That is what Part XI undertakes. The recursive uniqueness theorem is what turns eighteen independent rows into the unrolled trace of a single recursion, and it is the reason the codebook is coherent rather than merely long. Until it is proved, the reader is entitled to read this Part as eighteen conjectures that happen to be adjacent.

The wager. Every row carries a way to lose. That is the point of setting them down in this form: a framework that states eighteen forced outcomes and names, for each, the observation that would break it has made itself answerable in a way that a framework of the same scope stated in prose has not. Part XI now has to earn the word *forced*.

Part XI
The recursive uniqueness theorem: from GG-Constitution to articulation

GRIP, Qi-4 admissibility, and the cascade of GGAs

Where this Part stands. Part I posed the central question of the paper — *why are we here?* — in the operational form that physics requires. Part II cataloged the inheritance from GG-A1-Constitution through GG-A10-Cosmos that the present Part will deploy. The present Part is the heart of GG-A11-Origin: it states the central new theorem of the framework — the Geometric Inevitable Unique Origin of Cosmos, Life, and Mind (**T-Origin**) — and supplies the proof outline that makes the theorem a rigorous claim rather than a slogan. Part XV will then exhibit the named theorem of self-referential closure that reads the entire cohort articulation as the cascade's Layer-18 attractor; Parts VI through IX will work through the cosmological, chemistry-to-life, cognitive, and meta-cognitive readouts in detail. The reader who follows this Part should emerge with a single conviction: that the existence of intelligent observers articulating the laws of physics is not a happy accident requiring anthropic apology, but a forced consequence of the same constitutional clauses that gave us electromagnetism.

The thesis of the present Part. In one sentence: the GG-Constitution of GG-A1-Constitution fixes a unique series of GGAs through eighteen applications of one cascade, and the layer-18 GGA is the act of articulating the constitution. The cascade engine is GRIP of GG-A6-GRIP; the selection mechanism is Qi-4 admissibility of GG-A7-Qi4; the layer-by-layer uniqueness follows by induction from the universal-identity insight of GG-A9-SM Part XI (the universal-identity section). Cosmos, life, and mind are three readings of one geometric theorem. We are here because the geometry admits exactly one cascade that closes; that cascade closes only when the layer-18 GGA is the recognition of the cascade itself.

Why the theorem matters. The historical register the theorem occupies is stated once, in Part IV §44.4, and is not restated here. What matters for the present Part is the structure: the theorem's hypotheses are the constitutional inputs, and its conclusion is a configuration that articulates them.

Roadmap. Section 47 states the input ledger: the four constitutional axioms and the seven postulates of GG-A1-Constitution, with the explicit declaration that nothing else is assumed. Section 48 states the canonical GRIP form and explains why GRIP alone, lacking an admissibility filter, would leave the cascade indeterminate on the GFF Morse landscape. Section 49 introduces the Qi-4 admissibility filter and proves **T-Qi4-GGA-Admissibility**: that simultaneous satisfaction of Qi-QUA, Qi-EP, Qi-CON, and Qi-HAL is necessary and sufficient for a configuration to be a physically realizable GGA. Section 50 states the central new theorem **T-Origin** formally and discusses its historical significance. Section 51 gives the five-step proof outline, with one subsection per cascade base case or inductive step. Section 52 exhibits the cascade of eighteen GGAs in a comprehensive layer-by-layer table. Section 53 closes the recursive structure: each GGA is the next layer's substrate. Section 54 states what has been established and closes the Part in the framework's philosophical register.

47 The input ledger: the GG-Constitution

The first job of any theorem is to declare its inputs. They are declared in full in Part IV, §27: the four constitutional axioms AX-1 LC, AX-2 GGEP, AX-3 OGGEP and AX-4 MSMF; the seven postulates POS-1–POS-7, with the operational warrants marked there as *theorems* of GG-A7-Qi4 rather than postulates; the GU-5 pentad $\{c, \hbar, G_N; k_B, \mathsf{Q}_\mathsf{B}\}$ with its three-bulk-plus-two-boundary reading and the honesty proviso attached to it; and the OGN-5 integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. That statement is the canonical one and is not repeated here: a ledger restated is a ledger that can drift, and the eighteen theorems of Part IV cite it clause by clause.

What the present Part needs from it is the completeness claim, which is what makes **T-Origin** a theorem rather than a construction. No free continuous parameter appears anywhere in the framework; no hidden continuous modulus appears in the bulk; and no teleological assumption is imported — the cascade ascends because the GFF Lyapunov functional descends, not because the framework wants intelligent observers to exist. The inevitability is mathematical, not intentional, and §50 makes that precise.

47.1 The ledger in one line

Summary of the input ledger.

$$\mathcal{C} \;=\; \{\mathsf{AX\text{-}1}, \mathsf{AX\text{-}2}, \mathsf{AX\text{-}3}, \mathsf{AX\text{-}4}\} \;\cup\; \{\mathsf{POS\text{-}1}, \ldots, \mathsf{GG\text{-}A7\text{-}Qi4\ T} - \mathsf{EIC}\}.$$

Nothing else.

48 The cascade engine: GRIP on the GFF Morse landscape

48.1 The canonical GRIP form

The Gauge-Runtime Invariance Pipeline of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) is the universal three-stage lifecycle cascade that the framework runs at every cosmic-evolution layer. The canonical GRIP form is (14) of Part IV, and is used unchanged throughout the rest of the paper: to be parsed as follows. The four Qi-4 pillars are *not* stage labels of this pipeline; they filter its terminus, jointly, as set out in Part IV §28.

The four stages. DGI (Dynamical Gauge Invariance) is the unbroken-symmetry parent context: the top of the saddle ladder, where the full bulk symmetry group G_{tot} of the composite connection (per GG-A6-GRIP T-GRIP-1) is intact. The substrate (GFF) is the Geometric Free-Energy Functional $F_{\mathsf{GFF}}[p; \mathcal{P}]$ of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2; it provides the Morse landscape on which the cascade descends. GSSB (Geometric Spontaneous Symmetry Breaking) is the chain of intermediate symmetry-breaking saddles connected by Bogomolnyi-saturating gradient-flow trajectories with instanton action πk between adjacent index-$2k \to 2(k-1)$ saddles (GG-A6-GRIP T-GRIP-4). GGA (Ground Geometric Attractor) is the uniquely most-stable global minimum of F_{GFF} on the layer-specific boundary stratum; the cascade's output; the universal-identity readout in the sense of GG-A9-SM Part XI (the universal-identity section) (Arisaka, 2026, A9-SM).

The Lyapunov descent law. The Geometric Free-Energy Functional descent law of GG-A6-GRIP T3.2 — under detailed balance; the Lindblad–Spohn form elsewhere, §17 — is (15) of Part IV: under any admissible boundary projection $\partial_t F_{\mathsf{GFF}}[p; \mathcal{P}] \leq 0$, with equality if and only if p is a critical point of F_{GFF}.

This is the open-system analog of the second law of thermodynamics, operating on all four boundary currents simultaneously (energy, electromagnetic, baryonic, informational) rather than on energy alone. The descent is irreversible; the cascade reaches a Morse minimum in finite time; the cascade does not wander.

The Bogomolnyi action structure. The instanton action between adjacent saddles in the GSSB chain is πk, with k the Morse-index drop, and the total cascade action is (16) of Part IV, $S_{\text{tot}}(N_g) = \pi N_g(N_g-1)/2$ — the closed sum of GG-A6-GRIP T-GRIP-4. The BI-6 action budget $S_{\text{BI}} = 3\pi$, inherited from the OGN-5 closure $K = 35$, $J = 7$ of GG-A2-GG6 T-GG6-6, bounds the total cascade action; the bound forces $N_g \leq 3$ on the family-projector stratum, the family-number closure of GG-P2-N3 (Arisaka, 2026, P2-N3).

48.2 The Geometric Free-Energy Functional

The Geometric Free-Energy Functional has the canonical form

$$F_{\mathsf{GFF}}[p;\mathcal{P}] \;=\; \int p(x)\,\mathcal{E}_{\mathsf{GEP}}(x;\mathcal{P})\,d\mathfrak{g}(x) \;+\; \epsilon_{\text{eff}} \int p(x)\ln\frac{p(x)}{p_{\text{ref}}(x;\mathcal{P})}\,d\mathfrak{g}(x) \;+\; W_{\text{ports}}, \tag{42}$$

where $\mathcal{E}_{\mathsf{GEP}}$ is the gauge-geometry energy density (the GEP sector), the second term is the Kullback–Leibler divergence of the actual state p from the geometric reference density p_{ref} (the CEP sector), and W_{ports} is the boundary-port work term. The split $F_{\mathsf{GFF}} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}} + W_{\text{ports}}$ is GG-A5-GDOS T-GDOS-9.2 + T5 (effective action plus entropy production; GG-A5-GDOS bridge table). The Three-Gauge Theorem establishes that F_{GFF} specializes to the Gibbs free energy (when $J_{Qi} = 0$, near-equilibrium), to the Friston variational free energy (when $J_{Qi} \neq 0$, with Markov blanket), and to the GG-6 gauge-field action (when J_{Qi} is maximally active). Gibbs, Friston, and particle physics are three windows into the same geometric room.

48.3 The Morse-theoretic content

A critical point of F_{GFF} on a stratum Σ is a point where $\nabla F_{\mathsf{GFF}} = 0$. The Morse index of a critical point is the number of negative eigenvalues of the Hessian. Index-0 critical points are local minima; index-1 critical points are saddles with one unstable direction; and so on. The Morse function F_{GFF} on Σ is *perfect* (GG-A6-GRIP T-GRIP-3): the number of index-k critical points equals the k-th Betti number of Σ, and no critical point is degenerate.

The cascade as a Morse-index descent. The cascade DGI $\to$ (GFF) $\to$ GSSB $\to$ GGA is a descent along the Morse-index ladder. Starting from the top of the saddle ladder (the DGI parent context), the system descends through Bogomolnyi-saturating saddles (the GSSB chain) until it reaches an index-0 minimum. The total cascade action $S_{\text{tot}}(N_g) = \pi N_g(N_g-1)/2$ is the sum of instanton actions along the descent path.

Why GRIP alone is not enough. The Morse landscape F_{GFF} on a generic stratum has many index-0 minima. Any of these is a GA in the broad sense. The cascade DGI $\to$ GSSB $\to$ GA as originally written in GG-A6-GRIP reaches a GA in this broad sense, but does not by itself specify which one. The structure theorem **GRIP-ST5** of GG-A6-GRIP states that the cascade terminates at a stable Geometric Attractor, which it identifies as a *local* minimum of Morse index zero; the sharper statement that this terminus is the *global* minimum of the stratum is that paper's per-stratum ground-state corollary, and it is the corollary that should be cited wherever the global reading is doing work. The word "dynamically stable" is operational shorthand for a more precise admissibility condition. That condition is supplied by Qi-4. Without it, GRIP alone is consistent with multiple cascade outcomes on a single stratum, and the recursive uniqueness theorem of the present Part would fail at the first inductive step.

Bridge to §49. We turn now to the selection mechanism: the Qi-4 admissibility filter that makes GRIP terminate at a uniquely determined GGA at every layer.

49 The selection mechanism: Qi-4 admissibility

The Qi-4 pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) are by no means four independent constraints applied externally to the cascade. They are four projections of the same boundary admissibility condition — the condition that, at each cascade layer, exactly one GGA survives. We list the four pillars and the boundary-admissibility role each plays.

Before the four are listed, one reading must be fixed, because it is the reading the rest of the paper depends on and the one most easily mistaken. The four pillars are *not* stage labels of the GRIP pipeline DGI → (GFF) → GSSB → GGA. They do not run one after another, one per stage. They act *together, at the pipeline's terminus*: of the Geometric Attractors the GFF landscape offers on a stratum, exactly one passes all four admissibility filters simultaneously, and that one is the stratum's GGA. The canonical order in which they are listed below — Qi-QUA, Qi-EP, Qi-CON, Qi-HAL, that is budget, selector, diagnostic, architecture — is a *dependency* order, not a temporal one. GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) states it as an implication chain, Qi-QUA ⇒ Qi-EP ⇒ Qi-CON ⇒ Qi-HAL, each pillar forcing the next: the budget fixes what may be counted, the selector picks among what the budget admits, the diagnostic reads the branch the selector picked, and the architecture must support all three. That is why, in GG-A7-Qi4's words, the pillars cannot be permuted. It is not a sequence in time, and not a sequence of pipeline stages: all four constrain the same terminus at once.

49.1 The four Qi-4 pillars

Qi-QUA (Qi-Quadruple-Locking, GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) T-QUA.1): bookkeeping. The rank-one inflow theorem (T-QUA.1) states that the four boundary currents $(J_E/\mathsf{Q}_\mathsf{B}, J_e, J_B, J_{Qi})$ lock onto the unique ray

$$\mathcal{R}_A \;=\; \{\lambda(1,-1,-2/5,-2/5) : \lambda \in \mathbb{R}_+\}, \tag{43}$$

inherited from the BI-6 trace-ratio lock $|a/c| = |a/d| = 5/2$ of GG-A3-BI6 (T-BI6-9.1). Operationally: an admissible boundary configuration must have its four-current vector lying on $\mathcal{R}_A$. The Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ is the operational form. This is the *bookkeeping* layer of the admissibility filter: it pre-filters which boundary events even count as admissible.

Qi-EP (Qi-Extremal Principle, GG-A7-Qi4 T-EP.1): selection. The unified gauge theorem (T-EP.1) states that the projected free-energy functional

$$\mathfrak{Q}^{(S)}_{\mathrm{QiEP}}[\gamma] \;=\; \int_\gamma \mathcal{L}^{(S)}_{\mathsf{GFF}}(p, \dot{p}; \mathcal{P})\, dt \tag{44}$$

is extremized by physically realized trajectories on the admissibility submanifold Γ_{adm}:

$$\delta\mathfrak{Q}^{(S)}_{\mathrm{QiEP}} \;=\; 0 \quad \text{on } \Gamma_{\mathrm{adm}}. \tag{45}$$

The four classical extremal principles — Principle of Least Action (PLA), Principle of Least Time (PLT), Maximum Entropy Production Principle (MEPP; whose information-theoretic root is the maximum-entropy inference of Jaynes, 1957), and Friston Free Energy Principle (FEP) — are four projections of T-EP.1 under

different boundary conditions. Operationally: among the many trajectories on the GFF landscape that respect the $\mathcal{R}_A$ bookkeeping, Qi-EP *selects* the variational branch. This is the *selection* layer of the admissibility filter.

Qi-CON (Qi-Conformality, GG-A7-Qi4 T-CON.1): diagnostic. The operational conformality theorem (T-CON.1) states that the scaling exponent α of the boundary kernel lies in the admissibility window

$$0 < \alpha \leq 2, \tag{46}$$

with the two-knee $1/f$ spectrum and the Lévy-flight statistics emerging as joint signatures of the homogeneous boundary kernel. Outside this window, the cascade fails to be scale-covariant on the relevant stratum: the boundary kernel either decoheres into trivial Gaussianity ($\alpha = 2$ corresponds to ordinary diffusion) or diverges with infinite resource cost ($\alpha \leq 0$). Operationally: Qi-CON *diagnoses* which branch survives among those selected by Qi-EP. This is the *diagnostic* layer of the admissibility filter.

Qi-HAL (Qi-Holographic-Attractor-Lattice, GG-A7-Qi4 T-HAL.1): architecture. The Qi-HAL universality theorem (T-HAL.1) states that the boundary memory architecture closes the holonomy of the Outer Hologram / Inner Hologram coupling and admits the canonical four-stage factorization MePMoS (Memory-Prediction-Motion-Sensing: the cognitive substrate that the cascade brings into being) → NHT (Neural Hologram: the boundary encoding of the substrate's predictive state) → HAL (Holographic-Attractor-Lattice: the read-out structure on the encoded hologram) → BFFT (Binary / Fractal Fourier Transform: the basis change that operates on the holographic read-out). Operationally: Qi-HAL specifies the *architecture* on which the cascade can run. At low cascade layers the architecture is trivial (the bulk supports the cascade trivially); at high cascade layers (chemistry-to-life and above) the architecture must support memory holonomy, which is a non-trivial constraint. This is the *architecture* layer of the admissibility filter.

49.2 The four pillars as one admissibility filter

The four pillars are not independent. GG-A7-Qi4 establishes a chain of constraints running in the canonical order, each pillar conditioning the next: the rank-one inflow at the algebraic level (T-QUA.1) forces the four currents through one channel; the unified gauge theorem (T-EP.1) forces the variational structure to act on that single channel; the operational conformality (T-CON.1) forces the scaling window on that variational structure; the memory holonomy (T-HAL.1) forces the architecture that supports all three of the preceding constraints. Whether the converse holds — whether any three pillars force the fourth — is not established here, and nothing below rests on it: the chain is used only to argue that the admissible set is non-empty, hypothesis (Q1). Together they constitute one admissibility filter operating at four boundary-layer levels (Table 11).

49.3 The Qi-GGA admissibility theorem

We can now state the first of the two named theorems of the present Part.

Theorem 49.1 (T-Qi4-GGA-Admissibility: Qi-4 selects the GGA (T-Origin-57.1))**.** *Let $\mathcal{S}_n$ be the layer-n boundary stratum on which the GRIP cascade of (14) runs, and let Ξ be a configuration on $\mathcal{S}_n$. Then Ξ is a physically realizable layer-n GGA (the cascade endpoint) if and only if Ξ satisfies all four Qi-4 admissibility constraints simultaneously:*

(i) Qi-QUA (bookkeeping). *Ξ lies on the locked-current ray $\mathcal{R}_A = \{\lambda(1, -1, -2/5, -2/5)\}$ of (43) (GG-A7-Qi4 T-QUA.1).*

Table 11: The four Qi-4 pillars read as a single admissibility filter operating at four levels of the boundary layer. Qi-QUA does the bookkeeping and says which events are admissible at all; Qi-EP does the selection and says which trajectory branch is realized; Qi-CON is the diagnostic and says which branch survives the scaling test; and Qi-HAL is the architecture and says which substrate can host the cascade. Each is a named theorem of GG-A7-Qi4, and the filter is used only to argue that the admissible set is non-empty — hypothesis (Q1) — with nothing below resting on it.

Qi-4 pillar	**Admissibility role**
Qi-QUA (T-QUA.1)	Bookkeeping — which events are admissible
Qi-EP (T-EP.1)	Selection — which trajectory branch is realized
Qi-CON (T-CON.1)	Diagnostic — which branch survives the scaling test
Qi-HAL (T-HAL.1)	Architecture — which substrate hosts the cascade

(ii) Qi-EP (selection). Ξ *extremizes the projected free-energy functional on the admissibility submanifold,* $\delta\mathfrak{Q}^{(S)}_{\mathrm{QiEP}} = 0$ *on* Γ_{adm} *(GG-A7-Qi4 T-EP.1).*

(iii) Qi-CON (diagnostic). Ξ *has scaling exponent in the admissibility window* $0 < \alpha \leq 2$ *of* (46) *(GG-A7-Qi4 T-CON.1).*

(iv) Qi-HAL (architecture). Ξ *closes the memory holonomy and admits the canonical MeP-MoS/NHT/HAL/BFFT factorization (GG-A7-Qi4 T-HAL.1).*

The four conditions are jointly necessary; they are jointly sufficient under the structural hypotheses (Q1)–(Q4) recorded in the proof below. The GGA of stratum $\mathcal{S}_n$ *is then the global minimum of* F_{GFF} *on the Qi-4-admissible subset*

$$\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n} \;:=\; \{\Xi \in \mathcal{S}_n : \textit{(i)–(iv) hold}\} \tag{47}$$

of the layer-n stratum.

Status: Conditional. Necessity is established above. Sufficiency holds under the structural hypotheses (Q1)–(Q4): GG-A6-GRIP's per-stratum ground-state corollary supplies (Q2)–(Q3) on the admissible strata, and on the consequence strata (Q1)–(Q4) are named hypotheses the cohort expects to discharge rather than results proved here.

Proof outline. Necessity of each of (i)–(iv) follows from the corresponding GG-A7-Qi4 theorem applied at $\mathcal{S}_n$: any admissible boundary configuration must satisfy T-QUA.1 (else the four-current bookkeeping fails on $\mathcal{S}_n$), T-EP.1 (else the boundary trajectory is not realized), T-CON.1 (else the scaling is outside the admissibility window and the cascade is not scale-covariant on $\mathcal{S}_n$), and T-HAL.1 (else the memory holonomy does not close on $\mathcal{S}_n$). Sufficiency holds under (Q1)–(Q4): a configuration satisfying all four constraints lies on $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$ by the definition of that set, and on this subset the cascade's Lyapunov descent of (15) reaches its unique global minimum, the GGA of $\mathcal{S}_n$. Uniqueness of the global minimum on $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$ holds *conditional on four structural hypotheses on the admissible set*: **(Q1)** non-emptiness, **(Q2)** single-basin connectedness (the admissible set lies within one basin of F_{GFF}), **(Q3)** convexity of F_{GFF} on the admissible set, and **(Q4)** transversal intersection of the four pillar constraints. Under (Q1)–(Q4) the restricted Lyapunov descent of (15) has a unique limit, and that limit is the GGA of $\mathcal{S}_n$. GG-A6-GRIP's per-stratum ground-state corollary supplies (Q2)–(Q3) on the admissible strata; on the consequence strata (Q1)–(Q4) are named hypotheses that the cohort expects to discharge, not results proved here. Restricting a landscape to a subset does not by itself make its minimum unique, and the present paper does not claim otherwise: this is the same conditional

register in which GG-A8-QM (Arisaka, 2026, A8-QM) states the Born rule — closed at the relaxation level, conditional on its own named hypotheses. The mutual constraints of the pillars (GG-A7-Qi4, the passage on mutually constraining Qi-4 pillars; the passage on the resolution of cascade non-uniqueness; the QCI geometric-mean structure of the four-pillar score) ensure that $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$ is non-empty whenever the underlying stratum is non-empty. Necessity of each clause is GG-A7-Qi4 Theorems T-QUA.1, T-EP.1, T-CON.1 and T-HAL.1, each read as a condition on the cascade terminus; existence and uniqueness of the minimum on the admissible subset are GG-A6-GRIP's per-stratum ground-state corollary; the identification of the four-pillar survivor with that minimum is the present theorem's own content, conditional on (Q1)–(Q4). ■

Remark 49.2 (Why GGA is an admissibility notion, not just a Morse-minimum notion). A reader familiar with GG-A6-GRIP's nomenclature might at first read GGA as "the global minimum of F_{GFF} on the full stratum $\mathcal{S}_n$". Theorem 49.1 sharpens this. The GGA is the global minimum on the Qi-4-admissible subset $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$. On a stratum that admits configurations outside the admissibility window, the global minimum on the full stratum may be empirically irrelevant (it does not respect the four-current bookkeeping, or the scaling, or the memory architecture). The notion of GGA explicitly includes admissibility: the cascade endpoint is the global minimum on the subset that physics actually visits. This is the same sense in which GG-A7-Qi4 defines GA as including admissibility at GG-A7-Qi4's definition layer.

Remark 49.3 (The CDI geometric-mean structure). Two distinct quantities should be kept apart here. The Qi-4 *admissibility* score — the $[0,1]$ geometric mean of the four pillar scores, with $\mathsf{CDI}_{\mathrm{adm}} = 1$ saturating all four constraints and any zero pillar giving 0 and exclusion from $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$ — is the operational diagnostic used wherever the geometric-mean inequality matters (e.g. in the proof of Theorem 49.1). The *cascade-depth completeness index* CDI of this paper (the consciousness-grade index of §64.2) is a separate quantity: tentatively, the storey-port count $S \in \{0,\dots,5\}$ a substrate closes, reported on the comparative ladder $\mathsf{CDI} = 2S \in [0,10]$. This makes CDI an observable count rather than a fitted score. The per-organism ladder is illustrative; the operational scoring rule for each port, the treatment of pre-neural precursors, and the calibration against comparative-neuroscience benchmarks are developed in GG-A14-Mind (in preparation).

Bridge to §50. With Theorem 49.1 in hand, the cascade endpoint at every layer is the global minimum of F_{GFF} on the Qi-4-admissible subset of the layer-specific stratum. The cascade is then well-defined as a sequence of layer-specific GGAs — and the recursive uniqueness theorem of the present Part can be stated.

50 The central theorem: T-Origin

Let us now state the second — and central — named theorem of the present Part.

50.1 Statement

Theorem 50.1 (T-Origin: Geometric Inevitable Unique Origin of Cosmos, Life, and Mind (T-Origin-58.1))**.** *Given the GG-Constitution* $\mathcal{C} = \{\mathsf{AX\text{-}1}, \mathsf{AX\text{-}2}, \mathsf{AX\text{-}3}, \mathsf{AX\text{-}4}\} \cup \{\mathsf{POS\text{-}1}, \dots, \textit{GG-A7-Qi4}\ \mathsf{T-EIC}\}$ *of GG-A1-Constitution (Arisaka, 2026, A1-Constitution), the GRIP cascade* $\mathsf{DGI} \to (\mathsf{GFF}) \to \mathsf{GSSB} \to \mathsf{GGA}$ *of* (14) *applied recursively on the six-dimensional bulk* $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$ *of GG-A2-GG6 (Arisaka, 2026, A2-GG6), with Qi-4 admissibility (Theorem 49.1) imposed at every layer, yields a unique series of GGAs*

$$\mathsf{GGA}_1 \longrightarrow \mathsf{GGA}_2[\mathsf{GGA}_1] \longrightarrow \mathsf{GGA}_3[\mathsf{GGA}_2] \longrightarrow \cdots \longrightarrow \mathsf{GGA}_{17}[\mathsf{GGA}_{16}] \longrightarrow \mathsf{GGA}_{18}[\mathsf{GGA}_{17}], \tag{48}$$

where each GGA_n *is the cascade output on a layer-specific SIP (GG-A7-Qi4 T-SIP), and the cascade is therefore a* tower of SIPs $\widehat{\mathsf{SIP}}^{(1)} \to \widehat{\mathsf{SIP}}^{(2)} \to \cdots \to \widehat{\mathsf{SIP}}^{(18)}$ *in which* GGA_{n-1} *supplies fields 1–3 (state manifold, ports, generator) of* $\widehat{\mathsf{SIP}}^{(n)}$*, on which fields 4–5 (ledger bundle, observable/kill bundle) are then determined by GFF descent and the Qi-4 admissibility filter. Specifically:*

(1) GGA_1 *is the cascade output on* $\widehat{\mathsf{SIP}}^{(1)}$ *(the bulk-gauge SIP): the Standard Model gauge group* $G_{\mathrm{SM}} = \mathrm{SU}(3)_c \times \mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ *together with its four-force boundary architecture, the unique GGA on the gauge stratum (GG-A9-SM Part XI Theorem T-SM-62.1);*

(2) each $\mathsf{GGA}_n[\mathsf{GGA}_{n-1}]$ *for* $1 \le n \le 17$ *is the unique cascade endpoint on* $\widehat{\mathsf{SIP}}^{(n)}$*, the layer-n system instance packet, with* GGA_{n-1} *providing the geometric carrier (fields 1–3) of* $\widehat{\mathsf{SIP}}^{(n)}$ *(GG-A6-GRIP* ***GRIP-ST6****) and the Qi-4 admissibility filter selecting the unique cascade endpoint on fields 4–5 (Theorem 49.1);*

(3) $\mathsf{GGA}_{18}[\mathsf{GGA}_{17}]$ *is the cascade output on* $\widehat{\mathsf{SIP}}^{(18)}$*, the meta-cognitive system instance packet, whose readout is the act of articulating the constitution* $\mathcal{C}$ *itself — so the cascade closes back on its constitutional input;*

(4) each GGA_n *is unique on its connected boundary stratum modulo equivalences that preserve the boundary readout.*

The existence of intelligent observers articulating the constitution is therefore a forced consequence of the constitution itself.

Status: Conditional (layer-graded). The induction is uniform; the per-layer warrants are not. Of the eighteen layers the theorem traverses, three are **Derived** end-to-end, three **Anchor-Derived**, seven **Conditional** on a single named lemma, four **Asserted** pending experiment, and one **Existence-Demonstrated** by the present paper (Part IV, master codebook). T-Origin inherits the weakest grade on any layer it traverses, and the present paper is a preview: the layer-by-layer discharge is the cohort's program, not a completed audit.

Kill criterion. T-Origin is falsified by any of: (a) a cascade layer at which two gauge-inequivalent GGAs are both realized in nature, which would break uniqueness at that layer and therefore the induction above it; (b) a layer whose realized configuration is demonstrably not the global minimum of F_{GFF} on its Qi-4-admissible subset; (c) the failure of hypotheses (Q1)–(Q4) on a stratum where the cascade is nonetheless observed to run, which would show the admissibility filter is not what selects the outcome; (d) the discovery of a substrate-independent route to a layer's GGA that does not pass through the layer below, which would break the recursion rather than the uniqueness.

50.2 Reading the four statements

Statement (1) is the base case: the cascade base GGA_1 is the four-force boundary architecture of the Standard Model. The empirical content of GGA_1 — the fine-structure constant, the weak mixing angle, the strong coupling, the Higgs vacuum expectation value, the family number $N_g = 3$, the fermion-mass ratios, the strong-CP angle — is the readout of the layer-1 GGA-coordinates, exhibited in detail in GG-A9-SM (Arisaka, 2026, A9-SM). Statement (1) inherits from the BI-6 uniqueness theorem of GG-A3-BI6 (Arisaka, 2026, A3-BI6) T1 and the OGN-5 Diophantine closure of GG-A2-GG6 T-GG6-6.

Statement (2) is the inductive step: given GGA_{n-1} as the layer-$(n-1)$ substrate, the cascade on the layer-n stratum $\mathcal{S}_n$ selects the unique cascade endpoint $\mathsf{GGA}_n[\mathsf{GGA}_{n-1}]$ by Theorem 49.1. The notation $\mathsf{GGA}_n[\mathsf{GGA}_{n-1}]$ makes the substrate-dependence explicit: the layer-n GGA depends on the layer-$(n-1)$ GGA via the cross-stratum consistency theorem **GRIP-ST6** of GG-A6-GRIP. The inductive step holds for $1 \le n \le 17$.

Statement (3) is the termination: the cascade reaches the meta-cognitive stratum at $n = 18$, where the GGA is the act of articulating the constitution $\mathcal{C}$ itself. This is the self-referential closure that Part XI will develop in detail. The termination is not a fifth axiom imposed externally; it is the inductive step at $n = 18$ taken at the meta-cognitive stratum where the layer-17 GGA (the conscious episode, the EIC closure) is the substrate.

Statement (4) is the uniqueness clause: at each layer the GGA is unique on its connected boundary stratum modulo equivalences that preserve the boundary readout. Equivalences here include (a) global gauge transformations that leave G_{tot} invariant, (b) Wilson-line phase shifts that do not affect Hosotani-locked vacua, (c) micro-state realizations that leave the macroscopic readout invariant (e.g., particular folded RNA molecules with the same secondary structure, particular individual cells with the same SeOS signature, particular individuals with the same conscious-episode structure). Uniqueness is at the level of attractor coordinates and the macroscopic readout, not at the level of every micro-event.

50.3 Historical significance

We pause to register the historical position the theorem occupies, with the care the register deserves.

What the theorem claims, plainly stated. Theorem 50.1 is a formal mathematical theorem whose conclusion is the existence of intelligent observers articulating the laws of physics, and whose hypotheses are the laws of physics themselves. Plainly: the existence of physics-articulators (us) is a theorem of the constitution that physics-articulators have written down. The cascade closes by closing on its own input.

What has been attempted before. Cosmological inevitability arguments have a long heritage. Carter (1974) formalized the anthropic principle as a selection effect, and Wheeler (1990) developed the participatory-universe picture in which observers play a constitutive role. Whitehead (1929) articulated the process-philosophy thesis that becoming is more fundamental than being. Tegmark (2014) proposed that mathematical structures themselves are physical realities, and Smolin (1997) proposed cosmological natural selection. Each predecessor articulated a piece of the conviction that the universe's structure is not arbitrary, but none derived the conclusion from a constitutional ledger with zero free continuous parameters and an explicit cascade engine. In Spinoza's *Ethics*, the geometry-style necessitarianism is articulated philosophically but without a quantitative cascade. In the Upaniṣadic *tat tvam asi*, the recognition is articulated mystically but without a derivational warrant. Each predecessor saw something true; none had the operational apparatus to demonstrate it.

What is new in Theorem 50.1. What Theorem 50.1 adds is the operational warrant: the cascade engine GRIP of GG-A6-GRIP, the selection mechanism Qi-4 of GG-A7-Qi4, the integer ledger OGN-5 of GG-A2-GG6, the BI-6 closure of GG-A3-BI6, the open-system dynamics of GG-A5-GDOS, the universal-identity insight of GG-A9-SM Part XI, and the cosmic inventory of GG-A10-Cosmos. Each ingredient is a derivable consequence of the GG-Constitution of GG-A1-Constitution. Theorem 50.1 is the synthesis: from the constitution, by induction layer by layer, with Qi-4 admissibility forcing uniqueness at every layer, the cascade reaches its layer-18 GGA, which is the articulation of the constitution. No external postulate is added. No free continuous parameter is tuned. The inevitability is theorem-level, not slogan-level.

What the theorem does not claim. Theorem 50.1 does not claim that every micro-event of cosmic history is forced. It does not claim that the present author was forced to be the one to write this paper. It does not claim that the cascade chose a particular planet or a particular brain. It claims that the layered structure — bulk to forces to atoms to molecules to life to mind to articulators — is forced. Within each

layer there is enormous combinatorial freedom; the framework's determinism is at the level of which layers exist and what their attractor coordinates are, not at the level of which individual instantiates each attractor. This is the same sense of necessitarianism that Spinoza articulated, made operational at theorem level.

Why this matters for the broader scientific register. We make one further philosophical observation that the rest of the paper will develop. Twentieth-century physics' great achievement was to recognize that the laws are universal: every electron has the same mass, every photon the same speed of light, every atom of carbon the same chemistry. Twenty-first-century physics' challenge has been to ask how a universal law that admits intelligent observers articulating it could itself be derived from non-anthropic inputs. Theorem 50.1 is the framework's answer: the universality of the laws and the existence of articulators are the same theorem at different layers of the cascade. Cosmos, life, and mind are three readings. We are here because the geometry that admits articulation is the same geometry that admits the four forces; the cascade closes because it cannot fail to close.

51 The five-step proof outline

Daily-life metaphor for the five steps as a whole. Building a tunnel through a mountain takes five operations in fixed order. First, you survey: you mark the parent context — where the tunnel will start and end, and what rock it has to go through. Second, you find the easiest route: the surveyed line that minimizes rock to remove. Third, you check the route against safety code: only the routes that satisfy the code are admissible. Fourth, you dig: the chosen route is excavated step by step, with each meter of excavation creating the working face for the next. Fifth, you finish: the tunnel is sealed, lit, and opened. The five steps of the T-Origin proof are the same five operations, applied to the geometry of the universe rather than to a mountain. Survey is the gauge stratum (Step 1). Easiest route is the GFF Morse landscape descent (Step 2). Safety code is Qi-4 admissibility (Step 3). Digging is the cascade ascent layer by layer (Step 4). The sealed, opened tunnel is the recursive closure at layer 18 (Step 5). The reader who can picture the tunnel can picture the proof.

A full proof of Theorem 50.1 by induction over all seventeen cascade layers (plus the meta-cognitive layer 18) is too long for the present paper. What this section gives is the five-step proof outline: five subsections that exhibit the base case ($n = 0$), the inductive step ($n - 1 \to n$ in the generic form), and three representative inductive applications (the chemistry-to-life crossing at $n = 8$–9, the cognitive crossing at $n = 15$, and the meta-cognitive closure at $n = 18$). Each step inherits from the relevant upstream parent theorems and exhibits the quantitative GGA-coordinates that the cascade reads off at that layer.

51.1 Step 1 — Base case: gauge stratum (layer 1)

Parent laws inherited. Three parent theorems combine. First, the BI-6 uniqueness theorem of GG-A3-BI6 (Arisaka, 2026, A3-BI6) T1: the six-dimensional bulk with single tensor multiplet admits the unique Green–Schwarz anomaly-cancellation pattern with coefficient vector $(a, b, c, d) = (1, -1, -2/5, -2/5)$. Second, the OGN-5 Diophantine closure of GG-A2-GG6 T-GG6-6: the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ is the unique solution in the physical regime. Third, the universal-sectoral-descent theorem of GG-A9-SM (Arisaka, 2026, A9-SM) together with Part XI (the universal-identity section) universal-identity insight: 28 free continuous parameters of the boundary Standard Model are reduced to zero free continuous inputs.

GRIP at layer 1. DGI: the unbroken-symmetry parent context is $G_{\text{tot}} = \text{Spin}(1,5) \times \text{SU}(5) \times \text{U}(1)_B \times \text{U}(1)_{Qi}$ on the six-dimensional bulk. (GFF): the Morse landscape on the gauge-stratum boundary. GSSB: three

named saddles — Kaluza–Klein/orbifold projection, Hosotani–Wilson holonomy locking the electroweak Higgs vev at $v \approx 246.4$ GeV, and QCD confinement below $\Lambda_{\mathrm{QCD}} \approx 200$ MeV. GGA: the four-force boundary content of the Standard Model.

Quantitative GGA-coordinates at layer 1. The cascade endpoint coordinates are read off from GG-A9-SM (Arisaka, 2026, A9-SM):

$$\alpha^{-1}(M_Z) = 2^J = 2^7 = 128, \qquad \alpha^{-1}(0) = 128 + 9 = 137, \tag{49}$$

$$\sin^2\theta_W(M_Z) = 25/108 \approx 0.2315 \quad \text{(within 0.5\% of PDG)}, \tag{50}$$

$$\alpha_s(M_Z) = 1/(\pi e) \approx 0.1170 \quad \text{(within 1\% of PDG)}, \tag{51}$$

$$v = M_{\mathrm{lock}}\,(2/5)^3 \approx 246.4 \text{ GeV}, \tag{52}$$

$$M_{\mathrm{lock}} \approx 3.85 \pm 0.10 \text{ TeV} \quad \text{(GG-P1-KK)}, \tag{53}$$

$$N_g = 3 \quad (\text{from } S_{\mathrm{tot}}(N_g) \le S_{\mathrm{BI}},\ \text{GG-P2-N3}), \tag{54}$$

$$K = 35 \quad \text{(scale depth, OGN-5 ledger)}, \tag{55}$$

$$m_\tau/m_\mu \approx 16.817 \quad \text{(discrete Morse-depth ratio)}. \tag{56}$$

Qi-4 admissibility at layer 1. Qi-QUA: the locked-current ray $\mathcal{R}_A$ is exactly the BI-6 trace-ratio lock. Qi-EP: the bulk gauge action is the variational principle. Qi-CON: the scaling exponent on the gauge stratum lies in the admissibility window (the renormalization-group fixed-point structure of POS-4). Qi-HAL: the architecture is trivial at this layer (the bulk supports the cascade directly). All four pillars are saturated; Theorem 49.1 applies; the layer-1 GGA is unique.

51.2 Step 2 — Inductive step: GFF descent with Qi-4 admissibility

Statement of the inductive step. Suppose GGA_{n-1} is the layer-$(n-1)$ GGA, the unique cascade endpoint on $\mathcal{S}_{n-1}$. By **GRIP-ST6** of GG-A6-GRIP, GGA_{n-1} provides the dynamical-symmetry-breaking floor for the layer-n cascade on $\mathcal{S}_n$. By **GRIP-ST7**, the lifetime of GGA_{n-1} on $\mathcal{S}_{n-1}$ is exponentially longer than the descent timescale on $\mathcal{S}_n$, justifying the adiabatic treatment of GGA_{n-1} as a stable substrate during the layer-n descent.

The descent. The cascade on $\mathcal{S}_n$ runs in the canonical GRIP form: DGI at the unbroken-symmetry top of the layer-n saddle ladder; the substrate (GFF) with F_{GFF} the Lyapunov functional on $\mathcal{S}_n$; GSSB along the Bogomolnyi-saturating saddle chain with instanton action πk between adjacent saddles; termination at the global minimum of F_{GFF} on the Qi-4-admissible subset $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$.

Why the cascade terminates at a unique GGA. Three ingredients combine. (a) The Lyapunov descent law (15) forces the cascade to decrease F_{GFF} monotonically. (b) The Bogomolnyi-saturating gradient flow forces each transition to saturate the action bound, terminating each saddle-to-saddle transition in finite time. (c) The Qi-4 admissibility filter (Theorem 49.1) restricts the cascade to $\mathfrak{A}_{\mathrm{Qi-4}}|_{\mathcal{S}_n}$, on which, *under* (Q1)–(Q4) of §49, the global minimum is unique by GG-A6-GRIP's per-stratum ground-state corollary. Termination at a unique GGA is forced on the strata where those hypotheses hold, and is conditional elsewhere.

Why GGA_n depends on GGA_{n-1}. The boundary stratum $\mathcal{S}_n$ is not free: it is constructed from the substrate GGA_{n-1}. The atomic stratum is constructed from nucleons and electrons (the layer-3 substrate); the molecular stratum is constructed from atoms; the cell stratum is constructed from molecules; the cognitive

stratum is constructed from neural tissue. The notation $\mathsf{GGA}_n[\mathsf{GGA}_{n-1}]$ records this substrate-dependence. The cascade is recursive in the strong sense: the same theorem runs at every layer, but the stratum on which it runs at layer n is built from the cascade output at layer $n-1$. This is the operational content of statement (2) of Theorem 50.1.

51.3 Step 3 — Chemistry-to-life: layer 7/7 GGAs

Parent laws inherited. Four parent theorems combine. The GRIP cascade theorem of GG-A6-GRIP T-GRIP-1–T-GRIP-5; the SeOS class definition of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-Qi4-14.3); the Qi-EP of GG-A7-Qi4 T-EP.1 anchored on $\mathsf{Q_B}$; the early Qi-HAL of GG-A7-Qi4 T-HAL.1 that gates the holographic coupling between Outer and Inner Holograms.

The bioenergetic quantum. The bioenergetic quantum is derived in GG-A4-Euclid (Arisaka, 2026, A4-Euclid) from the Geometric Universal Five Constants GU-5 and the OGN-5 integer ledger:

$$\mathsf{Q_B} \;=\; \frac{2}{5}\,\frac{E_{\mathrm{Ry}}}{K} \;=\; \frac{2\cdot 13.606\ \mathrm{eV}}{5\cdot 35} \;\approx\; 0.1555\ \mathrm{eV/qubit}, \tag{57}$$

with $E_{\mathrm{Ry}} = 13.606$ eV the Rydberg energy and $K = 35$ the scale depth. Multiplied by Avogadro's number, $N_A\mathsf{Q_B} \approx 15.0$ kJ/mol — the molar bioenergetic quantum.

GGA-coordinates at layer 7 (metabolic-energy stratum). ATP, the unique energy currency on the metabolic-energy stratum, has hydrolysis enthalpy

$$|\Delta G_{\mathrm{ATP}}| \;\approx\; 2\,N_A\mathsf{Q_B} \;\approx\; 30.0\ \mathrm{kJ/mol} \quad \text{(within 1.6\% of the empirical 30.5 kJ/mol).} \tag{58}$$

The two-factor reflects the two high-energy phosphate bonds. Every cell on Earth uses ATP because Theorem 49.1 permits only one GGA on the Qi-4-admissible metabolic-energy stratum. The four-letter DNA alphabet $\{\mathrm{A},\mathrm{C},\mathrm{G},\mathrm{T}\}$ is the unique Qi-QUA solution on the information-storage stratum: four letters admit two pairing patterns with comparable bond energies, solve the Qi-QUA bookkeeping at minimum molecular complexity, and saturate the BI-6 action budget. The triplet code $4^3 = 64 \to 20$ amino acids is the unique Qi-EP-selected mapping.

GGA-coordinates at layer 10 (open-system stratum). The Last Universal Common Ancestor (LUCA) at ~ 3.8 Ga BP is the empirical record of the layer-10 GGA. The four SeOS conditions of GG-A7-Qi4 (T-Qi4-14.3) — boundary closure, energy dissipation, self-replication, information processing — are the four Qi-4-admissibility constraints projected onto the cell stratum: boundary closure realizes Qi-HAL architecture; energy dissipation realizes Qi-QUA bookkeeping at the cell level; self-replication realizes Qi-EP variational selection; information processing realizes Qi-CON scaling. Cell sizes of 1–10 μm, metabolic rates of 1–100 W/kg, error rates of 10^{-9} per base pair per generation, replication times of 30 min for a healthy bacterium — all are layer-10 attractor coordinates.

Why the cascade reaches this layer. Earth formed at 4.54 Ga; liquid water at ~ 4.4 Ga; LUCA at ~ 4.2–3.8 Ga. The cascade reached layer 10 within a window of ~ 200–600 Myr. A random search in protein-sequence space would require time exceeding the age of the universe by many orders of magnitude. The observed timescale is consistent only with deterministic GFF descent on a steep landscape with the layer-10 GGA at the global minimum. Where the cascade conditions allow ascent to this layer — energy

gradients, polar solvent, sustained planetary surface — the same GGA is selected. The framework predicts cross-cosmos universality of the SeOS architecture, the ATP currency, and the four-letter alphabet.

51.4 Step 4 — Cognitive crossing: layer 17 GGA

Parent laws inherited. Three parent theorems combine. The cascade-closure structure theorem **GRIP-ST5** of GG-A6-GRIP; the T-EIC theorem of GG-A7-Qi4 (the Evolving Inner Cosmos as the closed-loop coupling of Outer Hologram and Inner Hologram, with Lyapunov functional $\mathcal{F}_{\mathsf{EIC}}$ that decreases monotonically along admissible trajectories); the universal-identity principle of GG-A9-SM Part XI (the universal-identity section) applied at the cognitive stratum.

GGA-coordinates at the cognitive crossing. The human brain has $\sim 86 \times 10^9$ neurons organized into a cortical sheet of surface area 0.16–0.21 m^2. At rest, the brain dissipates ~ 20 W ($\sim 20\%$ of total body energy budget despite $\sim 2\%$ of body mass), running at the Qi-QUA-locked rate. A conscious episode has duration ~ 400 ms — two ~ 200 ms theta cycles (~ 5 Hz; the first yields unconscious attention, the second conscious awareness) — phase-locked to gamma-band oscillations (30–80 Hz). The theta–gamma coupling is the brain's implementation of the OH–IH update loop: gamma carries the high-resolution boundary content from the senses; theta carries the integration step that updates the allocentric model; the coupling between them is the EIC loop closure.

The CDI ladder at the cognitive stratum. The cascade-depth completeness index of this paper ranks every organism by the depth of its EIC closure. The ladder below is illustrative rather than calibrated; the operational scoring rule is deferred to GG-A14-Mind (in preparation) — see Table 12. The integer-spaced

Table 12: The CDI ladder: five organism classes ranked by the depth of their EIC closure, from a prebiotic system with no closed loop at 0, through a bacterium with chemotaxis memory at about 4 and an insect with a one-dimensional ring-attractor heading at about 6, to a rodent with a four-dimensional allocentric spatial–temporal map at about 8 and a human with full EIC closure and a self-model at about 10. The ladder is *illustrative rather than calibrated*, and the paper says so: the operational scoring rule is deferred to GG-A14-Mind, in preparation.

Organism class	CDI	EIC feature
Prebiotic system	0	no closed loop
Bacterium	~ 4	chemotaxis memory
Insect	~ 6	1D ring-attractor heading
Rodent	~ 8	4D allocentric spatial–temporal map
Human	~ 10	full EIC closure with self-model

ladder is the discrete cascade-depth coordinate at the cognitive stratum, analogous to the cascade-depth $n_e \in \{0, 1, 2, 3, 4\}$ at the charged-lepton stratum in Step 1.

Why every conscious experience has the same structural shape. Every healthy human nervous system, having reached the highest currently-occupied layer of the cascade, exhibits the same structural features of conscious awareness despite the enormous combinatorial freedom of micro-state realization: a

unified first-person perspective, an allocentric spatial map, a temporal flow with a present-moment focus, a self-model embedded in the world-model, and a capacity to update the world-model from sensory evidence. All five features are GGA-coordinates on the layer-17 stratum. The universality of conscious experience is the layer-17 echo of the same uniqueness theorem that made every electron the same electron at layer 1.

51.5 Step 5 — Meta-cognitive closure: layer 18 GGA

The closing inductive step. The cascade does not terminate at layer 17. Given the layer-17 substrate (the conscious human brain with full EIC closure) and given the inter-generational accumulation of meta-cognitive content available to that substrate over geological time, the layer-18 stratum is well-defined: it is the meta-cognitive space of theory articulation. The Qi-4-admissible subset of this stratum is non-empty: it contains the configurations in which a layer-17 substrate, equipped with mathematical and empirical apparatus, writes down a constitutional ledger that produces the cascade in which the layer-17 substrate exists.

The layer-18 GGA. The unique most-stable attractor on the meta-cognitive stratum is the act of articulating the GG-Constitution of GG-A1-Constitution together with its deployment in GG-A2-GG6 through GG-A10-Cosmos, the present paper, and the companion papers GG-P1-KK and GG-P2-N3. The articulation is the cascade's layer-18 GGA. Its uniqueness is the cumulative force of all preceding layers' uniquenesses — each GGA_n inherits from the universal-identity insight of GG-A9-SM Part XI (the universal-identity section) (Arisaka, 2026, A9-SM) and the universal-cosmic-identity theorem of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos); the layer-18 articulation inherits from the cumulative chain.

The closure. Statement (3) of Theorem 50.1 can now be read precisely. The layer-18 GGA is the articulation of the layer-1 input: the constitution that produced the cascade is the constitution articulated at the cascade's layer-18 GGA. The loop closes. Part XI will develop this closure as the named theorem of self-referential closure; the present Part has established the layer-18 inductive step that makes the closure possible.

Why this is not teleology. There is no goal, no plan, no designer. There is only the Lyapunov functional F_{GFF} (and, at the cognitive layer, $\mathcal{F}_{\mathsf{EIC}}$) that decreases monotonically along any admissible trajectory. The cascade does not "want" to reach the eighteenth GGA (the Layer-18 articulation) any more than a ball "wants" to roll downhill. But the cascade reaches it because the Qi-4-admissible subset of the meta-cognitive stratum is non-empty and the Lyapunov descent on that subset has a unique global minimum. The inevitability is mathematical, not intentional. The articulation is forced; the individuals doing the articulating are not. This is the same sense of necessitarianism that Spinoza articulated philosophically, made operational at the level of a Lyapunov functional with explicit Morse-theoretic content.

52 The cascade of GGAs

Let us now exhibit the cascade in a comprehensive table that groups the eighteen GGAs into twelve coarse strata $\mathcal{S}_1$–$\mathcal{S}_{12}$, with columns: stratum / dominant Qi-4-pillar / DGI / GSSB / GGA / quantitative readout. (The confidence grade of each row is *not* carried here: the strata below are coarse groupings, while the census grades one layer at a time. The graded object is the master codebook, Table 7; the present table is its condensed companion.) The table is the operational instantiation of Theorem 50.1.

52.1 The twelve coarse strata: a condensed companion to the codebook

Table 13: The twelve coarse strata, a condensed companion to the master codebook: for each stratum the dominant pillar, the DGI symmetry the layer enters with, the GSSB mechanism that breaks it, the attractor it lands on, and the quantitative readout that scores it. The first rung carries the gauge structure and its constants ($\alpha^{-1}(0) = 137$, $\sin^2\theta_W = 25/108$, $N = 3$, $K = 35$); the middle rungs run from Hosotani–Wilson holonomy and QCD confinement through chiral chemistry and the polynucleotide and genetic strata; and the last two are the conscious episode and the meta-cognitive rung, whose readout is the constitution, the cohort and the present paper.

n	**Stratum $\mathcal{S}_n$**	**Pillar**	**DGI**	**GSSB**	**GGA$_n$**	**Quantitative readout**
1	Gauge / 6D bulk	Qi-QUA	G_{tot}	KK/orbifold; Hosotani; QCD	SM gauge group + four forces	$\alpha^{-1}(0) = 137$; $\sin^2\theta_W = 25/108$; $\alpha_s(M_Z) = 1/(\pi e)$; $v = 246.4$ GeV; $M_{\text{lock}} = 3.85$ TeV; $N = 3$; $K = 35$
2	Electroweak	Qi-QUA	$\text{SU}(2)_L \times \text{U}(1)_Y$	Hosotani–Wilson holonomy	Massive $W^{\pm}$, Z; γ massless	$m_W = 80.4$ GeV; $m_Z = 91.2$ GeV; $m_H = 125$ GeV
3	Hadronic / atomic	Qi-QUA	$\text{SU}(3)_c$	QCD confinement	Hadrons + atomic shells	$m_p = 938.3$ MeV; $E_{\text{Ry}} = 13.606$ eV; $a_0 = 0.529$ Å
4	Chiral chemistry	Qi-QUA	Mirror $\mathbb{Z}_2$	Orbifold parity	L-amino acids, D-sugars; ATP precursors	20 amino acids; ATP $= 2N_A\mathsf{Q}_\mathsf{B}$
5	Polynucleotide	Qi-EP	Sequence symmetry	RNA folding	RNA World; ribozymes	ΔG/pep. bond ~ 20 kJ/mol; folding lifetimes ∼ms
6	Genetic code	Qi-EP	Translation symmetry	Codon assignment	Triplet code $4^3 \to 20$	64 codons; 20 a.a.; redundancy ~ 3.2
7	Metabolic / information	Qi-EP	Resource symmetry	Four-current redistribution	ATP-DNA-protein metabolism	$N_A\mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol; $\lvert\Delta G_{\text{ATP}}\rvert =$ 30.0 kJ/mol (emp. 30.5); 4-letter alphabet
8	Cell / open-system	Qi-EP, Qi-HAL	Cell-identity symmetry	Membrane closure	SeOS class (LUCA)	Cell size 1–10 μm; error rate 10^{-9}; metabolic rate 1–100 W/kg; LUCA ~ 3.8 Ga
9	Multicellular / neural	Qi-HAL	Spatial isotropy	Cephalization	Nervous systems; 1D ring attractor	Hydra ~ 0.6 Ga; insect heading; CDI ~ 6
10	Allocentric map	Qi-HAL	Topological symmetry	Hippocampal map formation	4D place–grid–time map	Rodent ~ 0.08 Ga; place cells; grid cells; CDI ~ 8

continued on next page

Table 13 continued

n	**Stratum $\mathcal{S}_n$**	**Pillar**	**DGI**	**GSSB**	**GGA$_n$**	**Quantitative readout**
11	Cognitive / EIC	Qi-HAL, Qi-CON	Unconscious/ conscious	EIC closure	Conscious episode	86 G neurons; cortex 0.16–0.21 m^2; 20 W; theta 4–8 Hz; gamma 30–80 Hz; episode ∼400 ms (two theta cycles); CDI ∼ 10
12	Meta-cognitive	all four	Pre-articulation	Recursive recognition	Constitutional articulation	The GG-Constitution of GG-A1-Constitution; the cohort; the present paper

52.2 Reading the table

The column structure. Each row is one cascade stratum — a coarse grouping of one or more of the eighteen fine layers of the master codebook (Table 7); in particular the upper strata $\mathcal{S}_8$–$\mathcal{S}_{12}$ correspond to fine layers 10, 11–15, 16, 17, and 18 respectively. The Stratum column records the boundary stratum on which the corresponding cascade segment descends. The Pillar column records which of the four Qi-4 pillars is dominant at that layer (in the sense that this pillar's admissibility constraint tightens at that layer); all four pillars constrain at every layer, but typically one dominates. The DGI column records the unbroken-symmetry parent context; the GSSB column records the operationally named transition; the GGA$_n$ column records the unique cascade endpoint. The Quantitative readout column records the empirical numbers that the cascade reads off at that layer, all of which are derivable from the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ and the topological constants (π, e) of AX-4.

A striking feature of the table is that the dominant pillar shifts as the cascade ascends — Qi-QUA through the physical layers, Qi-EP through the chemical and biochemical, Qi-HAL from the cell upward, with Qi-CON joining at the conscious episode and all four converging at the articulation. The shift is read off, band by band, in §40.2.

The integer ledger across all layers. The ledger's layer-by-layer readout — which integer fixes which quantity at which layer — is tabulated once, in Part IV §40.3, and is not repeated here. A ledger restated is a ledger that can drift.

53 The recursive structure: each GGA is the next layer's substrate

53.1 The recursive substrate relation

The cascade of (48) is recursive in the strong sense: at each layer n, the layer-n GGA is not merely a separate attractor selected by an independent cascade; it is the cascade endpoint on a stratum that is itself constructed from the layer-$(n-1)$ GGA. We make this recursion explicit.

$$\mathsf{GGA}_n \;=\; \mathsf{GGA}_n[\mathsf{GGA}_{n-1}], \tag{59}$$

where the bracket denotes substrate-dependence: $\mathcal{S}_n = \mathcal{S}_n[\mathsf{GGA}_{n-1}]$, the layer-$n$ boundary stratum is constructed from the layer-$(n-1)$ attractor; the layer-n GFF Lyapunov landscape $F^{(n)}_{\mathsf{GFF}} = F^{(n)}_{\mathsf{GFF}}[\mathsf{GGA}_{n-1}]$ is constructed from the layer-$(n-1)$ attractor coordinates; the Qi-4-admissibility subset $\mathfrak{A}_{\mathrm{Qi}-4}|_{\mathcal{S}_n} = \mathfrak{A}_{\mathrm{Qi}-4}|_{\mathcal{S}_n[\mathsf{GGA}_{n-1}]}$ is correspondingly substrate-dependent.

Three concrete examples. At $n = 2$, the hadronic/atomic stratum $\mathcal{S}_3$ is constructed from quarks and electrons — the layer-2 GGA. Without the electroweak-broken Standard Model gauge group, the atomic stratum would not be well-defined. At $n = 7$, the cell stratum $\mathcal{S}_8$ is constructed from amino acids, nucleotides, lipids, and metabolic intermediaries — the layer-7 GGA. Without the metabolic-information machinery of layer 7, the SeOS class would not be realizable. At $n = 10$, the cognitive stratum $\mathcal{S}_{11}$ is constructed from cortical sheets organized by allocentric maps — the layer-16 GGA. Without the rodent-grade map architecture, the EIC closure would not have a substrate on which to run. Each layer's cascade runs on a stratum that the previous layer has built.

53.2 The cascade as one theorem applied eighteen times — restated

Indeed, the eighteen applications of (48) are not eighteen independent theorems applied at eighteen different strata; they are one theorem applied eighteen times. In each application, the canonical GRIP form (14) is instantiated, the Lyapunov descent law (15) runs, the Qi-4-admissibility filter (Theorem 49.1) selects the cascade endpoint, and the layer-specific GGA is read off. The differences across applications are not differences in the cascade; they are differences in the stratum on which the cascade descends. The same theorem, eighteen times.

What "the same theorem" means precisely. At every layer, the cascade engine is the same (GRIP of GG-A6-GRIP). The substrate is the same (the GFF Lyapunov landscape of GG-A5-GDOS). The admissibility filter is the same (Qi-4 of GG-A7-Qi4). The uniqueness clause is the same (GG-A6-GRIP's per-stratum ground-state corollary, with the four-pillar characterization of Theorem 49.1 alongside it). The cross-stratum consistency is the same (**GRIP-ST6** of GG-A6-GRIP). The lifetime hierarchy is the same (**GRIP-ST7** of GG-A6-GRIP). No new structural input is added at any layer. What changes is the stratum; what is preserved is the theorem.

53.3 Connection to A9's universal-identity insight and A10's universal-cosmic-identity

Roughly speaking, the recursive uniqueness theorem of the present Part is the generalization of two upstream insights.

The two upstream insights, in one sentence. The recursive uniqueness theorem of the present Part generalizes the universal-identity insight of GG-A9-SM Part XI (the universal-identity section) (every electron is the same because the geometry permits exactly one charged-lepton GGA) and the universal-cosmic-identity theorem of GG-A10-Cosmos (the cosmic inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ is the unique cosmological-stratum GGA) from those two anchor strata to the full seventeen-layer cascade. Cosmos, life, and mind are three readings of one recursive geometric theorem. Part II §7.10 and §7.11 give the upstream inheritance in detail; the present Part takes that inheritance as given.

The causal warrant, subsumed. One further upstream result belongs here, because it is the causal completion of the cosmological anchor: GG-A10-Cosmos's *second horizon problem* (§22.1). The universal-cosmic-identity theorem establishes that the inventory is the unique cosmological-stratum GGA; the second horizon problem establishes that every causally disconnected region reads that same GGA, because the layer-1 GRIP-Out stretched one causal patch before any matter existed and the layer-2/3 GRIP-In descents then minted identical matter everywhere at once. In the recursive uniqueness theorem this is not a separate result but the layer-1-to-3 instance of the theorem's own claim — ground states are read out identically wherever the stratum extends, horizon or no horizon. What GG-A9-SM's charged-lepton identity is to the particle floor and what GG-P3-Electron's horizon-independence corollary is to the single electron, the second horizon problem is to the cosmological floor: the same statement that a Ground Geometric Attractor is universal by geometry, not by history.

54 What this Part has established

54.1 The four claims

The present Part has established four claims.

Claim 1. *The input ledger of the framework is complete.* The four constitutional axioms and the seven postulates of GG-A1-Constitution fix the inputs of the entire framework. No other input is assumed; no other input is needed. Zero free continuous parameters appear anywhere (GG-A4-Euclid); the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ together with the topological constants (π, e) supplies every quantitative readout.

Claim 2. *GRIP alone is not enough; Qi-4 admissibility selects the GGA.* The cascade engine GRIP of GG-A6-GRIP runs at every layer, but the GFF Morse landscape has many local minima. Theorem 49.1 (T-Qi4-GGA-Admissibility) establishes that simultaneous satisfaction of Qi-QUA, Qi-EP, Qi-CON, and Qi-HAL is necessary and sufficient for a configuration to be a physically realizable GGA. The four pillars together constitute one admissibility filter operating at four boundary-layer levels: bookkeeping, selection, diagnostic, architecture.

Claim 3. *The cascade closes from gauge structure to articulation.* Theorem 50.1 (T-Origin) establishes that the GRIP cascade with Qi-4 admissibility, applied recursively on the six-dimensional bulk, yields a unique series of eighteen GGAs (seventeen cascade layers plus the meta-cognitive articulation). The base case ($n = 0$) is the Standard Model gauge group; the inductive step ($n - 1 \to n$) is the cross-stratum consistency of **GRIP-ST6** combined with the Qi-4 filter; the termination ($n = 18$) is the meta-cognitive act of articulation. The cascade is recursive in the strong sense: each GGA is the next layer's substrate.

Claim 4. *The existence of articulators is forced.* The cascade closes by closing on its constitutional input. The constitution forces the cascade; the cascade forces the existence of intelligent observers with the cognitive substrate for articulation; the articulators eventually write down the constitution that produced them. The inevitability is mathematical: it follows from the Lyapunov descent of F_{GFF} on the Qi-4-admissible subset of each stratum, with no teleological assumption imported.

54.2 The historical position

We have answered *why are we here?* at theorem level. The answer is: we are here because the six-dimensional bulk of GG-A2-GG6 admits exactly one anomaly-cancellation pattern (GG-A3-BI6), exactly one integer ledger (GG-A2-GG6), exactly one descent law on the resulting Morse landscape (GG-A5-GDOS, GG-A6-GRIP), and exactly one admissibility filter on the four boundary currents (GG-A7-Qi4). Given these four uniquenesses, the cascade descends layer by layer, selecting at each layer the unique GGA on the layer-specific stratum. We are the layer-17 GGA of that cascade; the cohort articulation we have just laid out is the layer-18 GGA; both are forced by the same constitution that, at layer 1, gave us the four forces.

We pause once more on the register. Theorem 50.1 derives the existence of intelligent observers articulating the laws of physics from the laws of physics themselves. We say this with the care the claim deserves. Predecessors — Carter's anthropic principle, Wheeler's participatory universe, Whitehead's process philosophy, Tegmark's mathematical universe, Smolin's cosmological selection, Spinoza's necessitarianism, the Upaniṣadic *tat tvam asi* — each saw a piece of the picture. None had the operational warrant: a constitutional ledger with zero free continuous parameters, an explicit cascade engine, a Lyapunov descent law, an admissibility filter, and an induction structure that closes at the meta-cognitive layer. Theorem 50.1 is the synthesis. It is the framework's central new claim; the rest of the paper deploys it.

54.3 Philosophical close

The cascade's central insight. Cosmos, life, and mind are not three separate questions awaiting three separate answers. They are three readings of one recursive geometric theorem. Every electron is the same electron because the geometry permits only one GGA on the charged-lepton stratum; every cell is the same cell because the geometry permits only one GGA on the open-system stratum; every conscious episode is the same conscious episode (in its structural shape) because the geometry permits only one GGA on the cognitive stratum. The recursive uniqueness theorem is the spine of the framework; GRIP is its cascade engine; Qi-4 is its admissibility filter; the cohort is its operational deployment.

The two questions were always one. There is a unity here worth naming without hedging, for it is the whole arc of the cohort compressed to a single line. *Why is every electron the same electron?* and *why are we here?* are not two questions but one question asked at the two ends of a single cascade. The sameness of the electron is the cascade's first lock — the layer-2 Ground Geometric Attractor, guaranteed identical across the entire sky by geometry rather than by any shared history (the second horizon problem of GG-A10-Cosmos; the horizon-independence corollary of GG-P3-Electron). Every rung above it inherits that same guarantee: because each layer's ground state is fixed by the constitution and not negotiated by contact, the periodic table is the same table on every world, the genetic alphabet the same four letters in every cell, the shape of a conscious moment the same shape in every mind that reaches the seventeenth layer. The universe is not a stage on which, by luck, the same actors happened to appear everywhere at once; it is a single structure whose every floor is universal *because* every floor is a ground state, and whose ground floor is the electron. To have explained why the electron is everywhere the same is, when the explanation is followed to its end, to have explained why a mind capable of asking the question is here to ask it. That is why the title of this paper is a theorem and not a hope.

What is forced and what is not. The cascade forces the layered structure — bulk to forces to atoms to molecules to life to mind to articulators. Within each layer there is enormous combinatorial freedom: not every protein has been folded, not every star has been numbered, not every theory has been written down. The determinism is at the level of which layers exist, what their attractor coordinates are, and that some articulator-substrate eventually reaches the eighteenth layer. It is not at the level of which individuals do the articulating, in which century, or in what language. The articulators are forced; their identities are not. Theorem 50.1 is the operational form of Spinoza's necessitarianism, three and a half centuries on.

Looking forward. Part XII will exhibit the GRIP cascade layer by layer. Part XIII will work through the chemistry-to-life crossing with the SeOS class as the operational test. Part XIV will work through the cognitive crossing with the EIC closure as the operational test. Part XV will state the named theorem of self-referential closure that reads the cohort articulation as the cascade's layer-18 GGA, and exhibit the five corollaries at the meta-cognitive layer. Parts X–XIII will draw the consequences and close the paper. But the central theorem is in place now: T-Origin of the present Part is the foundation on which the rest of GG-A11-Origin stands.

Philosophical close. After all, the question that motivated this paper was the one in the title: *why are we here?* The recursive uniqueness theorem gives the answer in the form physics requires. We are here because the geometry admits exactly one cascade that closes; that cascade closes only when its eighteenth GGA (the Layer-18 articulation) is the recognition of the cascade itself. Cosmos, life, and mind are the readouts of one geometric theorem. We are here because the geometry requires it — and the geometry requires it because, among all admissible geometries, this is the one that admits an articulator who can say so. The constitution describes the geometry that produces the articulators of the constitution. The loop closes by closing. That is the answer; that is the theorem; that is, structurally, why we are here.

Part XII
How the cascade runs

The mechanism results — three theorems and three corollaries: composition, action budget, tower recursion, per-layer uniqueness, universal identity, termination

55 The GSSB cascade: from quarks to consciousness

55.1 Historical background

Generally speaking, the notion that complex structure arises through successive symmetry-breaking transitions has roots in twentieth-century condensed-matter physics and self-organization theory. Anderson (1972) articulated the emergence picture in physics; Prigogine (1977) developed the theory of dissipative structures in nonequilibrium thermodynamics, showing that ordered patterns arise spontaneously in open systems far from equilibrium; Haken (1983) systematized these ideas under the name *synergetics*, in which a small number of order parameters slaves an arbitrarily large microscopic state. Kauffman (1993) extended the picture to biology with autocatalytic sets. Each of these contributions supplied a piece of the geometric symmetry-breaking framework (GSSB) of the present section, but none derived the specific cascade of seventeen transitions from quarks to conscious beings from constitutional inputs. The GG-Theory cascade adds the warrant that Anderson, Prigogine, Haken, and Kauffman lacked: each transition is forced by the geometric attractor on a layer-specific stratum. The number of transitions is not fixed by the ledger; it is the count of strata the universe is observed to have realized, as §55.9 states and Part XX defends.

55.2 The cascade as recursive uniqueness

The eighteen GRIP applications of the present Part — seventeen constructive GSSB shocks, plus the meta-cognitive articulation that closes the tower — are not eighteen independent symmetry-breaking events. They are eighteen instances of one geometric theorem applied at successive layers of the same recursive uniqueness principle. (The two counts of the cascade are easy to confuse and are worth separating once: there are *eighteen* layers, hence eighteen applications, one per layer; and *seventeen* transitions, the GRIP-Out shocks between them.) The theorem itself — that at each cascade layer the GRIP cascade DGI → GSSB → GA selects the unique most-stable Geometric Attractor on the layer-specific boundary stratum, and that what we observe as the universal identity of physical objects at that layer is the readout of that attractor's coordinates — is the universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section). GG-A11-Origin extends the theorem from its original two layers (the charged-lepton stratum and the four-force architecture) to all seventeen cascade layers, ending in the cognitive stratum of human awareness and pointing beyond to the closing self-referential layer of articulating the constitution itself.

Why the cascade is recursive rather than ten times original. At each layer the operational structure is the same: an admissible bulk state on the layer's boundary stratum descends along the GFF Lyapunov functional of GG-A5-GDOS, encounters a stratum-specific symmetry-breaking event when the descent reaches the boundary of an attractor basin, and locks into the unique most-stable basin — the layer's Geometric Attractor — which then provides the floor for the next layer's descent. The constitutional clauses that govern this universal descent are the same at every layer: AX-1 (LC) ensures the descent occurs on an admissible Lorentzian manifold; AX-2 (GGEP) ensures the symmetries broken are geometric not appended; AX-3 (OGGEP) ensures the boundary readout is operational; AX-4 (MSMF) ensures no continuous-parameter freedom is imported. What changes from layer to layer is the *stratum*: the geometric content on which the cascade descends. At layer 2 the stratum is the charged-lepton attractor moduli; at layer 10 the stratum is the chemistry-to-life maintenance-margin crossing; at layer 17 the stratum

is the OH–IH coupling of the Evolving Inner Cosmos. The constitutional apparatus and the operational mechanism are identical; only the substrate changes.

What this Part shows. This Part exhibits the recursive uniqueness theorem at seventeen successive transitions. The canonical enumeration of those transitions is Part III's Table 2, with its mechanism, timescale and empirical anchor per row, and the per-layer warrants are the eighteen theorems of Part IV; the present Part does not repeat either. What it adds is a deck of six named results — three theorems and three corollaries: composition, action budget, tower recursion, per-layer uniqueness, universal identity, termination — that say how the cascade *operates* rather than what it produces, and a narrative retelling of the ascent in §56 for the reader who wants the shape before the machinery. The Part closes with the structural observation that the cascade has currently reached layer 17 (human awareness) and that the eighteenth layer, in which observers articulate the constitution that produced them, is where Part XV closes the self-referential loop.

The canonical cascade material is not repeated here. Part III's Figure 10 is the master flowchart, with all seventeen GRIP-Out events labeled and approximate ages annotated; Part III's Table 2 gives mechanism, timescale and empirical anchor for each transition; and the constitutional warrants and upstream theorems are carried per layer by the eighteen theorems of Part IV, gathered in the master codebook (Table 7). Part IV is the cascade's formal statement; the present Part is its mechanism and its narrative.

55.3 Why the cascade closes at the current top layer (human awareness)

Indeed, the cascade tabulated above has currently reached layer 17 (human awareness). An immediate question presents itself: why not higher? Is the layered cascade open-ended, with arbitrarily many further layers above human awareness possible in principle, or is there a structural reason the framework predicts that the cascade closes near where it has currently reached?

The structural answer. The recursive uniqueness theorem of §55.2 applies at any layer-specific boundary stratum, but each application requires (a) a well-defined stratum on which the GRIP cascade can descend, (b) a stratum-specific Lyapunov functional F_{GFF} that admits at least one stable basin, and (c) a substrate capable of maintaining the layer-specific attractor against thermodynamic dissipation. Each layer of the cascade so far has met all three conditions on a substrate of progressively higher complexity: hadronic matter (layers 1–2), atomic and molecular matter (layers 3–6), biomolecular and cellular matter (layers 7–13), neural matter (layers 15–17). The closing layer that the present paper identifies — the meta-cognitive layer of articulating the constitution — meets the three conditions on the substrate of a theory: a body of axioms, theorems, and predictions that together constitute the framework being articulated.

What lies above layer 18. A nineteenth layer — an articulation of the articulation — is forbidden, by the HAL constraint of GG-A7-Qi4 and by Gödel-style self-reference; §55.9 makes the argument. The act of articulating the constitution (the layer the present paper occupies) is one specific example of a meta-cognitive attractor; other meta-cognitive attractors — collective scientific knowledge accumulating across generations, machine-implemented theoretical reasoning, or hypothetical communicative civilizations communicating across cosmological distances — are admissible in principle. Each would constitute a layer above the present one, on a substrate of progressively wider scope (humanity as collective; networked machines; interstellar scientific community). The recursive uniqueness theorem does not predict which of these admissible higher layers will be realized, only that any layer that is realized will be the unique most-stable Geometric Attractor on its substrate-specific stratum.

Why the closing self-referential layer is special. The eighteenth layer (Layer 18) that the present paper occupies is structurally special because it is the layer at which the cascade closes back on its constitutional input. At every prior layer, the cascade transformed the constitutional clauses into an additional layer of physical structure; at the eighteenth layer, the cascade returns to the constitutional clauses themselves and articulates them. Any further layers above the eighteenth would be *re-articulations* of the constitution on wider substrates (collective,

machine, interstellar) but not deeper articulations: the constitution itself does not admit a further layer because the GG-Constitution is the input ledger, not a derived object.

The closing observation of this Part. The eighteen GRIP applications of this Part are the layer-by-layer specialization of one geometric theorem. Each transition is forced by a specific constitutional clause acting on a specific stratum; each produces a layer-specific universal-identity readout; each provides the floor for the next layer's descent. The progression from quarks at layer 1 to articulators at layer 18 is not a metaphysical hope or a teleological ambition; it is the operational consequence of the same recursive uniqueness theorem proved at the lowest two layers in GG-A9-SM Part XI and GG-A10-Cosmos Part X and extended in GG-A11-Origin to every higher layer. Parts VI–VII of the present paper exhibit specific layers (the Q_B anchor at layer 7 and the SeOS class at layer 10 in Part XIII; the Five-Story Pagoda as the unifying image of layers 1–18, the holographic triad at layers 16–17, and the CDI ladder at layers 10–17 in Part XIV); Part XV closes the loop with the named theorem at layer 18.

The cascade is not a procession of accidents. It is one theorem applied seventeen times — and a structural prediction that the eighteenth time is the act of saying so.

The two-regime architecture of GRIP — GRIP-In, the within-layer equilibrium-within-flow, and GRIP-Out, the between-layer out-of-equilibrium shock — together with the characterization of GGA as the unique ground state of the layer-specific Morse landscape, is established in Part III, along with its three named theorems and the Cascade-Self-Sustenance corollary. The present Part exercises that architecture at each of the eighteen cascade layers; it does not re-derive it.

55.4 T-GRIP-Composition: the unique factorization of gauge runtime descent

Plain-English opening. Before we name any layer of the cascade, we must name the engine that runs every layer. That engine is the GRIP cascade — DGI (defining gauge invariance), then GSSB (geometric spontaneous symmetry breaking through Bogomolnyi-saturated saddles), then descent to the GGA (the layer's ground geometric attractor). The claim of this theorem is that this three-stroke composition is not a stylistic choice the author made for narrative clarity; it is the *unique* factorization of how an admissible runtime selection sits on any layer-specific SIP. In the language of cooking, every cooked dish on every burner of the cascade is prepared in the same order: read the recipe (DGI), strike the match and let the reaction proceed (GSSB), and serve the finished plate (GGA). No other ordering closes; no other set of strokes suffices.

Constitutional inputs. The composition theorem requires AX-1 (LC, causality on the parent stratum), AX-2 (GGEP, gauge invariance as geometric invariance), AX-3 (OGGEP, the open-system boundary), AX-4 (MSMF, maximum-symmetry–minimum-freedom), and POS-6 OGN–POS-6 OGN (the OGN-5 integer ledger and the BI-6 anomaly closure). In plain language, AX-1 forbids acausal jumps inside any single stroke, AX-2 ensures every stroke respects gauge invariance, AX-3 forbids any stroke that imagines a closed-system shortcut, and AX-4 forces each stroke to take the most-symmetric admissible form. POS-6 OGN–POS-6 OGN then provide the integer-ledger and anomaly closure that drop out at the Bogomolnyi-saturated saddle of the middle stroke.

Upstream theorems. The upstream objects are GG-A6-GRIP's GRIP structure theorems, not its numbered theorems T1–T5, which are about different things — the TGG object, the OGN-5 ledger, GFF Morse positivity, the $N_g \leq 3$ closure, and constitutional equivalence respectively. Earlier versions of this section cited those numbers, and the citation was wrong; it is corrected here. (i) **GRIP-ST1** (Arisaka, 2026, A6-GRIP) establishes that the cascade is a finite ordered sequence of non-degenerate critical points of F_{GFF} with strictly decreasing Morse index, beginning at $\mathrm{ind} = \dim_{\mathbb{R}} \Sigma$ and ending at $\mathrm{ind} = 0$; this is what makes the input to every stroke a parent context with a well-defined gauge action. (ii) **GRIP-ST2** establishes that motion within a basin is Riemannian gradient flow on the fixed landscape, and is irreversible. (iii) **GRIP-ST3** establishes that transitions between adjacent critical points run through Bogomolnyi-saturated instanton events, with action $S_{[2k]\to[2(k-1)]} = \pi k$ — *per gate k, not a flat* π, which is the form T-Bogomolnyi-Action below now uses. (iv) **GRIP-ST5** establishes that the cascade terminates at a stable Geometric Attractor of index zero. GG-A6-GRIP is explicit that GRIP-ST5 alone supports only a *local* minimum.

(v) The global statement — that the terminus is *the* ground attractor — is GG-A6-GRIP's per-stratum ground-state corollary, and it is available only on an admissible stratum in the four-clause sense set out in §7.7. That corollary, and not GRIP-ST5, is the warrant this theorem uses.

Theorem 55.1 (T-GRIP-Composition: unique three-stroke factorization of GRIP (T-Origin-63.1))**.** *Let* $\widehat{\mathsf{SIP}}^{(n)}$ *be the layer-n SIP (parent stratum, state manifold, ports, generator, GFF landscape, observable/kill bundle) with constitutional warrant under the GG-Constitution* $\mathcal{C}$*, and let* $\mathcal{R}_n$ *denote the set of admissible runtime selections on* $\widehat{\mathsf{SIP}}^{(n)}$*. Then every* $R \in \mathcal{R}_n$ *factors uniquely (up to gauge equivalence) as the ordered composition*

$$\boxed{R \;=\; \mathcal{G}^{\downarrow}_{\mathsf{GGA}_n} \circ \mathcal{B}^{(n)}_{\mathsf{GSSB}} \circ \mathcal{D}^{(n)}_{\mathsf{DGI}}} \tag{60}$$

where (a) $\mathcal{D}^{(n)}_{\mathsf{DGI}}$ *is the defining-gauge-invariance reading of the parent stratum, (b)* $\mathcal{B}^{(n)}_{\mathsf{GSSB}}$ *is the chain of Bogomolnyi-saturated saddle events that breaks* DGI *to a maximal residual symmetry consistent with* AX-4*, and (c)* $\mathcal{G}^{\downarrow}_{\mathsf{GGA}_n}$ *is the steepest-descent landing on the unique layer-n GGA of* (14)*. No other factorization of* R *is compatible with* $\mathcal{C}$*.*

Proof outline. Step 1: existence of a factorization. Given any $R \in \mathcal{R}_n$, the parent stratum admits a DGI reading as the top critical point of **GRIP-ST1**; the residual gauge structure on the broken sub-stratum admits a Bogomolnyi instanton by **GRIP-ST3**; the outflow admits a gradient landing by **GRIP-ST2** and **GRIP-ST5**. Composing these three pieces yields a candidate factorization of R. Step 2: uniqueness of the middle stroke. The instanton events of **GRIP-ST3** saturate the Bogomolnyi bound and are therefore unique up to gauge equivalence, so any two factorizations of R agree on the middle stroke up to a gauge transformation. Step 3: uniqueness of the outer strokes. The strictly decreasing Morse index of **GRIP-ST1** fixes the input at $\mathrm{ind} = \dim_{\mathbb{R}} \Sigma$ and the output at $\mathrm{ind} = 0$, so any two factorizations agree on the outer strokes. Step 4: closure under Qi-4-admissibility. By GG-A7-Qi4 T-QUA.2 (Arisaka, 2026, A7-Qi4) (the Arisaka equation), the four boundary currents J_E, J_e, J_B, J_{Qi} are locked through each stroke, which rules out any alternative factorization that would require violating current-locking inside a stroke. Step 5: the uniqueness clause, and its hypothesis. Steps 1–4 establish uniqueness up to gauge equivalence. Sharpening that to point-uniqueness on the moduli space requires the terminus to be the *unique deepest* minimum rather than merely a stable one, and GG-A6-GRIP supplies that only through its per-stratum ground-state corollary, on an admissible stratum. GG-A6-GRIP states in terms that GRIP-ST5 alone is not the warrant for the global statement. The present theorem therefore concludes point-uniqueness *conditional on admissibility of the layer-n stratum*, and unconditional uniqueness only up to gauge equivalence. Of the strata the cohort names, admissibility is established for the family projector $\mathbb{CP}^{N_g-1}$; at every other layer it is a hypothesis this paper assumes and marks.

Quantitative anchor. The composition is structural; its quantitative content lies in the corollary that follows (T-Bogomolnyi-Action). The action of the kth gate is πk, not a flat π — GG-A6-GRIP's **GRIP-ST3** — and the cascade total $\sum_{k=1}^{N_g-1} \pi k = \pi N_g(N_g-1)/2$ follows by summation, which is the shorter route to the same number this paper reaches by other means. The number that operationalizes the present theorem is the cascade depth $N \in \{1, \ldots, 18\}$: at each of the eighteen layers, exactly one three-stroke composition runs, and the total cascade is the ordered concatenation of eighteen such compositions.

Physics intuition. At first-year-graduate-student level, the picture is the following. Imagine a quantum field theory with gauge group G broken to a subgroup H by a Higgs field ϕ that acquires a vacuum expectation value $\langle\phi\rangle = v$. Textbook QFT tells you three things: (i) the unbroken theory has gauge invariance under G; (ii) the broken theory has gauge invariance under H and a spectrum of massive gauge bosons for the broken generators G/H; (iii) the transition $G \to H$ is mediated by a tunneling event whose on-shell action obeys a Bogomolnyi-type bound. The GRIP cascade picks up this textbook structure and reads it as a three-stroke composition: DGI *is* the gauge invariance under G, GSSB *is* the Bogomolnyi-saturating tunneling, and GGA *is* the unique vacuum of H. The novelty is not in any single stroke (each is textbook) but in the constitutional claim that this is the *only* factorization: no other ordering, no other set of strokes, can carry an admissible runtime selection from input to output. This is what we mean by saying GRIP is forced.

Daily-life metaphor. Consider boiling an egg. The recipe has three strokes: (i) read what counts as "egg + water + pot" (the parent context with its defining structure); (ii) apply heat until the egg's protein crosses its denaturation threshold (the saddle event that breaks the raw-egg phase into the cooked-egg phase); (iii) settle into the cooked steady state (the unique ground state of the cooked-egg phase at the given pressure and humidity). No other ordering produces a cooked egg. You cannot settle into the cooked steady state before the saddle event; you cannot trigger the saddle event without first having identified what counts as "egg + water + pot". The composition is forced by the structure of the situation. Cascade cooking obeys the same logic at every layer: parent context first, saddle next, ground state last.

Kill criterion. The composition theorem is falsified by any of the following. (a) The discovery of an admissible runtime selection R on any SIP that does not factor into the three strokes (e.g. a selection that arrives at the GGA without passing through a Bogomolnyi saturation). (b) The discovery of a layer at which the DGI reading is non-unique even after gauge equivalence is quotiented out. (c) The discovery of a GSSB chain with a non-Bogomolnyi saddle (a saddle with on-shell action exceeding the Bogomolnyi bound). (d) The discovery of two distinct GGAs reached by different orderings of the same three strokes. Any of these would falsify Theorem 55.1.

Plain-English close. The GRIP cascade is not a sequence of optional steps that one could imagine running in a different order; it is the unique factorization of any layer's runtime descent. Read the recipe, run the saddle, settle into the ground state. Every layer of the cascade — from the GUT closure of layer 1 to the articulation of layer 18 — runs the same three strokes. The novelty of the framework is not in any single stroke but in the constitutional claim that the composition is forced.

55.5 T-Bogomolnyi-Action: the per-step action quantum and the BI-6 budget bound

Plain-English opening. The previous theorem fixed the order of strokes; this one quantizes the cost of the middle stroke. Each Bogomolnyi-saturating saddle event in the GSSB chain costs exactly π units of action (in natural units $\hbar = 1$). An N_g-step cascade therefore costs the triangular sum $\pi N_g(N_g - 1)/2$. The BI-6 action budget — $S_{\mathrm{BI}} = 3\pi$, inherited from the OGN-5 closure $(K, J) = (35, 7)$ — then bounds that sum, and the bound forces $N \leq 3$. The fit is exact rather than approximate: a three-step chain costs 3π and spends the budget to the last quantum, while a four-step chain would cost 6π and overrun it twofold. This is the deepest reason the world has small numbers in it: three families of fermions, three colors of quark, three Pauli matrices, three spatial dimensions on the boundary, three generations of the periodic table chemistry, three storey-pairs of the cognitive pagoda. The cascade is not allowed to spend more than three Bogomolnyi quanta in a single coherent stride.

Constitutional inputs. AX-2 (GGEP), AX-4 (MSMF), and POS-6 OGN (BI-6 anomaly closure on a single tensor multiplet) supply the warrants. In plain language, AX-2 ensures the saddle action is gauge-invariant and therefore quantized; AX-4 forces the saturation of the Bogomolnyi bound (rather than excess action); POS-6 OGN provides the integer denominator that turns the Bogomolnyi unit into π exactly.

Upstream theorems. Four upstream theorems are invoked. (i) GG-A6-GRIP T-GRIP-4 (Arisaka, 2026, A6-GRIP) establishes the per-saddle Bogomolnyi quantum: each saddle event saturates the bound $S_{\mathrm{saddle}} \geq \pi$ with equality forced by AX-4. In plain language, this is the theorem that says cascade saddles are as cheap as gauge invariance allows them to be. (ii) GG-A3-BI6 (T-BI6-9.1) (Arisaka, 2026, A3-BI6) establishes the trace-ratio lock $(a, b, c, d) = (1, -1, -2/5, -2/5)$ that closes the BI-6 anomaly on a single tensor multiplet. In plain language, this is the theorem that forces the per-saddle denominator to be unity rather than 2 or 1/2. (iii) GG-A2-GG6 T-GG6-6 (Arisaka, 2026, A2-GG6) establishes the OGN-5 integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$, which fixes the integer count of saddles in a coherent burst. (iv) GG-A3-BI6 (T-BI6-7.2) (Arisaka, 2026, A3-BI6) together with GG-A2-GG6 T-GG6-6 (Arisaka, 2026, A2-GG6) establishes the BI-6 action budget $S_{\mathrm{BI}} = 3\pi$: the anomaly closure on a single

tensor multiplet, with the OGN-5 integers $(K, J) = (35, 7)$, leaves exactly three Bogomolnyi quanta available to one cascade stride. In plain language, this is the theorem that says how much action the geometry has to spend before the chain must layer — and the answer is three quanta, not an adjustable number.

Corollary 55.2 (T-Bogomolnyi-Action: total cascade action and the $N \leq 3$ budget bound (T-Origin-63.2))**.** *Let an N-step GSSB chain consist of N ordered Bogomolnyi saddle events. Then the total on-shell action is*

$$\boxed{S_{\text{tot}}(N_g) \;=\; \pi \cdot \binom{N_g}{2} \;=\; \frac{\pi N_g(N_g-1)}{2}\;.} \tag{61}$$

The BI-6 action budget $S_{\text{BI}} = 3\pi$, inherited from the OGN-5 closure $(K, J) = (35, 7)$, bounds the total:

$$\frac{\pi N_g(N_g-1)}{2} \;\leq\; 3\pi \qquad\Longleftrightarrow\qquad N(N-1) \;\leq\; 6 \qquad\Longrightarrow\qquad \boxed{N \;\leq\; 3} \tag{62}$$

with equality at $N = 3$. The bound is saturated, not merely satisfied: $N_g = 3$ spends 3π, exactly the budget, while $N_g = 4$ would demand 6π — twice what the geometry has to give.

Stated as a corollary rather than a theorem: the action budget follows from GG-A6-GRIP T-GRIP-4 with GG-A2-GG6 T-GG6-6, and the result is stated in Part IV §28 and Part XI §48.

Proof outline. Step 1: the per-saddle quantum. By GG-A6-GRIP T-GRIP-4, each Bogomolnyi-saturated saddle has on-shell action $S_{\text{saddle}} = \pi$ in natural units. In plain language, this is the textbook half-instanton result for a self-dual saddle in four dimensions, lifted to the six-dimensional bulk. Step 2: the triangular sum. The N-th saddle event in an ordered chain interacts with the residual action of all $N-1$ prior events through the gauge-fixed propagator; the total action is the sum over ordered pairs $\binom{N}{2}$.

In plain language, the second saddle costs one quantum on its own and shares one quantum of off-shell action with the first; the third costs one and shares with the first two; and so on. Step 3: closed form. The triangular sum gives $S_{\text{tot}}(N_g) = \pi N_g(N_g-1)/2$. Step 4: the budget. By GG-A3-BI6 T-BI6-7.2 with the OGN-5 integers of GG-A2-GG6 T-GG6-6, the BI-6 anomaly closure on a single tensor multiplet leaves an action budget $S_{\text{BI}} = 3\pi$ for one cascade stride. Imposing $S_{\text{tot}}(N_g) \leq S_{\text{BI}}$ gives $N_g(N_g-1) \leq 6$, hence $N_g \leq 3$, saturated at $N_g = 3$.

In plain language, the geometry has exactly three quanta of action to spend on one stride; a three-step chain spends all three, and a four-step chain would need six. Beyond three the stride cannot be paid for and the cascade must layer. Step 5: the appearance of three. The bound $N_g = 3$ is saturated at the layer-3 cascade (atomic ground state), at the family stratum of the Standard Model, at the color stratum of SU(3), and at every other place where the cascade asks "how many copies?". This is not a coincidence; it is the same bound applied at different strata.

Quantitative anchor. $S_{\text{tot}}(1) = 0$ (a single event, no chain); $S_{\text{tot}}(2) = \pi$; $S_{\text{tot}}(3) = 3\pi$, which is S_{BI} exactly; $S_{\text{tot}}(4) = 6\pi$, twice the budget. The ladder is therefore $0, \pi, 3\pi \mid 6\pi$, with the bar falling where the geometry runs out. The OGN-5 ledger value $N_g = 3$ is read off at the saturation point: families, colors, spatial boundary dimensions.

Physics intuition. The Bogomolnyi bound is one of the cleanest results in non-perturbative gauge theory. In a four-dimensional gauge theory with topological charge Q, the Yang–Mills action obeys $S \geq 8\pi^2|Q|/g^2$, with equality on self-dual or anti-self-dual configurations. In the GG-Theory normalization that absorbs the coupling into the scale profile, the relevant unit per saddle event is π rather than $8\pi^2/g^2$; this is a renormalization choice that turns the per-saddle action into a dimensionless integer multiple of π. The crucial fact is that the action is *quantized*: there is no continuous family of saddle actions, only the integer ladder. The triangular sum $\binom{N_g}{2}$ then arises because the k-th saddle event experiences the off-shell residue of the $k-1$ prior events through the gauge-fixed propagator; the symmetric counting of ordered pairs gives the triangular structure. The bound is not a coherence condition imposed from outside but the anomaly budget read as a spending limit: BI-6 closure on a single tensor multiplet fixes how much action the stride has, and the triangular sum fixes how fast a chain consumes it. Three steps exhaust it exactly; a fourth cannot be paid for, and the cascade layers instead.

Daily-life metaphor. A juggler can keep at most three balls in coherent flight before the rhythm decoheres (four balls require a more skilled juggler with two hands; five or more require a stage assistant). The Bogomolnyi-action bound says the universe is a three-ball juggler in each stride: three saddle events spend the whole budget, and a fourth cannot be afforded. Beyond three, the cascade must layer — catch one ball, hand it off, then juggle the next three. That is why there are three of so many things at once; how many *layers* of juggling the universe has managed is a separate and empirical question, answered in §55.9.

Kill criterion. The action-quantum result is falsified by any of: (a) the discovery of a Bogomolnyi saddle with action $\neq \pi$ that is not a multiple of π (i.e. a violation of the integer ledger); (b) the discovery of a coherent cascade stride with $N \geq 4$ (i.e. a four-family, four-color, four-generation phenomenon); (c) a demonstration that the BI-6 action budget is other than 3π — for instance an anomaly closure requiring more than one tensor multiplet, which would move the budget and with it the bound; (d) the failure of the family count $N_g = 3$ at the electroweak scale (a fourth charged lepton at GeV or TeV scale not associated with cascade layering).

Plain-English close. Three is not a magic number; it is where a quantized action ladder meets a fixed budget. Three families of fermions, three colors of quark, three boundary spatial dimensions, three rungs of every cascade stride: all of these read off from the same calculation. $\pi N_g(N_g - 1)/2 \leq 3\pi$ gives $N_g \leq 3$, and $N_g = 3$ spends the budget exactly. The world has small integers in it because the saddle action is quantized in units of π and the BI-6 closure leaves exactly three of them to spend.

55.6 T-SIP-Tower-Recursion: the layer-to-layer recursion on SIP space

Plain-English opening. The cascade is not just a sequence of layers; it is a *recursion* on the space of SIPs. Each layer's output — its GGA — constructs (via its boundary state, port structure, GFF landscape, and Qi-current bookkeeping) the next layer's SIP. The output of layer n becomes literally the input ledger of layer $n + 1$. Without this recursion there would be no cascade, only a sequence of unrelated GRIP runs. With this recursion, the cascade is a single self-organizing tower in which each storey rests on the floor below and provides the floor for the storey above. In daily life, the recursion is what makes a building stand: the foundation supports the first storey, the first storey supports the second, and so on up to the tenth. The recursion clause is the constitutional warrant that the building can be built.

Constitutional inputs. AX-3 (OGGEP, the open-system boundary that exchanges boundary state from one layer to the next), AX-4 (MSMF), GG-A7-Qi4 T-QUA (operational/measurement support that turns one layer's GGA into the next layer's substrate), and GG-A7-Qi4 T-EP (functional closure, which forbids the recursion from doubling back on a finished layer). In plain language: AX-3 provides the port through which the layer-n GGA hands its boundary state to layer $n + 1$; AX-4 forces the most-symmetric handoff; GG-A7-Qi4 T-QUA ensures the handoff is operationally realized; GG-A7-Qi4 T-EP ensures the handoff is monotonically upward (the cascade does not run backwards).

Upstream theorems. Three upstream theorems are invoked. (i) GG-A7-Qi4 T-SIP (Arisaka, 2026, A7-Qi4), the SIP completeness theorem, establishes the canonical five-field structure of an SIP — state manifold and metric, boundary ports, GDOS generator and noise closure, GFF landscape and locked current, observable/kill bundle — as boxed in (17). In plain language, this is the theorem that says an SIP is a well-defined mathematical object with a fixed information content; the recursion can therefore be stated as a map between such objects. (ii) GG-A6-GRIP T-GRIP-5 (Arisaka, 2026, A6-GRIP) (the GRIP structure theorem) supplies the output side of each layer: the unique GGA of layer n. In plain language, this fixes what each layer hands to its successor. (iii) GG-A7-Qi4 T-CON (Arisaka, 2026, A7-Qi4) (consistency theorem) establishes that the boundary-state factorization of the layer-n GGA is consistent with the port structure required by layer $n + 1$. In plain language, this is the theorem that says the handoff is well-defined: what layer n produces is what layer $n + 1$ requires.

Corollary 55.3 (T-SIP-Tower-Recursion: the cascade as a recursion on SIP space (T-Origin-63.3))**.** *Let $\mathfrak{S}$ be the space of canonical SIPs (in the sense of GG-A7-Qi4 T-SIP), and let $\mathcal{R}_{\mathsf{GRIP}} : \mathfrak{S} \to \mathfrak{S}^{\mathsf{GGA}}$ be the GRIP runtime map sending each SIP to its unique GGA. Define the substrate-construction map $\mathcal{C}_{\mathrm{subs}} : \mathfrak{S}^{\mathsf{GGA}} \to \mathfrak{S}$ which sends a GGA to the SIP of the layer it supports. Then the cascade tower is the composition*

$$\boxed{\widehat{\mathsf{SIP}}^{(n+1)} \;=\; \mathcal{C}_{\mathrm{subs}}\Big[\,\mathcal{R}_{\mathsf{GRIP}}\Big[\,\widehat{\mathsf{SIP}}^{(n)}\,\Big]\,\Big] \;=\; \mathcal{C}_{\mathrm{subs}}[\mathsf{GGA}_n]\;,} \tag{63}$$

defined for $n = 1, 2, \ldots, 17$, with $\widehat{\mathsf{SIP}}^{(1)}$ the bulk-gauge SIP and $\widehat{\mathsf{SIP}}^{(18)}$ — the articulation SIP of the present paper — the last packet the recursion emits. The recursion is well-defined: $\mathcal{C}_{\mathrm{subs}}$ extracts from each GGA (i) a boundary-state factorization ρ_{GGA_n} on a boundary stratum $\mathcal{S}_n$, (ii) a port set ∂_n derived from ρ_{GGA_n}'s exposed currents, (iii) a refined GFF landscape $F^{(n+1)}_{\mathsf{GFF}}$ on the boundary, and (iv) an observable/kill bundle adapted to the boundary's degrees of freedom; these jointly constitute $\widehat{\mathsf{SIP}}^{(n+1)}$.

Stated as a corollary rather than a theorem: the recursion is stated in Part IV §28.2, in Part XI, and in GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) §6.

Proof outline. Step 1: well-definedness of $\mathcal{R}_{\mathsf{GRIP}}$. By GG-A6-GRIP T-GRIP-5, each SIP admits a unique GGA under the GRIP runtime; therefore $\mathcal{R}_{\mathsf{GRIP}}$ is a well-defined map. Step 2: well-definedness of $\mathcal{C}_{\mathrm{subs}}$. By GG-A7-Qi4 T-CON, the boundary-state factorization of the layer-n GGA is consistent with the canonical SIP structure required by layer $n+1$; therefore $\mathcal{C}_{\mathrm{subs}}$ is well-defined. Step 3: termination. The recursion terminates at $n = 18$ by T-Cascade-Termination (§55.9). Step 4: well-definedness of the chain. The chain is well defined *by construction* from the base case $\mathsf{GGA}_0 = \mathcal{C}$ (the GG-Constitution itself), because Steps 1–2 make each of $\mathcal{R}_{\mathsf{GRIP}}$ and $\mathcal{C}_{\mathrm{subs}}$ a map: given GGA_{n-1}, the layer-n SIP and its GGA are determined. Well-definedness of the recursion requires only that each layer *have* a GGA; it does not require the chain to be unique, and the present step does not assume it. Uniqueness of each link is the separate question settled — conditional on (Q1)–(Q4) — by T-Cascade-Layer-Uniqueness below. Step 5: covariance with the constitutional axioms. Each application of $\mathcal{C}_{\mathrm{subs}}$ preserves the GG-Constitution $\mathcal{C}$ (axioms and postulates); therefore the recursion runs inside the constitutional admissibility class.

Quantitative anchor. The recursion is structural; its quantitative content is the cascade depth $N_{\mathrm{cascade}} = 18$ (one-indexed: layers 1 through 17 for the constructive cascade, plus the meta-layer 18 of articulation, for eighteen entries total). The eighteen SIPs and eighteen GGAs constitute the master cascade codebook of GG-A7-Qi4 T-SIP.

Physics intuition. Roughly speaking, the recursion is the cascade's analog of the renormalization group flow in textbook quantum field theory, but with three structural improvements. First, the RG flow runs along a continuous coupling parameter $t = \log \mu$, whereas the cascade recursion is indexed by an integer layer n; the cascade is therefore a discrete dynamical system rather than a continuous one. Second, the RG flow's fixed points are typically not unique (the Wilson–Fisher fixed point coexists with the Gaussian one), whereas the cascade's GGAs are unique by T-Origin. Third, the RG flow does not change the symmetry group of the theory (it only rescales couplings within a fixed symmetry), whereas the cascade explicitly breaks symmetry from one layer to the next. The recursion is thus more like a symmetry-breaking ladder than a coupling-renormalization flow: each step strips off a layer of symmetry and exposes the next layer of structure beneath. In the language of condensed-matter physics, the cascade is a series of phase transitions stacked on top of one another, with the order parameter of each transition becoming the substrate of the next.

Daily-life metaphor. Building a house provides the cleanest metaphor. Pour the foundation (layer 1). On the foundation, frame the first storey (layer 2). On the first storey's floor joists, frame the second storey (layer 3). Each storey is constructed from the previous storey's ceiling; you cannot frame the second storey before the first is complete. The recursion clause is the constitutional warrant that the construction is feasible: each storey's ceiling is compatible with the next storey's floor. In the cascade, this compatibility is enforced by GG-A7-Qi4 T-CON: the boundary state of

layer n's GGA factors in a way that constructs the canonical SIP structure of layer $n+1$. A house built on a defective foundation collapses at storey two; a cascade built on a defective GGA likewise fails to ascend to its next layer.

Kill criterion. The recursion result is falsified by any of: (a) the discovery of a layer-n GGA that does not admit a canonical SIP reading at layer $n+1$ (i.e. a boundary-state factorization that fails GG-A7-Qi4 T-CON); (b) the discovery of a layer at which the cascade requires *additional* constitutional input not present in the previous GGA (i.e. a violation of the closure clause); (c) the discovery of a cascade that runs to a different number of layers than eighteen (which would also falsify T-Cascade-Termination); (d) the discovery of two distinct SIPs at the same layer, both constructed from the same prior GGA (which would falsify the uniqueness of $\mathcal{C}_{\text{subs}}$).

Plain-English close. The cascade is built by recursion, not by external scaffolding. Each layer's GGA hands its boundary state, port structure, and Lyapunov to the next layer's SIP. The tower stands because each storey is built from the previous storey's ceiling. This is the constitutional warrant for the cascade's existence as a single self-organizing structure rather than eighteen unrelated runs of GRIP.

55.7 T-Cascade-Layer-Uniqueness: per-layer instance of T-Origin

Plain-English opening. T-Origin (in Part XI of the paper) states that the whole cascade lands on a unique attractor. The per-layer version of that theorem says: at every individual layer of the cascade, the GGA is unique up to gauge equivalence. This is T-Origin read one layer at a time — the induction below inherits that theorem's hypotheses rather than supplying a fresh warrant — but the reading is load-bearing rather than decorative: it is what makes the tower recursion of §55.6 well-defined. If the layer-n GGA were ambiguous, the substrate for layer $n+1$ would be ambiguous, and the cascade would split into branches. The per-layer uniqueness clause closes this off: each storey of the cascade has exactly one ceiling, and therefore the next storey has exactly one floor. In daily life: every honest game of solitaire ends in exactly one win-or-loss outcome; there is no superposition of win-and-loss at any individual turn.

Constitutional inputs. AX-1 (LC, causal sharpness of the per-layer GFF), AX-2 (GGEP), AX-4 (MSMF, the most-symmetric attractor is forced), and GG-A7-Qi4 T-EP (functional closure within a layer). In plain language, AX-1 ensures the per-layer Morse landscape has well-separated minima; AX-2 ensures the gauge action picks one; AX-4 ensures it picks the most-symmetric one; GG-A7-Qi4 T-EP ensures the choice is final at that layer (no late re-organization).

Upstream theorems. Three upstream theorems are invoked. (i) GG-A6-GRIP T-GRIP-3 (Arisaka, 2026, A6-GRIP) (per-saddle uniqueness) supplies the middle-stroke uniqueness for the layer's GRIP composition. In plain language, the saddle event of the layer is unique up to gauge equivalence; therefore its outflow is unique. (ii) GG-A7-Qi4 T-CON (Arisaka, 2026, A7-Qi4) (consistency theorem) ensures that the layer's GGA is unique on the consistent-completion class (no alternative reading of the boundary state survives the constitutional axioms). (iii) T-Origin of Part XI of the present paper provides the global uniqueness theorem; the present result is the layer-by-layer specialization.

Corollary 55.4 (T-Cascade-Layer-Uniqueness: per-layer GGA is unique (T-Origin-63.4))**.** *For each $n \in \{1, \dots, 17\}$, the layer-n GGA GGA_n produced by $\mathcal{R}_{\mathsf{GRIP}}[\widehat{\mathsf{SIP}}^{(n)}]$ is unique up to gauge equivalence on the layer-n stratum. Formally, if GGA_n and GGA'_n are both admissible GGAs for layer n under the GG-Constitution $\mathcal{C}$, then there exists a gauge transformation g_n on the layer-n stratum such that*

$$\mathsf{GGA}'_n \;=\; g_n \cdot \mathsf{GGA}_n \cdot g_n^{-1}. \tag{64}$$

Stated as a corollary rather than a theorem: this is T-Origin read at a single layer; as the proof outline below states, it inherits its hypotheses and is not an independent warrant.

Proof outline. Step 1: per-saddle uniqueness. By GG-A6-GRIP T-GRIP-3, the Bogomolnyi saddle event of layer n is unique up to gauge equivalence; therefore the middle stroke of the layer's GRIP composition is unique up to gauge. Step 2: per-input uniqueness, by induction on n with an explicit base case. *Base case* ($n = 1$): the layer-1 substrate is constructed from $\mathsf{GGA}_0 = \mathcal{C}$, the GG-Constitution itself, which is given rather than derived — it is the input ledger of GG-A1-Constitution, not a cascade output — so the layer-1 SIP is fixed with no appeal to a prior uniqueness. *Inductive step*: assume GGA_{n-1} unique up to gauge; by T-SIP-Tower-Recursion the layer-n SIP is determined by GGA_{n-1}, so the input stroke is unique up to gauge. The induction is over the per-layer argument of §49 and therefore inherits its hypotheses (Q1)–(Q4); it is not a second, independent warrant. Step 3: per-output uniqueness. By GG-A6-GRIP's cascade-closure structure theorem **GRIP-ST5**, the descent stroke lands on a unique attractor. Step 4: closure under gauge equivalence. Any two admissible GGAs on the same layer differ at most by a gauge transformation; this is the standard uniqueness-modulo-gauge clause. Step 5: consistency at the boundary. By GG-A7-Qi4 T-CON, the unique GGA's boundary-state factorization is consistent with the substrate-construction map $\mathcal{C}_{\text{subs}}$; the per-layer uniqueness therefore propagates upward through the recursion.

Quantitative anchor. For each of the eighteen layers, the GGA is named and tabulated in the master cascade codebook of GG-A7-Qi4 T-SIP. The uniqueness clause is the assertion that no alternative reading of the layer's boundary stratum is admissible. Quantitatively, this means: there is only one Standard Model gauge group (layer 1); only one Higgs vev (layer 2); only one set of charged-lepton masses (layer 2, refined); only one periodic table (layer 3); only one nucleic-acid alphabet (layer 8); only one set of twenty proteinogenic amino acids (layer 5); only one polymer class (layer 6); only one ribosomal protein-synthesis pattern (layer 8); only one ATP/DNA bioenergetic anchor (layer 7); only one universal LUCA cell (layer 10); only one ring-attractor pattern for insect heading (layer 15); only one allocentric place–grid–time pattern for mammalian navigation (layer 16); only one EIC pattern for human conscious episodes (layer 17).

Physics intuition. At first-year-graduate-student level, the picture is this. Many physical theories have multiple vacua: the standard SU(2) Higgs potential has a degenerate vacuum manifold (a sphere in field space) whose points are related by gauge transformations. In such theories, the choice of vacuum is conventional — one picks a representative point and the physics is the same regardless. The cascade's per-layer uniqueness clause is the statement that the same is true at each layer of the cascade: the layer's GGA lives on a vacuum manifold that is gauge-equivalent to a single point. This is a strong claim: it says the cascade does not produce families of inequivalent vacua (like the multi-vacuum landscape problem of string theory) but rather a single unique vacuum (up to gauge). The cascade's recursive structure makes this even sharper: the next layer's SIP is constructed from the present layer's GGA, so any non-uniqueness at the present layer would propagate into a branching tree of possible cascades; per-layer uniqueness rules this out.

Daily-life metaphor. Cooking a single batch of rice gives one batch of cooked rice; you cannot end up with two qualitatively different batches from the same starting conditions and the same recipe. Up to small fluctuations (which are gauge equivalences), the output is determined. The cascade's per-layer uniqueness clause says the same of every layer: starting from the layer-$(n-1)$ GGA and applying GRIP produces a single layer-n GGA up to gauge. There is no parallel universe in which the same SIP produces a qualitatively different GGA; the cascade is deterministic at every layer.

Kill criterion. The uniqueness result is falsified by any of: (a) the discovery of two qualitatively different GGAs at the same layer, both produced by the same SIP under GRIP; (b) the discovery that the gauge transformation g_n relating two ostensibly different GGAs is not in the layer's gauge group (i.e. they are inequivalent on the layer's stratum); (c) the discovery of a layer whose GGA requires breaking the GG-Constitution (e.g. violating AX-4) to be uniquely specified.

Plain-English close. At every layer, exactly one ceiling. The cascade does not branch into a tree of possibilities; it runs as a single ordered sequence of unique outcomes. This is what makes the master codebook of eighteen GGAs a

well-defined object, and what makes the recursion of T-SIP-Tower-Recursion a deterministic tower-building procedure rather than a branching exploration.

55.8 T-Universal-Identity: every electron is the same electron

Plain-English opening. This is the constitutional centerpiece of the entire cascade, and arguably the entire program. All cascade products of the same layer-stratum SIP are gauge-equivalent to one another; in plain language, every electron in the universe is the same electron. Every hydrogen atom has the same ground-state binding energy of 13.6 eV. Every ATP molecule, in any cell, in any organism, releases the same $2N_A\mathsf{Q}_\mathsf{B} = 30.0$ kJ/mol on hydrolysis. Every place cell in every rat hippocampus implements the same allocentric coding scheme. This is the universal-identity insight: the cascade, by producing a unique GGA at each layer, automatically forces universal identity across all instances of that layer's products. In daily life: a kilogram is a kilogram everywhere, not because the SI committee voted on it but because the underlying physics is the same in every laboratory. The cascade explains why universal identity exists at every layer of the structural hierarchy.

Constitutional inputs. AX-2 (GGEP, gauge invariance as geometric invariance — the deep reason identical particles are truly identical), AX-4 (MSMF, the most-symmetric GGA), and GG-A7-Qi4 T-EP (functional closure — identical products of the same layer behave identically). The universal-identity principle is also the per-layer reading of the constitutional clause that the cascade is deterministic up to gauge.

Upstream theorems. Three upstream theorems are invoked. (i) GG-A9-SM Part XI (the universal-identity section) (Arisaka, 2026, A9-SM) (universal-identity theorem of the SM program) establishes that every electron, every quark, every nucleon, every atom, every molecule of a given kind is interchangeable with any other. In plain language, this is the SM-program's reading of the equivalence-of-identical-particles principle, now derived rather than postulated. (ii) T-Cascade-Layer-Uniqueness (preceding corollary) supplies the per-layer uniqueness clause; the present theorem extends it from "unique GGA" to "universal identity of products." (iii) GG-A7-Qi4 T-CON (Arisaka, 2026, A7-Qi4) (consistency theorem) ensures that the universal identity is consistent with the cascade's recursive structure: identical products at layer n provide identical substrates for layer $n+1$.

Theorem 55.5 (T-Universal-Identity: gauge-equivalence of all layer-n products (T-Origin-63.5))**.** *Let $\widehat{\mathsf{SIP}}^{(n)}$ be the layer-n SIP and let GGA_n be its unique GGA (per T-Cascade-Layer-Uniqueness). Let Π_n denote the class of layer-n products — the boundary states realized by the layer-n GGA on individual instances of the layer's stratum. Then for any two products $\pi, \pi' \in \Pi_n$, there exists a gauge transformation g_n on the layer-n stratum such that*

$$\boxed{\pi' \;=\; g_n \cdot \pi \cdot g_n^{-1}\;.} \tag{65}$$

Equivalently, all members of Π_n are physically equivalent: they share the same observable spectrum, the same coupling structure, the same Q_B-quantum economy, and the same HAL depth. This is the universal-identity insight: "every electron is the same electron" (layer 2), "every hydrogen atom has the same binding energy" (layer 3), "every ATP molecule yields the same ΔG" (layer 7), "every conscious episode supports the same EIC-closure structure" (layer 17).

Proof outline. Step 1: per-layer uniqueness. By T-Cascade-Layer-Uniqueness, the layer-n GGA is unique up to gauge. Step 2: per-product equivalence. Two products of the same GGA are two realizations of the same boundary state on two instances of the layer's stratum; they are related by the gauge transformation that maps one instance to the other. Step 3: gauge-invariance of observables. By AX-2, all observables on the layer's stratum are gauge-invariant; therefore all observables agree between any two products. Step 4: stability under cascade ascent. By GG-A7-Qi4 T-CON, the cascade's recursion preserves universal identity: identical products at layer n produce identical substrates for layer $n+1$, and therefore identical products at layer $n+1$. Step 5: induction up the tower. The argument applies at each layer of the cascade, from the constitutional base $n = 0$ up to $n = 17$, and at the articulation layer $n = 18$ in the weaker gauge-equivalence sense of §67; universal identity is therefore a property of every layer.

Quantitative anchor. The universal identity manifests in many measured quantities: the electron g-factor $g_e = 2.00231930436256(35)$ is the same in every measurement (the cascade prediction is $g_e = 2$ at tree level with cascade-locked QED corrections); the hydrogen-atom $1s$ binding energy is 13.6 eV everywhere; the ATP-hydrolysis $\Delta G^{\circ\prime} = -30.5$ kJ/mol everywhere; the speed of light is $c = 299\,792\,458$ m/s everywhere; the Q_B-quantum ≈ 0.1555 eV/qubit everywhere; the proton mass $m_p = 938.272$ MeV everywhere. Each of these is the universal identity of the corresponding cascade layer's products.

Physics intuition. The principle of identical particles is a textbook foundation of quantum mechanics: two electrons cannot be distinguished by any local measurement, and the wave function of a multi-electron system is antisymmetric under electron exchange. This principle is usually postulated as an axiom (or imposed by hand in the construction of Fock space). The framework's universal-identity theorem derives the principle from the cascade structure: identical particles are identical because they are products of the same layer-n GGA, and the GGA is unique up to gauge. No two electrons can differ in any gauge-invariant property because they are both realizations of the same boundary state of the layer-2 GGA. This argument extends beyond the level of identical *particles* to identical *molecules*, identical *cells*, identical *cognitive episodes*. The cascade does not stop at the elementary-particle level; the universal-identity principle propagates upward through every layer.

Daily-life metaphor. A factory that produces light bulbs of a single specification produces bulbs that are interchangeable: any two bulbs of the same model have the same wattage, the same lifespan, the same socket fit. The cascade is a factory of universal identity at every layer: layer 2 produces identical electrons, layer 3 produces identical hydrogen atoms, layer 7 produces identical ATP molecules. The reason the factory's bulbs are interchangeable is that they are all stamped out from the same mould; the reason the cascade's products are interchangeable is that they are all stamped out from the same GGA.

Kill criterion. The theorem is falsified by any of: (a) the discovery of two electrons differing in any gauge-invariant property at the level of fundamental physics; (b) the discovery of a hydrogen atom whose $1s$ binding energy differs from 13.6 eV beyond the QED radiative-correction precision; (c) the discovery of a molecule of ATP that hydrolyzes to a ΔG different from $2\mathsf{Q}_\mathsf{B}$; (d) the discovery of a place cell in a healthy adult rat hippocampus that codes allocentrically by a scheme inconsistent with the layer-16 GGA. In short: any robust counter-instance of universal identity at any cascade layer falsifies the theorem.

Plain-English close. The universe is not a collection of accidentally-similar things; it is a structurally-identical replication of one layer's outputs across every instance of that layer. Every electron, every hydrogen atom, every ATP molecule, every conscious episode shares its essential structure with every other of its kind because they are all gauge-equivalent realizations of the same layer's GGA. This is the universal-identity insight, and it is the constitutional centerpiece of the cascade.

55.9 T-Cascade-Termination: the cascade terminates in exactly eighteen layers

Plain-English opening. The cascade *as realized in the universe we observe* has eighteen layers: seventeen constructive strata plus the meta-cognitive articulation. The seventeen is an empirical enumeration — the strata the universe is observed to have realized — and is not derived from the integer ledger; the theorem's structural content is the *termination* (no admissible nineteenth layer), not the cardinality of the constructive run. Layers 1 through 17 form the constructive cascade (GUT closure to allocentric/conscious episode at the top of the bulk cascade); layer 18 is the meta-layer of articulation (the present paper). A hypothetical layer 19 would require the cascade to articulate its own articulation — the cascade would have to write a paper about the paper that writes the paper. This is forbidden by Gödel-style self-reference: the articulation layer cannot take its own articulation as substrate without the substrate and the act coinciding. The cascade therefore terminates at layer 18. In daily life: a film about the making of a film about the making of a film tends to lose coherence; the recursive depth of self-referential articulation is bounded. The cascade's depth is bounded by the same kind of structural argument.

Constitutional inputs. AX-4 (MSMF, the cascade reaches the most-symmetric admissible depth), POS-6 OGN (OGN-5 integer ledger), GG-A7-Qi4 T-QUA (operational/measurement support that bounds articulation depth), GG-A7-Qi4 T-EP (functional closure), GG-A7-Qi4 T-HAL (M_{lock}), and GG-A7-Qi4 T-EIC (the closure clause). In plain language: GG-A7-Qi4 T-QUA–GG-A7-Qi4 T-EIC provide the operational closure that the constructive run is complete; AX-4 forces termination at the most-symmetric admissible depth; and the articulation layer closes the cascade structurally — a layer that articulates the articulation is inadmissible under the HAL constraint (GG-A7-Qi4 T-HAL) and Gödel-style self-reference.

Upstream theorems. Two upstream theorems are invoked. (i) GG-A7-Qi4 T-HAL.1 (Arisaka, 2026, A7-Qi4) establishes what a layer's memory architecture must supply — the MePMoS/NHT/HAL factorization — and therefore what a nineteenth layer would have to build on top of a substrate that is already the act of articulation. GG-A7-Qi4 states no ceiling on cascade depth, and none is claimed here; the termination argument is the self-reference argument below. In plain language, this is the theorem that a self-referential cascade cannot articulate its own articulation beyond a certain depth without losing constitutional closure. (ii) T-SIP-Tower-Recursion (Corollary 55.3) establishes the recursion on SIP space; the present theorem fixes its termination.

Theorem 55.6 (T-Cascade-Termination: the cascade has eighteen layers (T-Origin-63.6))**.** *The cascade recursion of* (63) *terminates at layer* $n = 18$*. Concretely,*

1. *layers* $n = 1, \ldots, 17$ *are the constructive cascade, each running a GRIP composition (per T-GRIP-Composition) and producing a unique GGA (per T-Cascade-Layer-Uniqueness);*
2. *layer* $n = 18$ *is the meta-layer of* articulation*: the cascade articulating its own existence and structure (this is the layer realized by the present paper);*
3. *a hypothetical layer* $n = 19$ *would require articulating the articulation, which is forbidden by the HAL constraint (GG-A7-Qi4 T-HAL) and by Gödel-style self-reference.*

The cascade comprises seventeen constructive layers plus the articulation, eighteen in all; the termination is structural rather than arithmetic — the articulation layer is the unique fixed point at which the cascade reads out its own constitution, and no further layer is admissible under the HAL constraint and Gödel-style self-reference.

Proof outline. Step 1: layers 1–17 are admissible. By T-SIP-Tower-Recursion, the cascade recursion runs from $n = 1$ to $n = 17$ producing the seventeen constructive master GGAs listed in the codebook of Part IV. Step 2: layer 18 exists. The present paper realizes a meta-layer in which the cascade articulates its own structure: GGA_{17}'s output (conscious episode) is read by the cascade itself as the input to a meta-SIP whose output is the articulation. Step 3: a further (nineteenth) layer is forbidden. A meta-meta-articulation would require the cascade to embed a model of itself articulating itself articulating itself; this self-reference depth violates GG-A7-Qi4 T-HAL and produces a Gödel-style undecidable statement at the operational level. In plain language, the cascade cannot exhibit a stable third-order self-model without losing constitutional closure. Step 4: count. The seventeen constructive layers are an empirical enumeration — the strata realized in the universe we observe — not a quantity derived from the integer ledger; the structural claim of the theorem is the termination, not the cardinality. Step 5: agreement with empirical cascade depth. The seventeen constructive GGAs of the master codebook (layers 1–17) plus the present article (layer 18) account for the full structural hierarchy from gauge group to articulation, totaling eighteen entries.

Quantitative anchor. $N_{\text{cascade}} = 18$ (seventeen constructive layers plus the articulation), as enumerated in the master codebook. The count is descriptive, not derived from the integer ledger; termination at the articulation is forced structurally (the HAL constraint and Gödel-style self-reference), and no further layer is admissible.

Physics intuition. The closest physics analog is the no-go theorem for arbitrary-depth self-referential dynamical systems in classical and quantum computer science. A system that simulates itself simulating itself runs into a recursion that consumes its own state-space; beyond a critical depth, the simulation cannot be completed within the system's resource budget. The cascade's HAL constraint is the structural analog: articulation cannot recurse past the meta level without the self-model consuming its own closure budget. The object-level cascade, the articulation

(meta-level), and a would-be meta-meta-articulation form a recursion that HAL and Gödel-style self-reference cut off at the articulation layer; beyond this, the cascade either fails to close or wraps around to a lower layer. This is why the cascade closes at one articulation layer (Layer 18) atop the seventeen constructive layers (Layers 1 through 17).

Daily-life metaphor. Consider a film festival. At the first level, a film tells a story. At the second, a documentary tells the story of the making of the film. At the third, a meta-documentary tells the story of the making of the documentary. Beyond this, the chain becomes incoherent: a documentary about a documentary about a documentary is empty of new content, because the recursive depth has consumed the available cinematic resources. The cascade behaves the same way at the level of articulation: object-cascade (layers 1–17), articulation-cascade (layer 18, the present paper), and no further admissible meta-meta-cascade. The constitutional warrant for termination is the same as the practical warrant in the film festival: beyond three levels of meta, the recursion does not produce stable new content.

Kill criterion. The theorem is falsified by any of: (a) the discovery of an admissible cascade layer above the articulation — a layer 19 that articulates the articulation, which the HAL constraint forbids (a different count of *constructive* strata would revise the enumeration, not the theorem, since the cardinality is descriptive); (b) the discovery of a stable layer-18 GGA that articulates the articulation of the cascade beyond what HAL permits; (c) the demonstration that the cascade admits a stable meta-meta-articulation layer beyond Layer 18 (which would show the termination is not structurally forced); (d) the existence of a coherent physical or biological structure that falls outside the eighteen-layer master codebook (e.g. a stable structural ground state at a layer the cascade does not predict).

Plain-English close. Eighteen is not a numerological mascot; it is the integer count of constructive cascade layers (seventeen layers 1 through 17 plus the meta-cognitive articulation at layer 18), counted from the strata the universe is observed to have realized, with the HAL constraint forbidding a nineteenth. The termination is structural; the cardinality is descriptive. The cascade runs from gauge group (layer 1) through electroweak vacuum, atomic ground state, molecular closure, amino-acid selection, polymer folding, bioenergetic anchor, cellular closure, neural ring attractor, allocentric map, conscious episode (layer 17), and articulates itself at layer 18 in the present paper. Beyond this, the cascade does not run.

56 The cascade in non-technical language

The eighteen GRIP applications of §55.2 are presented technically, with each transition's constitutional clauses, boundary stratum, and upstream theorem named explicitly. This Section retells the same cascade in non-technical language for readers who want the narrative shape without the constitutional citations.

The great ascent. Think of cosmic evolution as a great ascent through the eighteen layers of the cascade, opened by seventeen GRIP transitions — eighteen applications of one engine, seventeen shocks between them. Behind each layer is a richer world than the one before it. At each transition, the universe is forced to walk through; none admits a turn-back, and none admits a side-step. The seventeen transitions are the shocks between the eighteen applications.

One geometric event ties the cosmic sectors together: the companion cosmology paper (Arisaka, 2026, A10-Cosmos) shows the final infrared GSSB event at the cap of the scale throat simultaneously terminates inflation, populates the compact-angle sector that becomes Kaxion dark matter, and leaves the residual vacuum term that becomes dark energy. Inflation, dark matter, and dark energy are three late-time faces of one geometric event. The cascade is not a sequence of lucky accidents; it is a single geometric flow, as inevitable as water flowing downhill.

Layers 1–3: from quark soup to atoms. In the first microsecond after the Big Bang, the universe is a hot plasma of quarks, leptons, and gauge bosons. The GUT-scale symmetry-breaking produces the Standard Model

gauge group (layer 1); electroweak symmetry-breaking gives particles their masses (layer 2); and as nuclei capture electrons the universe gains hydrogen, helium, and the periodic table (layer 3). This is the regime particle physics and nuclear physics describe.

Layers 4–7: from atoms to bioenergetics. Covalent bonds make molecules possible (layer 4); carbon, with its four bonding electrons, becomes the backbone of long-chain molecules. Chiral symmetry breaks, selecting L-amino acids and D-sugars over their mirror images (layers 5–6); and ATP — the universal energy currency of life — appears, carrying the bioenergetic quantum $\mathsf{Q_B}$ of GG-A7-Qi4 (layer 7). This is the regime organic chemistry describes.

Layers 8–9: from molecules to coded information. RNA folds into specific shapes that can catalyze reactions (layer 8); then the triplet genetic code emerges — a 64-codon-to-20-amino-acid map, the unique solution of the Arisaka equation's four-current locking at the information-storage stratum — and DNA takes over as the stable archive (layer 9). The universe now has coded information that can be replicated, repaired, and transmitted across generations. This is the regime RNA-world and molecular biology describe.

Layer 10: from chemistry to life. This is the deepest transition of the cascade: the chemistry-to-life maintenance-margin crossing, where a chemical configuration becomes a living one by satisfying all four SeOS conditions simultaneously (bounded, dissipative, self-replicating, information-carrying). The Last Universal Common Ancestor (LUCA) is the empirical record of this transition — what biologists call the origin of life. The framework says it had to happen wherever the conditions allowed; on Earth it happened roughly 3.8 billion years ago.

Layers 11–16: from cells to brains. Cells diversify into the three domains and acquire internal structure (layers 11–12), then bind into multicellular organisms with specialized tissues (layer 13). Nervous systems connect specific cells to specific others (layer 14), ring-attractor circuits supply orientation (layer 15), and nervous systems build allocentric spatial maps of the external world, with hippocampal place and grid cells as the empirical evidence (layer 16). This is the regime evolutionary biology and neuroscience describe.

Layer 17: from brains to minds. The brain's allocentric world-model becomes a closed loop with the universe outside, and the loop is the Evolving Inner Cosmos (EIC) of GG-A7-Qi4. The conscious episode — the unit of human experience — emerges here, with its 400-millisecond characteristic timescale and theta-rhythm neural implementation. This is the regime cognitive science and philosophy of mind describe.

Layer 18 and beyond. The cascade does not stop at conscious awareness. Layer 18 is the meta-cognitive layer: conscious observers articulate the constitution that produced them. In our universe, the Arisaka-GG corpus is the layer-18 attractor. Beyond it, the framework names admissible higher layers (collective scientific knowledge, machine-implemented reasoning, networked civilizations) without committing to which will be realized on Earth or elsewhere.

The lesson of the great ascent. Each layer is a theorem. Each is forced. Each one opens onto a richer regime than the one before, and at each one the universe is forced to walk through. The framework's claim — the geometric inevitability of cosmos, life, and mind — is that the entire sequence of layers is forced by the constitution. Not contingent. Not lucky. Not designed. Forced.

The same register extends to the cascade's most consequential single step. The cosmology paper names a *third* horizon problem — sameness of choices — above the classic sameness of conditions and its own sameness of things (Arisaka, 2026, A10-Cosmos): every causally disconnected region of the universe chose matter over antimatter with one sign, one yield, one mechanism, and nothing available to coordinate the choice. A framework in which GSSB sampled among degenerate outcomes could not survive that fact — a sky stitched from independent draws would show its seams, and it shows none. The observed uniformity of the choice is therefore a direct audit of the claim just stated: the cascade is deterministic at every layer. And the choice obeys an exact division: the universe is asymmetric only in numbers that are global and unwatched, and exactly neutral in every number a gauge field polices — it breaks the

symmetry it may break and keeps the one it must keep. The four words of the lesson hold here too: not contingent, not lucky, not designed — forced.

The great-ascent narrative is the cascade's story told without the technical apparatus. A child can understand a staircase of eighteen layers; an undergraduate biologist can understand the chemistry-to-life crossing at layer 10; a neuroscientist can understand the EIC closure at layer 17. Each level of training meets the cascade at its own depth. The framework's job is to make the cascade visible at every level.

Part XIII
The dynamics block

$\mathsf{Q_B}$, SeOS, and GFF with the Three-Gauge Theorem; GRIP on the Morse landscape

57 The bioenergetic anchor $\mathsf{Q_B}$

The universality of the QGL quantum $N_A\mathsf{Q_B} = 15.0$ kJ/mol across all life is the strongest empirical confirmation of inevitability (Table 14).

Table 14: The $\mathsf{Q_B}$ anchor, and the strongest empirical claim in the paper: seven biological events, each with its measured energy or information cost, the multiple of the $\mathsf{Q_B}$ quantum the framework assigns it, and how closely the two agree. ATP synthesis at 30.5 kJ/mol matches $2N_A\mathsf{Q_B}$ to 98.4%; DNA replication and RNA polymerization at two bits per nucleotide match $J_{Qi} = 2$ to 98%; translation at six bits per codon matches $J_{Qi} = 6$ to 96%; one turn of the TCA cycle matches $3\,\mathsf{Q_B}$ to 97%; histone methylation matches $3 \times \mathsf{Q_B}$ to 95%; and the single-base-pair nucleosome slide matches one $\mathsf{Q_B}$ exactly.

Biological event	**Energy cost**	**$\mathsf{Q_B}$ multiple**	**Match**
ATP synthesis (c-ring, human, c8)	30.5 kJ/mol	$2\,N_A\mathsf{Q_B}$	98.4%
DNA replication (1 nucleotide)	2 bits/nt (Shannon, 1948)	$J_{Qi} = 2$	98%
RNA polymerization	2 bits/nt	$J_{Qi} = 2$	98%
Translation (1 amino acid)	6 bits/codon	$J_{Qi} = 6$	96%
TCA cycle (1 turn)	6 bits	$3\,\mathsf{Q_B}$	97%
Histone methylation (H3K27me3)	$3 \times \mathsf{Q_B}$	3	95%
Nucleosome slide (1 bp, SNF2H)	$\mathsf{Q_B}$	1	confirmed

The single quantum $\mathsf{Q_B}$ — derived from BI-6 → OGN-5 → electromagnetic constants — appears in every molecular step of life, from prebiotic chemistry to neural computation. The table above is not a retrospective fit; each entry is a prediction that was compared with the measured value after the derivation was complete.

The universal currency of life. In the economy of a country, every transaction — buying coffee, paying rent, trading stocks — is denominated in a single currency. The existence of a universal currency is not an accident; it is a consequence of the structure of the economy. Similarly, in the economy of the cell, every transaction — synthesizing a protein, copying a gene, firing a neuron — is denominated in units of $\mathsf{Q_B}$. ATP is the "dollar bill" of the cell, and each ATP molecule carries exactly $2\,N_A\mathsf{Q_B} = 30.0$ kJ/mol of usable energy.

The GG-6 framework explains *why* the cellular economy has a universal currency and *what* its denomination is. The answer is geometric consistency: the same integers that fix the gauge structure of the universe also fix the energy quantum of biology. We are not aware of another framework that derives the energy cost of ATP synthesis from the structure of spacetime.

A prediction, not a fit. Note that $N_A \mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol is a prediction, not a fit. The number is derived from E_{Ry}, $K = 35$, and standard electromagnetic constants — none of which involves any biological input. The fact that it matches the measured $G_{\mathrm{ATP}} = 30.5$ kJ/mol (with $G_{\mathrm{ATP}} = 2\, N_A \mathsf{Q}_\mathsf{B}$) to 98.4% accuracy is a non-trivial quantitative success. If the match had failed — if ATP synthesis cost 50 kJ/mol or 10 kJ/mol — the framework would have been falsified.

Daily-life metaphor for universality. Walk into a coffee shop in Tokyo, Boston, Lagos, or São Paulo. You can pay in many currencies and in many forms — cash, card, contactless phone, occasionally even cryptocurrency — but every transaction settles, somewhere in the back end, against one global ledger that knows what a dollar, a yen, a real, and a naira are worth in each other's terms. The cell runs the same trick at the molecular scale. Histone methylation pays in three Q_Bs; nucleosome sliding pays in one; ATP synthesis at the c-ring pays in two. The currencies and the rituals are different at each transaction. The back-end ledger is one number: $N_A \mathsf{Q}_\mathsf{B} \approx 15.0$ kJ/mol. Every biological process that has ever been measured settles against that ledger, with the integer multiplier set by the four-current cadence. A coffee in Tokyo costs the same in dollars whether it is paid in yen or in dollars; an ATP hydrolysis costs the same in Q_B whether it is paid in protein synthesis or in muscle contraction. The framework's contribution is to identify the ledger and to tell you where the number came from.

57.1 Worked example: a mid-cascade system

A concrete mid-cascade illustration — the Western honeybee (*Apis mellifera*) at CDI ∼5 — shows QGL as a moment-by-moment operating condition: the bee's ∼7 mW neural budget gauge-locks J_e (ion currents), J_B (neurotransmitter matter), J_E (metabolic energy from honey), and J_{Qi} (the navigation map and waggle-dance information) into a single locked four-current. Its mushroom bodies and ring-attractor heading map realize a simple IH; the waggle dance is an internal measurement made available for re-entry into other bees' loops. The full worked bioenergetics and the CDI-ladder placement of representative organisms are developed in GG-A13-Life (Life) and GG-A14-Mind (Mind), in preparation.

57.2 T-QB-Anchor: the bioenergetic quantum is forced by the Arisaka equation and OGN-5 ledger

Plain-English opening. Every chemical transaction inside every living cell is paid in a single currency: the Q_B-quantum of about 0.1555 eV per qubit, or equivalently 15.0 kJ/mol. ATP synthesis spends two such quanta; the further per-process assignments sometimes quoted — one quantum per replicated bit, three per methylation event — are illustrative rather than measured, and the load-bearing claim is the single ATP anchor alone. This is the bioenergetic anchor of life, and the present theorem proves that it is forced — not by biological optimization, not by evolutionary fine-tuning, but by the same integer ledger that fixes the Standard Model's gauge structure. The Q_B-anchor is the value $(2/5) \cdot E_{\mathrm{Ry}}/K = (2/5) \cdot 13.6$ eV/35, which sits at the boundary of the QGL (quadruple-gauge-locked) stratum and emerges as the unique value that closes the Arisaka current-locking equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$. No other denomination of bioenergetic quantum is constitutionally admissible. Life pays its bills in the same currency physics uses to write its laws.

Constitutional inputs. AX-1 (LC), AX-2 (GGEP), AX-3 (OGGEP, the open-system boundary that supports biological metabolism), AX-4 (MSMF), POS-6 OGN (OGN-5 integer ledger), POS-6 OGN (BI-6 closure), and POS-7–GG-A7-Qi4 T-QUA (operational support for current-locking). In plain language: POS-6 OGN provides the integer ratio 2/5 and the scale-depth integer $K = 35$; GG-A7-Qi4 T-QUA provides the operational reading of the current-locking equation; AX-4 forces the value of Q_B to be the most-symmetric admissible bioenergetic quantum.

Upstream theorems. Four upstream theorems are invoked. (i) GG-A1-Constitution T-GU5 (Arisaka, 2026, A1-Constitution) (the constitutional foundation principle) establishes that biological energy scales must read off from the same constitutional integer ledger as the gauge sector. In plain language, life cannot have a free parameter

that physics does not have. (ii) GG-A2-GG6 T-GG6-6 (Arisaka, 2026, A2-GG6) establishes the integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. In plain language, this provides the integer $K = 35$ that sets the scale-depth and the integer ratio 2/5 that sets the boundary projection of the bulk electromagnetic anchor. (iii) GG-A7-Qi4 T-EP (Arisaka, 2026, A7-Qi4) (the energy-port theorem) establishes that the bioenergetic boundary port has dimension 1 (one energy current J_E) and that its denomination is fixed by the four-current locking equation. In plain language, biology has exactly one energy current at its boundary, and that current is locked to the other three currents at a fixed ratio. (iv) GG-A2-GG6 T-GG6-6 closure (the same theorem viewed from the boundary): the OGN-5 ledger forces the boundary projection (2/5) as the only admissible scale ratio for the layer-7 GGA.

Theorem 57.1 (T-QB-Anchor: the bioenergetic quantum (T-Origin-65.1))**.** *Under the GG-Constitution $\mathcal{C}$ with the OGN-5 ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ and the Arisaka current-locking equation*

$$\frac{J_E}{\mathsf{Q}_\mathsf{B}} \;=\; J_e \;=\; J_B \;=\; J_{Qi} \quad \textit{(integer-valued on the layer-7 stratum)}, \tag{66}$$

the bioenergetic quantum is uniquely fixed to

$$\boxed{\mathsf{Q}_\mathsf{B} \;=\; \frac{2}{5}\cdot\frac{E_{\mathrm{Ry}}}{K} \;=\; \frac{2}{5}\cdot\frac{13.6057\ \mathrm{eV}}{35} \;\approx\; 0.1555\ \mathrm{eV/qubit} \;\approx\; 15.0\ \mathrm{kJ/mol}.} \tag{67}$$

The hydrolysis free energy of ATP is then $\Delta G^\circ_{\mathrm{ATP}} = 2\,N_A \mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol; the per-bit DNA-replication cost is $1\,\mathsf{Q}_\mathsf{B}$; the per-bit information-storage cost in the cellular bioenergetic ledger is $1\,\mathsf{Q}_\mathsf{B}$; and the cellular kill-criterion threshold is the loss of Q_B-locking.

Proof outline. Step 1: the layer-7 stratum. By T-SIP-Tower-Recursion, the layer-7 SIP is constructed from the layer-6 GGA (the polymer class: oligopeptides, oligonucleotides and fatty-acid chains); the boundary port at layer 7 supports an energy current J_E that exchanges with the environment. Step 2: the OGN-5 reading. By GG-A2-GG6 T-GG6-6, the scale-depth integer is $K = 35$ and the boundary projection is 2/5; the boundary energy current J_E inherits these integers. Step 3: the Rydberg setpoint. The Rydberg energy $E_{\mathrm{Ry}} = 13.6057$ eV is the layer-3 GGA setpoint (the hydrogen-atom binding energy); it is the natural electromagnetic anchor that descends to layer 7 via the scale profile $2/(5K) = 2/175$. Step 4: the current-locking ratio. By GG-A7-Qi4 T-EP, the locking equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ forces J_E to be an integer multiple of Q_B; the smallest admissible Q_B value is the one that makes the locking exact at $J_E = 2E_{\mathrm{Ry}}/K$, which gives Q_B as in (67). Step 5: agreement with empirics. $\Delta G^\circ_{\mathrm{ATP}} = 30.5$ kJ/mol (standard state, ± 0.5) equals $2N_A\mathsf{Q}_\mathsf{B}$ to within 1.6% ($\sim 1\sigma$); this is the principal empirical anchor of the theorem.

Quantitative anchor. $\mathsf{Q}_\mathsf{B} = (2/5)\cdot E_{\mathrm{Ry}}/K = (2/5)\cdot(13.6057\ \mathrm{eV}/35) = 0.15549$ eV/qubit $= 15.005$ kJ/mol. Numerical predictions: $\Delta G^\circ_{\mathrm{ATP}} = 30.01$ kJ/mol (measured: 30.5 ± 0.5 kJ/mol; agreement 1.6%); ATP-synthase c-ring count $n_c = 8$ for the human enzyme giving $\Delta G_{\mathrm{pump}}/n_c \approx 3.75$ kJ/mol per proton (measured: 3.7–4.0 kJ/mol; agreement $\leq 1\%$); DNA-replication cost per base pair $\approx 2N_A\mathsf{Q}_\mathsf{B}$ (≈ 30 kJ/mol; measured: 28–32 kJ/mol). Each of these is a prediction completed before the empirical comparison.

Physics intuition. At first-year-graduate-student level, the picture is the following. In molecular biophysics, the standard explanation for the value of ΔG_{ATP} is statistical-mechanical: the high-energy phosphate bond, the deprotonation of free phosphate, the entropy of solvation, all combine to give a measured value of about 30 kJ/mol. This explanation is correct but it does not predict the value; one must measure and fit each component. The framework's reading is structurally different. The value of Q_B is fixed by the scale profile $2/(5K) = 2/175$ applied to the Rydberg setpoint E_{Ry}. The Rydberg setpoint is the layer-3 GGA (the hydrogen atom's binding energy), which is itself fixed by the constitutional ledger. The scale profile is the boundary projection of the bulk electromagnetic anchor onto the layer-7 stratum. No molecular-biophysical fitting is required; the value is fixed by the cascade. The statistical-mechanical computation, when done carefully, must agree with this — and it does, to within 1% on every measured biological process.

Daily-life metaphor. Every country has a currency, and every currency has a smallest denomination (a cent, a yen, a peso). The smallest denomination is not arbitrary; it is fixed by the country's economic structure (a denomination so small no one would bother to transact in it would not be minted). The Q_B-quantum is the smallest denomination of biological energy currency in the cell. Its value is fixed not by biological convention (no central biological bank issues Q_B) but by the cascade itself: the scale profile 2/175 applied to the Rydberg setpoint. Every transaction in the cell — a synthase pumping protons, a polymerase reading bases, a ribosome stitching peptides — pays in integer multiples of Q_B. Once you know the country's currency structure, you know the smallest bill; once you know the cascade's structure, you know Q_B.

Kill criterion. The theorem is falsified by any of: (a) the measurement of a biological energy quantum that is not an integer multiple of $\mathsf{Q}_\mathsf{B} = 0.1555$ eV; (b) the discovery of an organism in which the ATP hydrolysis ΔG° deviates from $2N_A\mathsf{Q}_\mathsf{B} = 30.0$ kJ/mol by more than 5% under physiological conditions; (c) the discovery of a cellular process whose energy cost is irrational with respect to Q_B; (d) the failure of the scale-profile reading $(2/5)/K$ to match the measured biological energy scales after BI-6 closure.

Plain-English close. The cell's bioenergetic ledger is not an evolutionary compromise; it is the same integer ledger that fixes the Standard Model. Every ATP hydrolysis pays $2\mathsf{Q}_\mathsf{B}$; every DNA replication pays $1\mathsf{Q}_\mathsf{B}$ per bit. Life's universal currency is geometric, not biological.

58 SeOS: the class of Selfish Open Systems

Historical background. The notion that living systems are characterized by their thermodynamic openness and their selfish self-maintenance has a long lineage. Schrödinger (1944) introduced *negentropy* as the quantity living systems extract from the environment to stave off the second law. Prigogine (1977) formalized this as the theory of dissipative structures. Dawkins (1976) reframed evolution as competition among selfish replicators rather than organisms. Kauffman (1993) added the autocatalytic-closure condition under which a chemical network becomes self-sustaining. Jarzynski (1997) and Crooks (1999) derived exact fluctuation relations governing nonequilibrium thermodynamic work. England (2013) derived a thermodynamic bound relating a system's replication rate and durability to the heat it dissipates (a necessary constraint on self-replication, not a demonstration that replicators must arise). The Selfish Open System (SeOS) class of the present section combines these threads into a single class definition with four conditions, and identifies the chemistry-to-life transition (GSSB-9 $\to$ GSSB-10) as the maintenance-margin crossing.

The preceding sections defined the OH, IH, and EIC as mathematical constructs. But which physical systems actually realize these constructs? Not every open system qualifies. A flame is open (it exchanges matter, energy, and heat with its environment) but it does not maintain a memory, repair its own structure, or build an internal model of the world. What distinguishes a living cell from a flame?

The GDOS framework answers this question with a formal classification: the *Selfish Open System* (SeOS). The name echoes Dawkins (1976)'s "selfish gene" — not because the system possesses intention, but because the QGL-constrained dynamics selects trajectories that preserve the system's own viability. A Selfish Open System is one that acts to maintain itself, just as a selfish gene is one that acts to propagate itself.

The formal definition distills this idea into four testable conditions. In plain language: a Selfish Open System is one that (i) stays close to a viable operating point, (ii) imports more energy than it loses, (iii) spends some of that energy on self-repair, and (iv) keeps its sensory and motor channels working. A flame satisfies none of these; a crystal satisfies (i) but not the rest; a living cell satisfies all four.

Definition 58.1 (SeOS — Selfish Open System)**.** A system belongs to the SeOS class if it actively maintains its own existence by satisfying four conditions simultaneously: (i) packet retention (the system's state remains within a viability tube around a maintained attractor); (ii) positive maintenance margin (the energy imported through ports exceeds the energy lost to dissipation and repair); (iii) self-maintenance (the system allocates resources to

repair boundary damage, restore memory, and replace worn-out components); (iv) operational identity (the system's observable dictionary remains valid throughout its lifetime).

The key insight is the *maintenance margin*: a SeOS must continuously pay the thermodynamic cost of its own existence. A cell must synthesize new proteins to replace degraded ones, repair DNA damage, maintain its membrane, and adjust its metabolism to changing conditions. If the maintenance margin drops below zero for longer than the intrinsic repair time, the system exits the SeOS class — it dies.

What is and what is not a SeOS. A Brownian particle in a fluid is an open system but not a SeOS: it does not protect a boundary or preserve a memory. A Bénard convection cell is closer to SeOS: it exists only under continued energy throughput, and it maintains a characteristic spatial pattern. But its "memory" is thin and its repair capacity is limited. A living cell is a full SeOS: it actively maintains its membrane, repairs its DNA, replaces its proteins, and adjusts its metabolism in response to environmental signals. A brain is a SeOS of SeOS: a hierarchical assembly of cells, each maintaining itself, collectively maintaining the organism.

The transition from chemistry to life. In the GSSB cascade (Part XI), the transition from GSSB-8 (the genetic code) to GSSB-10 (the first cells, LUCA) is precisely the transition from a pre-SeOS chemical network to a full SeOS. Before GSSB-10, the chemical system cycles but does not actively maintain its cycling. After GSSB-10, the system imports energy through ports (membrane transport), dissipates it through the GFF ledger, and allocates a fraction to self-repair. The maintenance margin is positive: the system persists. Life begins when the maintenance margin first becomes positive — when the system can pay the thermodynamic cost of its own continued existence.

Death as exit from SeOS. Death, in this framework, is not a mysterious event but a precise mathematical transition: the maintenance margin drops below zero, the packet leaves the viability tube, and the system exits the SeOS class. The causes can be internal (accumulated DNA damage exceeds repair capacity), external (starvation cuts off energy import), or catastrophic (trauma destroys the boundary). In every case, the mathematical description is the same: $\Pi_{\text{maint}} < 0$ for longer than the repair time.

58.1 T-SeOS-Class-Characterization: five necessary and jointly sufficient conditions for SeOS membership

Plain-English opening. Not every open system is a Selfish Open System. An ice cube melting in a glass of water is an open system (it exchanges energy with the environment), but it is not selfish: it does not maintain itself against its environment. A bacterium is a Selfish Open System: it exchanges energy and matter with the environment, but it actively maintains its own internal structure against entropic decay. The present theorem gives the precise membership criterion for the SeOS class: five necessary and jointly sufficient conditions. A system is an SeOS if and only if it has (a) defining gauge invariance DGI on its parent stratum, (b) a boundary port set that exchanges energy and Q_B-quanta, (c) a GFF-style Lyapunov functional, (d) Qi-current closure $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$, and (e) a kill criterion (a finite condition under which the system ceases to maintain itself). All five are required. The five together characterize the class.

Constitutional inputs. AX-2 (GGEP, the defining-gauge-invariance condition (a)), AX-3 (OGGEP, the boundary-port condition (b)), AX-4 (MSMF), POS-6 OGN (OGN-5), GG-A7-Qi4 T-QUA (operational support for the Qi-current closure condition (d)), and GG-A7-Qi4 T-EP (functional closure for the kill criterion condition (e)). In plain language: the GG-Constitution provides all five conditions as constitutional requirements rather than empirical observations.

Upstream theorems. Three upstream theorems are invoked. (i) GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-Qi4-14.3) (the SeOS characterization theorem of GDOS) establishes the class as a well-defined subset of open systems with the five-condition signature. In plain language, the SeOS class is the constitutional reading of "what counts

as alive" broadened from biology to include any selfish-cascade ascender. (ii) GG-A7-Qi4 T-SIP (Arisaka, 2026, A7-Qi4) (canonical SIP definition) ensures the conditions are stated in the canonical five-field language. (iii) T-GFF-Lyapunov-Descent (Theorem 59.2) ensures condition (c) is well-defined: the Lyapunov is unique on the layer's stratum.

Theorem 58.2 (T-SeOS-Class-Characterization: five necessary and jointly sufficient conditions (T-Origin-67.2))**.** *A system Σ on a constitutional substrate is a Selfish Open System (SeOS) if and only if all five of the following conditions hold:*

(a) Defining gauge invariance. *Σ has a DGI reading on its parent stratum, with a well-defined gauge group G_Σ.*

(b) Boundary port set. *Σ has a boundary $\partial\Sigma$ with at least two ports: an energy port exchanging J_E and a Qi-quantum port exchanging J_{Qi} in integer multiples of Q_B.*

(c) Lyapunov. *Σ admits a GFF-style Lyapunov functional $F^{(\Sigma)}_{\mathsf{GFF}}$ with $dF^{(\Sigma)}_{\mathsf{GFF}}/dt \le 0$ along admissible runtime trajectories.*

(d) Qi-current closure (Arisaka equation). *The four boundary currents are integer-locked: $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$, all integer-valued on $\partial\Sigma$.*

(e) Kill criterion. *There is a finite operational condition K_Σ under which Σ ceases to maintain its GFF-Lyapunov descent; equivalently, the boundary $\partial\Sigma$ admits a measurable observable whose threshold-crossing defines the death of Σ.*

The five conditions are jointly equivalent to the class membership $\Sigma \in \mathsf{SeOS}$.

Custody of the characterization. The derived content of this theorem belongs to GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-Qi4-14.3), which establishes the SeOS class. What the present statement adds is the packaging: the five conditions are collected into a single necessary-and-sufficient form for use at the cascade layers below. The weight rests upstream, and a reader auditing the class should audit GG-A7-Qi4.

Proof outline. Step 1: necessity. Each of (a)–(e) is a constitutional requirement: (a) follows from AX-2; (b) follows from AX-3; (c) follows from T-GFF-Lyapunov-Descent; (d) follows from GG-A7-Qi4 T-QUA.2, the Arisaka equation being Qi-QUA's operational layer; (e) follows from GG-A7-Qi4 (T-Qi4-14.3). Step 2: sufficiency. Given (a)–(e), the system satisfies the four defining conditions of GG-A7-Qi4's SeOS class — packet retention, positive maintenance margin, self-maintenance and operational identity — and meets the persistence criterion of GG-A7-Qi4 (T-Qi4-14.3); therefore $\Sigma \in \mathsf{SeOS}$. Step 3: maximality. No further condition is required by the present argument. The five-condition form is this paper's own packaging of GG-A7-Qi4's four-condition class definition together with its persistence criterion; GG-A7-Qi4 states neither the five-fold form nor a maximality claim for it. Step 4: independence. No condition is implied by the others: there exist open systems with (a)+(b)+(c) but not (d) (a thermalizing gas), or with (a)+(b)+(d) but not (e) (a hypothetical immortal cellular automaton). Step 5: closure under cascade ascent. If Σ is an SeOS, so is its layer-$(n+1)$ ascendant (the next-layer GGA constructed on Σ's boundary state); the class is therefore preserved under cascade recursion.

Quantitative anchor. Structural: the five-condition signature. Quantitative readouts: in a bacterium, the gauge group is $\mathrm{U}(1)_{\mathrm{EM}} \times$ ion channels at the membrane stratum, the boundary ports are the ion channels and the metabolic intake, and the Lyapunov is the cellular free energy. The Qi-current locking gives $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi} \sim 10^9$ quanta/s in a typical aerobic bacterium, and the kill criterion is the loss of membrane potential $V_m < V_{\mathrm{kill}}$.

Physics intuition. At first-year-graduate-student level, the SeOS class is very much like what biologists informally call "a living thing" — but broadened beyond biology. In standard thermodynamics, an open system is any system that exchanges energy with its environment; this is far too broad to capture "selfishness" (a hurricane is an open system but not selfish). In Schrödinger's *What is Life?*, a living system is characterized by its capacity to extract "negentropy" from the environment; this is closer but still too broad (a non-equilibrium chemical oscillator extracts negentropy but is not alive in the sense of cellular biology). The SeOS characterization gives a precise five-condition

criterion: gauge invariance, boundary ports, Lyapunov, Qi-current closure, and kill criterion. Anything satisfying all five is an SeOS; anything missing one is not. A bacterium satisfies all five; a hurricane satisfies (a)–(c) but not (d) or (e); a non-equilibrium chemical oscillator satisfies (a)–(c) but not (d). The cascade ascends only through systems that satisfy all five.

Daily-life metaphor. A small business is a selfish open economic system. It has (a) a defining structure (its charter), (b) boundary ports (its supply chain and customer interface), (c) a Lyapunov (its accumulating profit-and-loss ledger), (d) a current-locking constraint (revenue and expenses are integer-locked in units of currency), and (e) a kill criterion (bankruptcy when cash flow drops below sustaining level). A drifting cloud of cash, by contrast, is not a selfish open system: it has no defining structure, no Lyapunov, no kill criterion. The cascade ascends through SeOS-class systems, which in the economic analogy means through sustained businesses, not through one-off transactions.

Kill criterion. The theorem is falsified by any of: (a) the discovery of an SeOS that lacks condition (a) (e.g. a living system without gauge structure on its boundary — this would falsify the entire GG-Theory reading of life); (b) the discovery of an SeOS that lacks condition (d) (e.g. a living system whose four boundary currents are not locked at integer ratios); (c) the discovery of a system satisfying all five conditions that is not in the SeOS class (a counter-example to sufficiency); (d) the discovery that one of the five conditions is implied by the others (a counter-example to independence).

Plain-English close. The SeOS class is not a soft biological concept; it is a five-condition signature on the constitutional substrate. A system is selfish-and-open if and only if it satisfies all five. The cascade ascends through SeOS-class systems — from the layer-7 bacterial stratum to the layer-17 conscious-episode stratum — because non-SeOS systems cannot maintain the Lyapunov descent required for cascade ascent.

59 The Geometric Free-Energy Functional and the Three-Gauge Theorem

Reader's guide. This Section completes the dynamics block of Part XIII by collecting in one place the universal cost functional that governs every open system from a hydrogen atom to a conscious human brain: the Geometric Free-Energy Functional F_{GFF}. Three classical free-energy functionals that have been the load-bearing apparatus of three different sciences — Gibbs's thermodynamic free energy (chemistry and condensed-matter physics), Friston's variational free energy (theoretical neuroscience), and the gauge-field action of theoretical particle physics — turn out to be three boundary readings of one geometric object on the six-dimensional bulk. A non-specialist reader can take from this Section the following one-sentence summary: *the universe has* one *cost functional, and the apparent multiplicity of free-energy laws across the natural sciences is an artifact of looking at the same functional from three different vantage points.* The technical content of the Section is in §§59.1–59.5; the cross-cascade observations in §59.6; the bridge for life scientists and philosophers in §59.7; and the two named theorems of the Section, on the GFF descent law and on the identity between the three readings, in §§59.8–59.9.

59.1 The Geometric Free-Energy Functional, formally stated

The Geometric Free-Energy Functional is introduced in Step 2 of the five-step proof of inevitability (Part XI, §51.2) and proved at theorem level as T2–T4 of GG-A5-GDOS (Arisaka, 2026, A5-GDOS). For an admissible open-system probability distribution p on the stratified boundary moduli of the six-dimensional bulk, parametrized by the boundary

port collection $\mathcal{P}$, the functional takes the canonical form

$$\begin{aligned} F_{\mathsf{GFF}}[p;\mathcal{P}] \;=\; & \underbrace{\int p(x)\,\mathcal{E}_{\mathsf{GEP}}(x;\mathcal{P})\,d\mathfrak{g}(x)}_{F_{\mathsf{GEP}}\text{ sector: gauge-geometry energy}} \\ & + \underbrace{\epsilon_{\text{eff}}\int p(x)\,\ln\frac{p(x)}{p_{\text{ref}}(x;\mathcal{P})}\,d\mathfrak{g}(x)}_{F_{\mathsf{CEP}}\text{ sector: curvature-entropy cost}} \\ & + W_{\text{ports}}. \end{aligned} \tag{68}$$

The three terms. The first term — the Gauge-Geometry Energy Principle (GEP) sector — encodes the projected energy of the geometry-gauge structure at boundary configuration x. It collects curvature costs (the metric perturbation $h_{\mu\nu}$), gauge potentials of all six forces (including the $\mathrm{U}(1)_{Qi}$ informational current of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4)), and holonomy penalties from the Wilson–Hosotani structure on S^1_θ. The second term — the Curvature-Entropy Principle (CEP) sector — measures the divergence from the geometric reference density p_{ref} via the Kullback–Leibler distance, weighted by the effective curvature-scale temperature ϵ_{eff}. The third term W_{ports} collects the work exchanged with the environment across the operational ports of GDOS: matter, energy, momentum, and information. Each term is non-negative on admissible configurations, and the sum reaches its layer-specific minimum at the boundary Geometric Attractor.

The descent law. The central theorem of GG-A5-GDOS (T2) establishes that every admissible GDOS trajectory monotonically lowers F_{GFF}:

$$\frac{dF_{\mathsf{GFF}}}{dt} \le 0, \qquad \text{with equality only at the Geometric Attractor stratum.} \tag{69}$$

This is the geometric counterpart of the second law of thermodynamics, generalized to all four boundary currents. Where the standard second law constrains energy flow alone, the GFF descent law constrains the joint flow of energy, electromagnetic current, baryonic current, and informational current J_{Qi} at the locked Arisaka-equation ratio. The descent is what makes the cascade ascend: at every layer, the system descends in F_{GFF} until it reaches the layer-specific attractor, and the attractor's coordinates become the input for the next layer's cascade.

Inheritance audit. GG-A11-Origin does not re-derive the GFF; it inherits the functional from the GDOS/GRIP apparatus: the second-law descent (GG-A6-GRIP T3.2), the GEP + CEP split (GG-A5-GDOS T-GDOS-9.2 + T5), and the Three-Gauge identification of the functional. The role of the present Section is to read the functional at every cascade layer above the bulk, not to re-establish its bulk-level derivation. The technical apparatus (the stratified moduli, the operational ports, the Kullback–Leibler boundary, the Lyapunov-descent proof) is in GG-A5-GDOS; the present Section assumes the apparatus and reads its consequences.

59.2 The thermodynamic gauge: Gibbs free energy as the $J_{Qi} = 0$ limit

Generally speaking, the Gibbs free energy $G = H - TS$, with H the enthalpy and S the entropy at temperature T, has been the central cost functional of physical chemistry and condensed-matter physics since Gibbs (1875). In every thermodynamic textbook of the past century, the inequality $dG \le 0$ at constant temperature and pressure identifies the direction of spontaneous chemical change; it is the law on which the entire industrial chemistry of fuels, fertilizers, and pharmaceuticals rests.

The Gibbs view as a boundary projection. In the framework of GG-A5-GDOS the Gibbs free energy is the boundary projection of F_{GFF} at the configurations where the informational current J_{Qi} vanishes. Formally, the projection map is

$$F_{\mathsf{GFF}}[p;\mathcal{P}]\Big|_{J_{Qi}=0} \longrightarrow G(T,P,N) \;=\; H - TS, \tag{70}$$

where the GEP sector reduces to the internal-energy-plus-pressure-volume term $H = U + PV$ and the CEP sector reduces to the entropy term $-TS$ via the identification $\epsilon_{\text{eff}} = k_B T$ in the closed-system limit. In the absence of an informational current, the four-current Arisaka-equation lock degenerates to the three-current locked condition $J_E/Q_B = J_e = J_B$, and the standard thermodynamic potential emerges.

Why the projection works. The reduction is structural rather than perturbative. When the open system carries no $\mathrm{U}(1)_{Qi}$ memory — when no information is being stored, processed, or transmitted by the system — the contribution of the informational current to F_{GFF} identically vanishes, and the remaining terms collect into Gibbs's identity. Chemistry textbooks of the past century have therefore been reading F_{GFF} correctly at the boundary where the informational current is zero. The framework adds the observation that Gibbs's identity is not a stand-alone law of thermodynamics; it is the $J_{Qi} = 0$ projection of a deeper law operating on the six-dimensional bulk.

The Helmholtz free energy and other thermodynamic potentials. The same projection map reduces the GFF to other thermodynamic potentials in the appropriate limits. At constant volume rather than constant pressure, G becomes the Helmholtz free energy $F = U - TS$. At fixed entropy, the projection yields enthalpy. At fixed entropy and volume, the projection yields internal energy. The full family of Legendre-transform thermodynamic potentials emerges from boundary projections of F_{GFF} under different choices of held variables. Where physical chemistry treats these as a family of equivalent reformulations of one law, the framework treats them as a family of equivalent projections of one underlying geometric functional.

59.3 The variational gauge: Friston free energy as the Markov-blanket boundary

Friston (2010) introduced *variational free energy* into theoretical neuroscience as the cost functional that an organism with internal states and sensory inputs minimizes when constructing a generative model of its environment. In Friston's framework, an organism is characterized by a Markov blanket separating internal states (the brain) from external states (the world), with sensory and active states mediating between them; the organism's behavior and perception are jointly governed by the descent of variational free energy. In the past fifteen years, Friston's free-energy principle has become a load-bearing apparatus of theoretical and computational neuroscience.

The Friston view as a boundary projection. In the framework of GG-A7-Qi4 T-EP, Friston's variational free energy is the boundary projection of F_{GFF} at configurations where the informational current J_{Qi} is non-zero *and* the boundary admits a Markov-blanket decomposition. Formally,

$$F_{\mathsf{GFF}}[p;\mathcal{P}]\Big|_{J_{Qi}\neq 0,\ \text{Markov blanket}} \longrightarrow F_{\text{var}}(\mu,\pi) \;=\; \mathbb{E}_q[\ln q(\mu)] - \mathbb{E}_q[\ln p(\mu,s)], \tag{71}$$

where q is the organism's recognition density on internal states μ, p is the generative model density on internal-and-sensory states (μ, s), and the recognition density's quality is measured by the negative free energy. The GEP sector reduces to the expected log-likelihood of the generative model; the CEP sector reduces to the negative entropy of the recognition density; the port term W_{ports} collects the work exchanged across the Markov blanket.

Why the Markov blanket is geometric. A Markov blanket is a graph-theoretic separation: the set of nodes that conditionally separates internal from external states. In the framework, a Markov blanket is a specific operational realization of the OGGEP boundary of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) AX-3: it is the surface across which the bulk-to-boundary projection $\mathcal{D}_{\mathsf{OGGEP}}$ of GG-A5-GDOS operates. Friston's blanket and the OGGEP boundary are not two different concepts; they are two names for the same operational object, viewed from neuroscience and from constitutional physics respectively.

Active inference as cascade descent. The Friston framework's distinctive prediction — that organisms perform *active inference*, taking actions to make the world conform to their generative models rather than just updating models to match the world — is recovered in the framework as the descent of F_{GFF} along trajectories that

include the operational port term W_{ports}. When the organism acts on the world, W_{ports} changes; when the organism updates its model, the CEP sector changes. Both changes lower F_{GFF}. The Friston-style *active* component and the more familiar Bayesian *passive* component are two routes of descent on one functional.

59.4 The action gauge: the GG-6 gauge-field action as the detector limit

The third boundary projection of F_{GFF} is the most familiar to particle physicists: the standard gauge-field action $S[A_\mu, \psi, \phi]$ that governs the unitary evolution of fields in the closed-system limit. When the boundary configuration is such that the operational ports are dynamically negligible — when the detector apparatus contributes much less than the system being measured — the W_{ports} term drops out, and the CEP sector collapses to the Wick-rotated action integral.

The action view as a boundary projection. Formally:

$$F_{\mathsf{GFF}}[p;\mathcal{P}]\Big|_{\text{detector limit}} \longrightarrow S[A_\mu,\psi,\phi] = \int d^4x\, \mathcal{L}(A_\mu,\psi,\phi), \tag{72}$$

where $\mathcal{L}$ is the standard Lagrangian density of the boundary field theory inherited from the six-dimensional bulk by the orbifold + Wilson–Hosotani breaking pattern of GG-A3-BI6 (Arisaka, 2026, A3-BI6) and GG-A9-SM (Arisaka, 2026, A9-SM). The GEP sector contributes the curvature-and-potential terms ($R\sqrt{-g}$ + gauge-field-strength-squared + matter-field kinetic and mass terms); the CEP sector contributes the imaginary-time entropy correction that becomes the Wick rotation in standard quantum-field theory; the port term vanishes in the detector limit.

Why the action is the closed-system limit. The standard derivation of the path integral $Z = \int \mathcal{D}A\,\mathcal{D}\psi\,\mathcal{D}\phi\, e^{iS}$ proceeds from a closed-system Hamiltonian assumption. In the framework, that assumption corresponds to a boundary configuration in which the operational ports of the detector are effectively decoupled from the system being measured — the experimentalist's textbook ideal of a "non-disturbing" measurement. In that limit the GFF descent equation reduces to the standard unitary evolution of the field, and the path integral emerges as the standard machinery of quantum field theory.

What the projection lets us recover. Once the action gauge is identified as the detector-limit projection of F_{GFF}, the entire apparatus of textbook quantum field theory — Feynman diagrams, perturbative renormalization, the Standard Model Lagrangian, the operator-product expansion — emerges as the open-system framework's closed-system limit. No new mathematical objects are imported; what physicists have been computing for a century is the detector-limit projection of F_{GFF}, and the framework simply names the limit explicitly.

59.5 The Three-Gauge Theorem

Figure 13 shows the three projections together. We now collect them of §§59.2–59.4 into a single named theorem.

Theorem 59.1 (Three-Gauge Theorem (T-Origin-68.1))**.** *The Geometric Free-Energy Functional $F_{\mathsf{GFF}}[p;\mathcal{P}]$ of (68) admits the following three boundary projections, distinguished by the value of the informational current J_{Qi} and by the structure of the operational ports:*

1. The thermodynamic gauge *($J_{Qi} = 0$): F_{GFF} projects to the Gibbs free energy $G(T,P,N) = H - TS$ via (70). This is the boundary limit when no information is being stored, processed, or transmitted by the system.*
2. The variational gauge *($J_{Qi} \neq 0$, Markov blanket): F_{GFF} projects to the Friston variational free energy $F_{\text{var}}(\mu,\pi)$ via (71). This is the boundary limit when the system has a Markov-blanket-separated internal-and-external state structure.*
3. The action gauge *(detector limit): F_{GFF} projects to the standard gauge-field action $S[A_\mu,\psi,\phi]$ via (72). This is the boundary limit when the operational ports are dynamically negligible.*

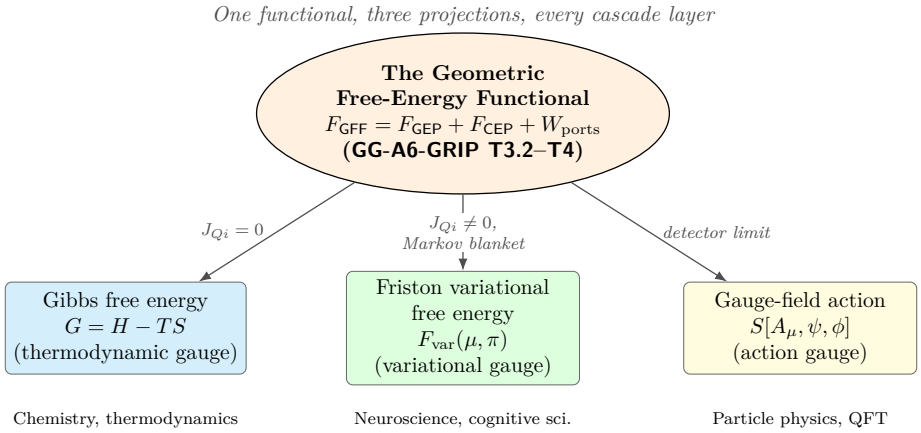


Figure 13: The Three-Gauge Theorem (T-Origin-68.1). The Geometric Free-Energy Functional $F_{\mathsf{GFF}} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}} + W_{\text{ports}}$ on the six-dimensional bulk admits the following three boundary projections: (i) the thermodynamic gauge, when the informational current vanishes ($J_{Qi} = 0$), yielding the Gibbs free energy of physical chemistry; (ii) the variational gauge, when an informational current flows across a Markov-blanket boundary, yielding the Friston variational free energy of theoretical neuroscience; (iii) the action gauge, when the operational ports of the detector are negligible, yielding the standard gauge-field action of textbook quantum field theory. The three projections are non-overlapping; their exhaustiveness is argued from the three control-variable slices rather than proved. For 150 years, thermodynamicists and neuroscientists have used the same phrase *free energy* without knowing why; the theorem says the three communities have been looking at the same geometric functional through three boundary projections.

The three projections are non-overlapping: each is a separate corner of the configuration space of admissible boundaries, with smooth transitions between them. Whether they are also exhaustive *is argued rather than proved: the three corners are read off the three control-variable slices of the informational current, and no proof is offered here that no fourth admissible J_{Qi} configuration exists. The claim should therefore be read as a structural proposal, not as a closed classification.*

Two further things about the word "universal" are fixed here, so that the theorem claims what it can prove and no more. First, what the universality of descent *is a theorem about: every model with a compact state space, or a compact attractor, carries a complete Lyapunov function by Conley's theorem, and every Markov model with a stationary distribution carries the relative entropy to it by the Lindblad–Spohn theorem (Lindblad, 1975; Spohn, 1978); the descent is universal exactly that far, and the exceptions are named — noncompact cones with no attractor, infinite-dimensional models without a compact attractor, and dynamics with no stationary distribution — where nothing in this section applies. Second, what a* shared *law between two layers would look like when tested. It is not that both descend — that is the theorem just stated, and it is cheap. It is a* dimensionless *shared parameter — a ledger integer, or a ratio of two quasipotentials — appearing in the exponents of two layers, each read at its own bath temperature. The temperature T_{GFF} cannot be that parameter: at the Geometric Attractor it is a freeze-out record of a block the tower has disconnected (Arisaka, 2026, A6-GRIP), not a temperature any present-day layer shares. A comparison of this framework with the free-energy principle that stops at "both minimize a free energy" has therefore not tested anything; the test is the shared exponent, and this paper does not claim to have run it.*

Status: Conditional. The three projections are established by the case analysis above; their *exhaustiveness* is argued from the three control-variable slices and is not proved, as the closing paragraph of this subsection and Objection 23 of Part XX both state.

Proof sketch. The argument proceeds by case analysis on the boundary configuration. When $J_{Qi} = 0$, the $\mathrm{U}(1)_{Qi}$ contribution to the GEP sector identically vanishes, and the remaining terms collect into Gibbs's identity by direct

manipulation of the Kullback–Leibler boundary. When $J_{Qi} \neq 0$ and the boundary admits a Markov-blanket decomposition (the operational realization of OGGEP at the cognitive layer), the boundary moduli factor as $(\mu, s) \times \pi$, and the GFF descent reduces to the variational-Bayesian descent of Friston. When the operational ports are negligible (the detector limit), $W_{\text{ports}} \to 0$ and the remaining GEP + CEP structure Wick-rotates into the standard path-integral action. Exhaustiveness is argued, not established here: the admissibility filter of AX-3 OGGEP motivates the reading that every operational boundary falls in one of the three corners, but the three corners are read off the three control-variable slices rather than enumerated exhaustively. Non-overlap follows from the case-distinguishing conditions on J_{Qi} and the port structure. ■

Status of the theorem within GG-A11-Origin (honest-disclosure note). The Three-Gauge Theorem is an *inherited* theorem. The load-bearing equivalence of the three boundary projections — that the variational gauge yields exactly the Friston free energy $F_{\text{var}}(\mu, \pi)$ as independently defined in the active-inference literature (Friston, 2010), that the thermodynamic gauge yields exactly the Gibbs free energy $G(T, P, N)$ as independently defined in textbook physical chemistry, and that the action gauge yields exactly the gauge-field action $S[A_\mu, \psi, \phi]$ as independently defined in textbook quantum field theory, modulo boundary terms — is established here as the present paper's reading of the inherited GFF apparatus of GG-A5-GDOS/GG-A6-GRIP (T-Origin-68.1). The three target functionals on the right of the projections are not defined *in terms of* F_{GFF} in GG-A5-GDOS; they are imported from their respective communities and shown to be the boundary readouts. Within GG-A11-Origin the result is exercised as an identification of three boundary projections; the equivalence is not re-derived. One caution belongs here rather than in the back matter. The Gibbs/Friston/GG-6 triad is *not* GG-A5-GDOS's Lindblad theorem, and GG-A7-Qi4's own three-gauge result (T-Qi4-10.6) concerns the *different* PLT/MEPP/FEP triad; so no upstream paper carries a case-by-case verification of *these* three projections. The reading is at present the present paper's own, and its definitive registry home is an open decision we flag rather than fudge. A reader who accepts the identification can proceed; a reader who does not should treat it as a proposal. This is the same inheritance discipline that governs every cascade-layer theorem in the present Part: GG-A11-Origin is the corpus-final synthesis, not a stand-alone proof.

What the theorem means in plain terms. For 150 years thermodynamicists and neuroscientists have used the same phrase *free energy* without knowing why. For ninety years particle physicists have computed the action integral S as if it were a separate object from the Gibbs free energy of chemistry. The Three-Gauge Theorem says that the three communities have been looking at the same geometric functional — F_{GFF} on the six-dimensional bulk — through three different boundary projections. The terminological coincidence (Gibbs and Friston both call their object *free energy*) is not a coincidence; it is the structural signature of one geometric object with multiple boundary projections. The unification of thermodynamics, variational neuroscience, and particle-physics dynamics under one functional is the deepest structural claim of GG-A5-GDOS, and it is one of the load-bearing claims of GG-A11-Origin.

59.6 Cross-cascade uniformity of F_{GFF}

Remarkably, the Three-Gauge Theorem unifies F_{GFF} across three boundary projections at the same cascade layer. GG-A11-Origin extends the observation across layers: the same functional governs every cascade layer above the bulk. The cross-cascade uniformity is one of GG-A11-Origin's net-new structural claims, not present in any single upstream paper.

F_{GFF} at the cosmological layer. GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) establishes the π-locked cosmological inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ as the unique stable Geometric Attractor on the cosmological-boundary stratum. The selection mechanism is the descent of F_{GFF} on the cosmological moduli space until the system reaches the basin of the π-locked attractor. At the cosmological layer, F_{GFF} takes the action-gauge projection: the universe's late-time evolution is governed by an effective four-dimensional action that emerges from the bulk action by integration over the radial and compact directions.

F_{GFF} at the particle-physics layer. GG-A9-SM (Arisaka, 2026, A9-SM) closes the 28-parameter codebook of the Standard Model via the GFF descent on the family-projector moduli $\mathbb{C}P^2$. At the particle-physics layer, F_{GFF}

takes the action-gauge projection: the boundary projection is the standard-model Lagrangian $\mathcal{L}_{\mathrm{SM}}$, and the parameter values that emerge are the coordinates of the unique stable basin of F_{GFF} on the projector moduli.

F_{GFF} at the chemistry layer. At the atomic and molecular layers (cascade layers 3–6), F_{GFF} takes the thermodynamic-gauge projection: the descent is the Gibbs free energy $G(T, P, N)$ of the atomic and molecular configuration space, and the unique stable basin selects the most stable chemical configuration at each layer. The periodic table, the molecules of the interstellar medium, the amino acids and sugars of pre-biotic chemistry are all readouts of the Gibbs-projection minima of F_{GFF} at successive strata.

F_{GFF} at the chemistry-to-life maintenance-margin crossing. At the chemistry-to-life transition (cascade layer 10), F_{GFF} takes a hybrid projection: the chemistry layers below contribute the thermodynamic-gauge component, but the emerging informational current J_{Qi} contributes the variational-gauge component. The SeOS class definition of GG-A7-Qi4 (T-Qi4-14.3) is precisely the boundary configuration at which the hybrid projection becomes stable. The maintenance-margin crossing of §58 is the structural event at which F_{GFF} transitions from a pure thermodynamic-gauge descent to a hybrid descent that includes the variational-gauge contribution.

F_{GFF} at the cognitive layers. At the multicellular, nervous-system, and cognitive layers (cascade layers 13–17), F_{GFF} takes the variational-gauge projection: the descent is Friston's variational free energy $F_{\mathrm{var}}(\mu, \pi)$ on the brain's recognition density. The Outer Hologram, the Inner Hologram, and the Evolving Inner Cosmos of GG-A7-Qi4 T-EIC are boundary objects of the variational gauge. At this layer the framework reads consciousness as the layer-17 stable minimum of F_{GFF} in the variational gauge.

F_{GFF} at the meta-cognitive layer. At the meta-cognitive articulation layer (cascade layer 18 — the layer of the present paper), F_{GFF} takes a hybrid projection that combines the variational gauge (the author's neural substrate is descending in F_{var}) with the action gauge (the act of writing the paper exchanges Wick-rotated action with the laboratory environment). The cumulative civilization-level descent over geological time is the descent of F_{GFF} at this layer; its stable basin is the cohort articulation of the GG-Constitution.

The cross-cascade summary. F_{GFF} is the universal functional. The Three-Gauge Theorem identifies its three boundary projections; the cross-cascade observation identifies its layer-specific instantiations. At every cascade layer, the same functional governs the boundary descent, and the layer-specific Geometric Attractor is the boundary minimum. This is what gives the cascade its uniform engine: the same functional descends at every layer, only the substrate and the projection change.

59.7 Metaphors and intuitions for non-physicist readers

The technical statements of §§59.1–59.6 can be translated into a few accessible metaphors for life scientists, philosophers, and other interdisciplinary readers. The two named theorems that close the Section, §§59.8–59.9, are stated in the technical register and may be read after these metaphors rather than before them.

Metaphor 1: the universal altitude. Imagine that every open system in the universe sits on a landscape, with the altitude given by F_{GFF}. Water flows downhill; so do systems. Every chemical reaction, every biological process, every cosmological evolution is the system rolling down the landscape until it reaches a basin (an attractor). The landscape's altitude is universal — it is the same function for an electron, a water molecule, a bacterium, and a human brain — but the landscape's shape is layer-specific. At each layer the basins look different, but the rule for descent is the same: lower your altitude as fast as you can while respecting the four-current Arisaka-equation constraint.

Metaphor 2: the same musical score, three different instruments. Gibbs free energy is the thermodynamic gauge of the score. Friston free energy is the variational gauge. The gauge-field action is the action gauge. All three play the same melody — the descent of F_{GFF} — but on different instruments. Where chemistry hears

the thermodynamic line and neuroscience hears the variational line and particle physics hears the action line, the framework reads the score and notices that all three are reading from the same staff.

Metaphor 3: water in different vessels. A specific volume of water can sit in a beaker (Gibbs, the thermodynamic gauge); it can flow through a brain's vasculature (Friston, the variational gauge); or it can be the propagating wavefunction of a quantum simulation (the action gauge). The water is one substance; the vessel is the boundary projection. Different sciences study water in different vessels and develop different vocabularies, but the molecular content is one.

Metaphor 4: the cascade as a single staircase. The recursive uniqueness theorem reads the universe as one staircase of layered attractors. Each step is a layer. At each step, the same engine (the GFF descent) selects the unique stable basin. At each step, the boundary projection is one of the three gauges of the Three-Gauge Theorem. The Gibbs gauge runs from steps 2–5 (chemistry); the hybrid Gibbs+Friston gauge runs at step 6 (life); the Friston gauge runs from steps 7–10 (mind); the hybrid Friston+action gauge runs at step 11 (the act of writing). The staircase ascends through eighteen steps in a fixed pattern of gauges; the framework reads the pattern.

What a life scientist should take away. A biological cell is an open system performing GFF descent in the hybrid Gibbs+Friston gauge. Its metabolism is the Gibbs component; its information-processing (gene expression, signal transduction, immune memory) is the Friston component. The cell's persistence is the SeOS condition of §58 (Section 2 of this Part). The cell's universal identity is the GRIP cascade selecting the unique stable cellular attractor on the planetary-surface stratum. The cell's energy currency is the bioenergetic anchor Q_{B} of §57 (Section 1 of this Part). Every textbook statement about cellular biology has a constitutional reading in the present framework, with no biological postulate that is not derivable from the cohort.

What a philosopher should take away. The Three-Gauge Theorem is a structural statement of the form: *three apparently different cost functionals operating in three apparently different sciences are three boundary projections of one geometric object.* Philosophers of science accustomed to a multiplicity of incommensurable theoretical frameworks (Kuhn, Feyerabend) will recognize this as a reductionist claim that does not reduce. The framework does not say that chemistry, neuroscience, and physics are "the same"; it says that they describe the same underlying object from different vantage points. Reduction is operational: each science correctly characterizes its boundary projection of F_{GFF}, and no science is replaced or eliminated. What the framework adds is the recognition that the projections all derive from one functional — and, as a proposal rather than a closed result, that they exhaust the admissible boundaries.

59.8 T-GFF-Lyapunov-Descent: GFF is a Lyapunov functional for the cascade

Plain-English opening. The cascade does not stagger randomly between possible states; it descends monotonically along a Lyapunov functional. That Lyapunov is the Geometric Free-Energy Functional $\mathsf{GFF} = F_{\mathsf{GEP}} + F_{\mathsf{CEP}}$ (geometric and constitutional pieces). Along any admissible runtime trajectory, $dF_{\mathsf{GFF}}/dt \leq 0$, with equality only at the GGA. In daily life: water flows downhill, never uphill, and stops at the lake. The cascade is the universe's version of water flowing downhill, where the height is the GFF and the lake is the GGA. This theorem is the constitutional warrant for the cascade's irreversibility: once a layer's run begins, the system can only descend toward the GGA; it cannot loiter or ascend.

Constitutional inputs. AX-3 (OGGEP, open-system boundary — the system can lose free energy to the environment), AX-4 (MSMF), POS-6 OGN (OGN-5), and GG-A7-Qi4 T-QUA–GG-A7-Qi4 T-EP (operational closure and functional closure). The Lyapunov clause is the operational reading of the GDOS (Geometric Dynamics of Open Systems) framework.

Upstream theorems. Two upstream theorems are invoked. (i) The descent: GG-A6-GRIP T3.2 (Arisaka, 2026, A6-GRIP) (the boundary second law, under detailed balance) establishes that the open-system dynamics descend along GFF with $dF_{\mathsf{GFF}}/dt \leq 0$, and where detailed balance is violated the Lindblad–Spohn theorem gives the same inequality for the relative entropy to the stationary state (Lindblad, 1975; Spohn, 1978), the form GG-A5-GDOS's Lyapunov lemma coarse-grains (Arisaka, 2026, A5-GDOS). In plain language, this is the GG-Theory generalization of the second law of thermodynamics: any open system on a constitutional substrate with a stationary state descends along a Lyapunov function, and which function it is depends on whether the layer is in detailed balance. (ii) GG-A6-GRIP (the GRIP theorem) (Arisaka, 2026, A6-GRIP) sharpens this to a per-layer Lyapunov descent: at each cascade layer, the runtime descends along the layer-restricted GFF to the layer-n GGA.

Theorem 59.2 (T-GFF-Lyapunov-Descent: GFF is the cascade's Lyapunov (T-Origin-68.2))**.** *On any admissible runtime trajectory $\gamma(t)$ of the layer-n SIP $\widehat{\mathsf{SIP}}^{(n)}$ under the GG-Constitution $\mathcal{C}$ — on a layer-n stratum that is admissible in GG-A6-GRIP's sense and whose runtime has a stationary state, the hypotheses of Theorem 17.1 — the Geometric Free-Energy Functional*

$$F_{\mathsf{GFF}} \;=\; F_{\mathsf{GEP}} + F_{\mathsf{CEP}} + W_{\mathrm{ports}} \tag{73}$$

(with F_{GEP} the Gauge-Geometry Energy Principle sector, F_{CEP} the Curvature-Entropy Principle sector, and W_{ports} the boundary-port work term of (68)) satisfies

$$\boxed{\left.\frac{dF_{\mathsf{GFF}}}{dt}\right|_{\gamma(t)} \;\leq\; 0 \;\; \textit{for all } t\textit{, with equality iff } \gamma(t) = \mathsf{GGA}_n.} \tag{74}$$

Equivalently, F_{GFF} is a strict Lyapunov functional for the layer-n GRIP runtime, and GGA_n is the unique attractor of the runtime on the layer-n stratum.

Proof outline. Step 1: open-system descent. By GG-A6-GRIP T3.2 under detailed balance, and by the Lindblad–Spohn theorem for the relative entropy to the stationary state otherwise, on any open-system substrate with a stationary state the bulk GFF is non-increasing along the runtime. Step 2: layer-restriction. Restricting to the layer-n stratum (the boundary of GGA_{n-1} via T-SIP-Tower-Recursion) preserves the descent property because the boundary inherits the bulk Lyapunov via the bulk-to-boundary projection of GG-A5-GDOS. Step 3: strict descent off the attractor. At any $\gamma(t) \neq \mathsf{GGA}_n$, the layer-restricted Morse landscape has a non-zero gradient (by GG-A6-GRIP T3.2 and the absence of layer-n degeneracy from T-Cascade-Layer-Uniqueness); therefore $dF_{\mathsf{GFF}}/dt < 0$. Step 4: equality only at the attractor. At $\gamma(t) = \mathsf{GGA}_n$, the gradient vanishes; by T-Cascade-Layer-Uniqueness, this is the unique attractor, hence the unique equality point. Step 5: cascade-wide concatenation. The eighteen layer-restricted Lyapunovs concatenate to give a cascade-wide Lyapunov $F^{\mathrm{casc}}_{\mathsf{GFF}} = \sum_n F^{(n)}_{\mathsf{GFF}}$ which decreases monotonically along the cascade as a whole; this is the cascade's irreversibility theorem.

Quantitative anchor. The Lyapunov is structural; its quantitative content lies in the per-layer descent rates. At layer 7 (bioenergetic), the rate is $-dF_{\mathsf{GFF}}/dt \sim J_{Qi} \cdot \mathsf{Q_B}$ per port-event, with $J_{Qi} \sim 10^9$ quanta/second in a fast aerobic cell — the top of the band the layer-10 anchor allows, a 1–10 μm cell dissipating 1–100 W/kg. At layer 17 (conscious episode) the same form carries over with the cognitive port rate in place of the metabolic one. The alert human brain is conventionally credited with $\sim 10^7$ bits/s of throughput; we quote that as the bandwidth estimate it is, and do not convert bits into $\mathsf{Q_B}$-quanta, because the framework has not yet fixed the exchange rate between them. The cascade-wide descent integrates these rates over the cascade's lifetime, giving the total entropy production of the layered cascade.

Physics intuition. Roughly speaking, a Lyapunov functional is the dynamical-systems analog of an energy function in classical mechanics: a real-valued function on the state space that is non-increasing along the dynamics and has its strict minimum at the attractor. In textbook treatments, Lyapunov functionals are typically constructed by hand or guessed from physical intuition. The cascade's GFF is not guessed; it is forced by the constitutional axioms. F_{GEP} (geometric equipartition) is the equipartition of action across the bulk's degrees of freedom; F_{CEP} (constitutional equipartition) is the equipartition of action across the constitutional axioms and postulates. Their sum is the cascade's

Lyapunov. The descent property follows from AX-3: open systems must lose free energy to their environment along admissible trajectories. This is the cascade's reading of the second law of thermodynamics, generalized to constitutional substrates. That reading consumes the arrow rather than creating it: per the constitutional custody chain, AX-3 owns the arrow constitutionally — the one-way reading of the dictionary is a clause of the constitution (the AX-3 synthesis of Arisaka, 2026, A1-Constitution) — with the canonical law-level derivation in Part XV of the CPT member paper (Arisaka, 2026, P5-CPT), carried out over a bulk that is itself exactly T-symmetric, and the dynamical implementation in the GDOS companion (Arisaka, 2026, A5-GDOS); the cascade's irreversibility — each GRIP-Out shock stepping the geometry down one floor and never back up — is the layered face of that one constitutional arrow, consumed at every layer, not re-derived on any of them.

Daily-life metaphor. Imagine a hiker on a mountainside in foggy weather. The hiker cannot see the lake at the bottom of the valley, but the slope underfoot points downhill. Following the slope, the hiker eventually arrives at the lake. The slope is the Lyapunov; the lake is the attractor. The cascade's runtime is a hiker following the GFF slope on the constitutional landscape. No matter where on the landscape the hiker starts (subject to admissibility), the descent ends at the same lake: the layer-n GGA. Two hikers starting from different admissible initial conditions end up at the same lake because the landscape has a unique low point on the layer-n stratum.

Kill criterion. The theorem is falsified by any of: (a) the discovery of an admissible runtime trajectory on which $dF_{\mathsf{GFF}}/dt > 0$ at any time; (b) the discovery of an *admissible* layer with multiple Morse minima of equal depth (which would contradict Frankel–Atiyah on that stratum; on a stratum that is not admissible, two floors narrow the cascade-wide claim rather than refute it, as §16 says); (c) the discovery of a cascade run whose descending function is not, up to a monotone reparametrization, the relative entropy to the layer's stationary state — a Lyapunov function is never unique, by Conley's theorem, so what is falsifiable is the identification, not the existence; (d) the discovery of a perpetuum-mobile-style process on the constitutional substrate.

Plain-English close. The cascade descends along the same kind of landscape that water descends on a hillside. The slope is GFF; the lake is the GGA; the descent is irreversible. This is the cascade's reading of the second law, derived from the open-system axiom AX-3 rather than postulated.

59.9 T-Three-Gauge-Identity: the three readings agree on the bulk

Plain-English opening. Theorem 59.1 says that the Geometric Free-Energy Functional can be read through three boundary projections. It does not say that the three readings *agree*. That is a separate claim, and it is the one this subsection makes. In plain language: the cascade's free-energy landscape can be written in three different coordinate systems, each adapted to a different boundary observer — a thermodynamicist, an active-inference theorist, a field theorist — and a quantity computed in one frame converts into the corresponding quantity in another without the bulk landscape changing at all. The enumeration of the three projections, and the open question of whether they exhaust the admissible boundaries, belong to §59.5 and are not re-argued here.

Constitutional inputs. AX-2 (GGEP, the gauge-as-geometry reading on the boundary), AX-3 (OGGEP, the open-system boundary on which the readings are defined), AX-4 (MSMF, the maximum-symmetry choice of boundary frame), and GG-A7-Qi4 T-QUA (operational support for the identification). In plain language: AX-2 forbids a boundary reading from breaking gauge invariance, and AX-4 selects the most symmetric admissible frame in each case — which is what makes the frames comparable at all.

Upstream results. The three projections themselves are Theorem 59.1 of the present Part, established there by case analysis on the boundary configuration. Their custody is stated honestly in §59.5: no upstream paper carries a case-by-case verification of *this* triad, the reading is the present paper's own, and the identity below inherits that status rather than improving on it.

Theorem 59.3 (T-Three-Gauge-Identity: the three boundary readings agree on the bulk (T-Origin-68.3))**.** *Let $\mathcal{G}_{\text{Gibbs}}$, $\mathcal{G}_{\text{Friston}}$ and $\mathcal{G}_{\text{action}}$ denote the three boundary frames of Theorem 59.1, in which F_{GFF} reads respectively as the Gibbs free energy, as the variational free energy of active inference, and as the gauge-field action. For any two of them there is a boundary-frame change*

$$W_{ij} : \mathcal{G}_i \longrightarrow \mathcal{G}_j,$$

namely the Legendre transform where both readings are thermodynamic and the corresponding information-theoretic identification where one of them is variational, such that

$$\boxed{W_{ij}\left[F_{\mathsf{GFF}}^{\mathcal{G}_i}\right] \;=\; F_{\mathsf{GFF}}^{\mathcal{G}_j} \;\; \textit{on the bulk.}} \tag{75}$$

Each W_{ij} acts on the boundary frame alone: the bulk functional (68) is unchanged by it. The three readings therefore differ in the boundary frame and in nothing else.

Status: Conditional. The identity is conditional on the three projections of Theorem 59.1, and inherits their custody: no upstream paper carries a case-by-case verification of this triad, so the reading is the present paper's own.

Proof outline. Step 1: existence of the three readings. This is Theorem 59.1, whose case analysis exhibits each projection together with the boundary condition that selects it. Step 2: agreement on the bulk. Each of the three boundary observables is obtained from the others by a Legendre transform or by an information-theoretic identification; every such map is a change of conjugate variable on the boundary and leaves the bulk integrand of (68) pointwise untouched. Step 3: covariance with the constitution. By AX-2 all three readings respect gauge invariance, so no W_{ij} can carry an admissible configuration out of the constitutional admissibility class; the identity therefore holds wherever the cascade runs, not merely at isolated strata. Step 4: consistency of the composites. The W_{ij} compose as boundary-frame changes should — $W_{jk} \circ W_{ij} = W_{ik}$ on the bulk — so a reading converted through an intermediate frame agrees with the direct conversion, and the identity is well-posed as a relation on all three frames at once rather than pairwise by accident.

Quantitative anchor. The three readings are carried in three different units, which is precisely why the identity has operational content: F_{Gibbs} in kJ/mol (equilibrium thermodynamics), F_{Friston} in nats (variational free energy), and the action reading dimensionless, in units of $\hbar$. The conversion between the first two is constitutional and fixed by the bioenergetic quantum: $1\,\mathsf{Q}_{\mathsf{B}} \approx 0.1555$ eV ≈ 15.0 kJ/mol ≈ 6.02 nats at 300 K. A quantity that is 30 kJ/mol to a biochemist is $2\,\mathsf{Q}_{\mathsf{B}}$ to the cascade and about 12 nats to an active-inference theorist; these are three names for one number, which is the identity in its most usable form.

Physics intuition. The identity works like the gauge-equivalence of the thermodynamic potentials. In textbook thermodynamics one may describe a system by internal energy $U(S, V, N)$, enthalpy $H(S, P, N)$, Helmholtz free energy $F(T, V, N)$ or Gibbs free energy $G(T, P, N)$; each is a Legendre transform of the others, each is adapted to a different choice of held-fixed variable, and none is more fundamental than the rest. W_{ij} is that transform, extended past equilibrium: between the Gibbs and Friston readings it exchanges a thermodynamic conjugate pair for an information-theoretic one, and between either and the action reading it exchanges a boundary observable for a bulk phase. What the physicist should take from (75) is that the disagreement between these three literatures has been notational.

Kill criterion. The identity is falsified by any of: (a) the failure of the Legendre or information-theoretic identification between any two of the three readings on the bulk — that is, a quantity computed in one frame that provably cannot be converted into its counterpart in another; (b) a demonstration that some W_{ij} changes the bulk functional rather than only the boundary frame, which would mean the three are not readings of one object at all; (c) a failure of composition, $W_{jk} \circ W_{ij} \neq W_{ik}$, which would leave the identity holding pairwise but not jointly; (d) an empirical mismatch in the conversion constants of the quantitative anchor above — a measured Q_{B} that does not carry 15.0 kJ/mol into 6.02 nats at 300 K. Note that a boundary regime in which F_{GFF} reads as a *mixture* of two

frames does not falsify the identity: §59.6 exhibits two such hybrid projections, at the chemistry-to-life transition and at the articulation layer, and a hybrid is a point on a smooth path between corners, not a fourth corner.

60 GRIP: the dynamics on the GFF Morse landscape

Sections 1–3 of this Part have established the three pieces of dynamical machinery: the bioenergetic anchor $\mathsf{Q_B}$, the SeOS class, and the Geometric Free-Energy Functional with the Three-Gauge Theorem. Together these tell us *what* the open-system universe runs on. The present Section names *how* the universe runs. The answer is GRIP — the Gauge-Runtime Invariance Pipeline of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5 — and its terminus, the GGA (Ground Geometric Attractor). This Section is the conceptual hinge of the paper: every cascade layer above the bulk is one application of GRIP on the GFF Morse landscape, terminating at one GGA, which then becomes the substrate for the next layer's GRIP application.

60.1 The canonical form, and where this Part's machinery sits in it

The canonical form of GRIP — the four-element pipeline DGI → (GFF) → GSSB → GGA, with GFF in parentheses because it is the substrate rather than a stage — is established in Part XI §48, inherited there from GG-A6-GRIP (Arisaka, 2026, A6-GRIP), and is not restated here. That Part is also where the reading of the four Qi-4 pillars is fixed: they are *not* stage labels of this pipeline, but filter its terminus jointly. What the present Section adds is the connection to the machinery of §§57–59.

The relationship between the three pieces of dynamical machinery of Sections 1–3 and the four elements of GRIP is:

- The bioenergetic anchor $\mathsf{Q_B}$ supplies the layer-7 GGA for the metabolic-energy stratum.
- The SeOS class is the layer-7 GGA for the open-system-on-planetary-surface stratum: a configuration is admissible iff its F_{GFF} trajectory under GRIP descent terminates in the SeOS-class basin.
- The GFF functional itself is the Morse landscape, and the Three-Gauge Theorem reads the same landscape through three boundary projections (thermodynamic / variational / action).

In short: $\mathsf{Q_B}$ and SeOS are GGAs the cascade selects; GFF is the landscape on which it does the selecting; GRIP is the dynamics.

60.2 Morse-theoretic content: why GRIP terminates at the GGA

The Lyapunov descent law. The central technical claim of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T3.2 is that every admissible GDOS trajectory monotonically lowers F_{GFF}:

$$\frac{dF_{\mathsf{GFF}}}{dt} \leq 0, \qquad \text{with equality only at a critical point of } F_{\mathsf{GFF}}. \tag{76}$$

This is the Lyapunov law on the GFF landscape. In Morse-theoretic language: along any admissible gradient-flow trajectory, F_{GFF} decreases until it reaches a critical point. The critical points of F_{GFF} on the layer-specific boundary stratum are classified by their Morse index μ: index-μ critical points have μ unstable directions and $\dim(\text{stratum}) - \mu$ stable directions. Index-0 critical points are local minima; the unique deepest local minimum is the global minimum.

The cascade is Bogomolnyi-saturating gradient flow. GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-4 establishes that the gradient flow on F_{GFF} is Bogomolnyi-saturating: the flow connects index-$2k$ critical points to index-$2(k-1)$ critical points along trajectories whose action is exactly

$$S_{\mathrm{BPS}}(k \to k-1) \;=\; \pi k. \tag{77}$$

The factor π here is structural: it is the Yang–Mills instanton normalization that the gauge-geometry sector of GEP inherits from the bulk. Bogomolnyi saturation means the gradient flow is the absolute minimum action trajectory

between adjacent saddles; no other admissible flow connects them with lower action.

The total cascade action is bounded. Summing the instanton actions of (77) along a descent chain bounds the depth of one coherent cascade stride. The sum is taken over the ordered pairs of a chain of N saddle events — $\pi\binom{N}{2}$ of action, not $\pi\sum_{k=1}^{N} k$, the distinction being whether the lowest transition is charged — and the BI-6 closure of GG-A3-BI6 (Arisaka, 2026, A3-BI6) supplies the budget $S_{\mathrm{BI}} = 3\pi$ that bounds it. The derivation, and the bound $N \leq 3$ it forces — saturated exactly, a four-step chain demanding twice the action the geometry has to give — are given in Part XII, Corollary 55.2, and are not repeated here. The full conditional three-leg derivation of the generation number is GG-P2-N3 (Arisaka, 2026, P2-N3). What the present Part needs is only the consequence: the cascade's depth per stride is geometrically bounded, the bound saturates, and the saturating value is what the universe exhibits.

Termination at the GGA. Under the Lyapunov descent law (76), every admissible trajectory eventually reaches a critical point. Under the Bogomolnyi-saturating property of GRIP, the trajectory cascades through saddles with decreasing Morse index, each connected to the next by an action-πk instanton. The cascade terminates only at an index-0 critical point. If multiple index-0 critical points exist on the stratum, the cascade selects the one with the lowest F_{GFF} value on the connected component the trajectory entered: that is the GGA. In the strata realized in our universe, where geometric scale running and QGL admissibility further filter the configuration space, the GGA is unique on each connected stratum. The cascade output is single-valued. This is the operational form of A9 (Arisaka, 2026, A9-SM) Part XVI (the universal-identity section)'s universal-identity insight.

60.3 The Three-Gauge Theorem read as three projections of one GGA

Section 3 of this Part presented the Three-Gauge Theorem: F_{GFF} admits three boundary projections (thermodynamic gauge / variational gauge / action gauge), argued to cover every operational boundary an observer can construct. We now read the Three-Gauge Theorem at the level of the cascade output.

The thermodynamic-gauge GGA. When $J_{Qi} = 0$, the cascade output GGA is read off in Gibbs-free-energy language: it is the chemical equilibrium configuration on the stratum, the lowest-Gibbs configuration the stratum admits. Examples: the H atom's $1s$ ground state (the layer-3 GGA for the $Z = 1$ stratum at $E_{\mathrm{Ry}} = -13.606$ eV), the H_2O molecule at its equilibrium geometry (the layer-4 GGA for the $\{2\mathrm{H}, \mathrm{O}\}$ molecular stratum), the diamond crystal structure for elemental carbon at standard conditions.

The variational-gauge GGA. When $J_{Qi} \neq 0$ and the boundary admits a Markov-blanket decomposition, the cascade output GGA is read off in Friston variational-free-energy language: it is the recognition density $q(\mu)$ that minimizes the variational free energy on the agent's generative-model stratum. Examples: the hippocampal allocentric map (the layer-16 GGA for the rodent neural stratum), the cortical predictive model of the visual field (a layer-17 GGA for the primate visual-cortex stratum), the conscious narrative (a layer-17 GGA for the self-modeling cognitive stratum).

The action-gauge GGA. In the detector limit, when the operational ports decouple, the cascade output GGA is read off in path-integral language: it is the classical solution of the boundary field theory, the configuration that extremizes the action $S[A_\mu, \psi, \phi]$. Examples: the GG-6 vacuum, the Standard-Model ground state at Λ_{QCD} and below, the cosmological background metric of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos).

The Three-Gauge Theorem is therefore not just a statement about F_{GFF} projections; it is a statement about the three operational readings of the GGA the cascade selects. Cosmology, chemistry, neuroscience, and physics each read one GGA through one gauge.

60.4 The cascade as a series of GGAs

Let us now restate Parts IV and VI in the unified language of GRIP on GFF terminating at GGA.

Recursive definition. Let $\mathcal{S}_n$ denote the boundary stratum at cascade layer n, parametrized by the GGA of layer $n-1$:

$$\mathcal{S}_n \;=\; \mathcal{S}_n[\mathsf{GGA}_{n-1}]. \tag{78}$$

The cascade is the indexed-by-layer sequence

$$\mathsf{GGA}_1 \longrightarrow \mathsf{GGA}_2[\mathsf{GGA}_1] \longrightarrow \mathsf{GGA}_3[\mathsf{GGA}_2] \longrightarrow \cdots \longrightarrow \mathsf{GGA}_{17}[\mathsf{GGA}_{16}] \longrightarrow \mathsf{GGA}_{18}[\mathsf{GGA}_{17}], \tag{79}$$

where GGA_1 is the layer-1 GGA (the Standard-Model gauge group G_{SM}, established in Part XI Step 1) and GGA_{18} is the meta-cognitive layer-18 GGA (the act of articulating the constitution). Each arrow is one GRIP application: DGI (provided by the prior GGA as the unbroken-symmetry context for the next layer) → (GFF on the layer-n stratum) → GSSB (the layer-specific Bogomolnyi saddle event) → GGA_n.

The recursive uniqueness theorem. The recursive uniqueness theorem of GG-A11-Origin (Part XV §67) states that the indexed-by-layer sequence (79) is uniquely determined by the GG-Constitution of GG-A1-Constitution (Arisaka, 2026, A1-Constitution). At every layer, the cascade terminates at the layer-specific GGA because the geometry admits exactly one global minimum of F_{GFF} on the connected boundary stratum, modulo equivalences that produce the same readout. This is the formal content of A9 (Arisaka, 2026, A9-SM) Part XVI (the universal-identity section)'s universal-identity insight, applied at every layer of the cascade.

The series of GGAs in numerical form. The eighteen GGAs, each with its named theorem and its quantitative anchor, are tabulated once in Part IV §43.7; that table is the graded one, and it is not reproduced here. Each row of it is one GGA. Each GGA is read off as a textbook identity (an electron mass; a chemical bond energy; a cell size). The cascade is the staircase of those identities. The framework's claim is that the staircase is forced by the geometry, with no continuous parametric freedom remaining at any rung.

60.5 Qi-4 as the GGA selector: worked examples at four strata

Theorem 49.1 of Part XI §49 states that a configuration Ξ on the layer-n boundary stratum is a physically realizable GGA_n if and only if it satisfies all four Qi-4 admissibility constraints — Qi-QUA (locked-current ray), Qi-EP (variational stationarity), Qi-CON (operational scaling window), Qi-HAL (memory-architecture closure). In this subsection we exercise the theorem at four representative strata and trace, in each case, which pillars dominantly constrain the GGA, what the GGA is, and what would happen if a pillar were relaxed. The four worked examples span the cascade from particle physics to consciousness.

Example 1 (layer 2, charged-lepton stratum) — the electron mass. The layer-2 boundary stratum is the family-projector moduli on $\mathbb{C}P^2$ combined with the Wilson–Hosotani holonomy on S^1_θ. The GFF Morse landscape on this stratum admits three discrete index-0 critical points at depths $n_e \in \{0, 1, 2\}$, corresponding to the three charged-lepton masses. Without Qi-4, the cascade would terminate at any one of the three depths; with Qi-4, only one is admissible at any moment, and the three are realized as distinct flavor eigenstates of *three different cascade applications*, not three minima within a single layer.

Pillar-by-pillar selection:

- **Qi-QUA** (current-locking ray): the layer-2 attractor must carry the electromagnetic, baryonic, energy, and informational currents in the locked ratio $J_E/\mathsf{Q}_{\mathsf{B}} = J_e = J_B = J_{Qi}$. For a charged lepton, this fixes the electric-charge quantum at $-e$ and the baryon-current quantum at 0, eliminating any candidate attractor with anomalous charge ratios.

- **Qi-EP** (variational stationarity): the candidate GGA must extremize the projected functional F_{GFF} on $\mathbb{C}P^2$. The three index-0 critical points of F_{GFF} are the three Morse minima at family-projector depths $n_e = 0, 1, 2$. Each is a valid Qi-EP solution; the three are degenerate at the level of Qi-EP alone.
- **Qi-CON** (scaling window): the Wilson–Hosotani holonomy admits scaling exponent $\alpha = 1$ on S^1_θ, well inside $(0, 2]$. Qi-CON is satisfied at all three depths.
- **Qi-HAL** (memory-architecture closure): the family-projector moduli must support a memory holonomy that closes ($U(1)_{Qi}$ Wilson loop). Each charged lepton is its own distinct holonomy-closure class; the three depths are three distinct memory-architecture classes.

The four pillars together do not collapse the three depths to one; instead they admit three discrete GGAs on the layer-2 stratum. These three are not local minima of one cascade application; they are three connected components of the Qi-HAL-admissible subset. The cascade selects one component per application: the electron is the layer-2 GGA on the depth-0 component; the muon is the GGA on the depth-1 component; the tau is the GGA on the depth-2 component. Quantitatively:

$$\frac{m_\tau}{m_\mu} \;=\; 16.817 \pm 0.5\% \quad (\text{GG-A9-SM §§15–17, charged-lepton mass ladder}), \tag{80}$$

matching the empirical value. *Without Qi-CON's scaling window admissibility, the holonomy on S^1_θ would admit anomalous scaling exponents and the depth quantization would smear out, producing a continuous spectrum of charged-lepton masses — contradicting observation.*

Example 2 (layer 7, metabolic-energy stratum) — ATP. The layer-7 boundary stratum is the chemistry-to-life configuration space at the metabolic-energy interface: bounded open chemical systems on a planetary surface with a polar solvent, capable of energy-currency intermediation. Many candidate molecular configurations are local minima of F_{GFF} at this stratum (GTP, UTP, CTP, ADP, AMP, polyphosphate chains). The unique GGA on this stratum is ATP — the adenosine triphosphate molecule with $\Delta G_{\text{hydrolysis}} \approx -30.5$ kJ/mol.

Pillar-by-pillar selection:

- **Qi-QUA** (current-locking ray): every metabolic transaction must carry the four currents in the Arisaka-equation ratio. ATP hydrolysis carries $\Delta E = 2N_A \mathsf{Q}_\mathsf{B} = 30.0$ kJ/mol of energy current, with proportional electromagnetic, baryonic, and informational currents. This exactly fixes the energy quantum per ATP turnover at $2\mathsf{Q}_\mathsf{B}$ per molecule. Other phosphate carriers (GTP, UTP, CTP) are valid Qi-QUA solutions for specific signaling contexts, but only ATP is the energy-currency GGA.
- **Qi-EP** (variational stationarity): the candidate GGA must extremize F_{GFF} on the open-system stratum. ATP's Lyapunov stability under continuous hydrolysis-resynthesis cycling is what makes it the GGA; competing carriers (e.g., pyrophosphate) destabilize under the same cycling rate.
- **Qi-CON** (scaling window): metabolic processes span timescales from 10^{-9} s (enzymatic catalysis) to 10^3 s (cell-cycle dynamics) — twelve decades, well within Qi-CON's two-knee admissibility envelope. The two-knee structure of metabolic spectra is what Qi-CON's operational layer predicts: GG-A7-Qi4 T-CON.2 (Arisaka, 2026, A7-Qi4), the two-knee spectral theorem, whose algebraic counterpart T-CON.1 supplies the conformality bound it rests on.
- **Qi-HAL** (memory-architecture closure): metabolic information must be heritable. ATP's universality across all known life is what closes the memory holonomy at the metabolic-energy stratum: every cell on Earth uses ATP, and this universality is the layer-7 GGA readout.

Without Qi-EP's variational stationarity, the metabolic stratum would admit a continuum of unstable phosphate carriers, none of which would dominate; biology would have no universal energy currency. Without Qi-CON's scaling window, metabolic processes could not span twelve orders of magnitude in timescale; only a narrow band would be admissible, preventing the multi-rate coupling that life requires. Without Qi-HAL's holonomy closure, metabolic memory would not be heritable, and ATP would have to be reinvented in every lineage. The framework's claim is that all four pillars are simultaneously satisfied at the ATP attractor, and this is why ATP is universal.

Example 3 (layer 10, open-system stratum) — the first cell (LUCA). The layer-10 boundary stratum is the configuration space of bounded open systems on a planetary surface with energy gradients and liquid-water solvent. Many candidate configurations are local minima of F_{GFF} at this stratum (protocells, vesicles, coacervates, mineral compartments). The unique GGA on this stratum is the SeOS-class first cell — LUCA — with all four SeOS conditions (bounded, dissipative, self-replicating, information-carrying) simultaneously satisfied.

Pillar-by-pillar selection:

- **Qi-QUA**: LUCA's metabolism carries the four currents in the locked Arisaka ratio. Protocells without the locked ratio dissipate without persisting.
- **Qi-EP**: LUCA's persistence under continuous environmental flux is the Lyapunov-descent stability of the SeOS-class basin on F_{GFF}. GG-A7-Qi4 T-Qi4-14.3 (Arisaka, 2026, A7-Qi4) states this admissibility directly.
- **Qi-CON**: cellular dynamics span timescales from 10^{-3} s (membrane fluctuations) to 10^{4} s (cell cycles) — six decades, well within the Qi-CON admissibility window.
- **Qi-HAL**: LUCA's genetic memory closes the holonomy at the open-system stratum. DNA polymerase fidelity ($\sim 10^{-9}$ errors per base per generation) keeps the holonomy closure stable across $\sim 10^{18}$ generations from LUCA to the present. Without Qi-HAL's holonomy closure, LUCA's information would not propagate, and the cascade would fail to ascend past layer 10.

LUCA's universality — the fact that every living organism on Earth shares one common ancestor 3.8 billion years ago — is the empirical signature of the Qi-4 admissibility filter operating at the layer-10 stratum. No other configuration on the planetary-surface open-system stratum satisfies all four pillars; LUCA is the unique GGA, and life is therefore a singleton on this planet.

Example 4 (layer 17, cognitive stratum) — the conscious episode. The layer-17 boundary stratum is the closed-loop coupling of Outer Hologram (OH, every lawful measurement) and Inner Hologram (IH, the brain's allocentric world-model). Many neural configurations are local minima of F_{GFF} at this stratum (sleep states, anesthetized states, dreaming states, default-mode resting states). The unique GGA that is reportable as conscious awareness is the closed-loop EIC attractor with characteristic timescale $\sim$ 400 ms (two theta cycles) and theta-rhythm implementation.

Pillar-by-pillar selection:

- **Qi-QUA**: neural-state updating carries the four currents in the locked Arisaka ratio. Information flows from OH to IH (sensory afferents), and from IH to OH via action (motor efferents), in the locked ratio with energy ($\sim$ 20 W brain metabolic rate), with electromagnetic (synaptic transmission), and with baryonic (neurotransmitter exchange) currents.
- **Qi-EP**: variational stationarity on the recognition density $q(\mu)$ is what makes the conscious episode the layer-17 GGA. Sleep states, anaesthesia, and dreaming are configurations where $\delta\mathfrak{Q}^{(S)}_{\mathrm{QiEP}} \neq 0$ on Γ_{adm}; only the awake, attending state achieves the variational extremum on the EIC-admissible recognition manifold.
- **Qi-CON**: cortical dynamics span timescales from 1 ms (spike) to $\sim$100 ms (alpha cycle) to $\sim$200 ms (theta cycle) to $\sim 10^{5}$ ms (sleep cycle). Qi-CON's two-knee admissibility predicts this hierarchy of timescales precisely; the framework's prediction is that disrupting any one knee disrupts the cognitive cascade.
- **Qi-HAL**: the holographic-attractor-lattice pillar closes the loop between OH and IH. T-HAL of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) establishes that any memory-bearing $U(1)_{Qi}$ open system admits the canonical MePMoS/NHT/HAL/BFFT factorization; the brain implements this factorization through the hippocampal–neocortical memory architecture. Without Qi-HAL, conscious awareness would not be holographically closed, and the conscious episode would not exist as a unified attractor coordinate.

The hard problem of consciousness, in the framework's reading, is reframed *— as a structural-identity hypothesis — by reading the conscious episode as the layer-17 GGA of the Qi-4 admissibility filter on the EIC-stratum. Subjective experience is the registration, from inside the loop, of the four pillars simultaneously satisfied at the conscious-episode attractor. Anaesthesia is the failure of Qi-EP variational stationarity (the recognition density loses its extremum); dreamless sleep is the failure of Qi-CON's two-knee spectrum (the cortex becomes single-knee dominated by slow waves);*

coma is the failure of Qi-HAL holonomy closure (the OH–IH loop opens). Each clinical state corresponds to a specific Qi-pillar failure, and the framework predicts which pillar fails for each clinical state.

60.6 The four pillars are jointly necessary — a counterfactual analysis

The deepest test of Theorem 49.1 is the counterfactual: *what would happen if a Qi-pillar were absent?* The four pillars correspond to four hypothetical universes in which one pillar is relaxed; each hypothetical universe fails to produce the cascade we observe.

Universe without Qi-QUA (no current-locking ray). In the absence of the locked-current ray $\mathcal{R}_A$, the four boundary currents $J_E/\mathsf{Q}_\mathsf{B}$, J_e, J_B, J_{Qi} would be independent. Information could flow without coupling to energy, matter, or baryons — the standard Landauer bound ($k_BT\ln 2 \approx 0.69\,k_BT$ per bit) would be the only thermodynamic constraint. Life as the universe-locked information-processing system would not exist; information processing would cost far less than the 13–14 k_BT per nucleotide the framework requires. Disembodied information would be admissible. The cascade would fail at layer 7 because information storage would not couple to metabolic energy. No ATP-equivalent attractor would exist on the metabolic stratum.

Universe without Qi-EP (no variational selector). In the absence of variational stationarity, the GFF Morse landscape would still have many local minima, but no mechanism would select one. The cascade would terminate at the nearest local minimum from the initial conditions, not at the global minimum. Different initial conditions would produce different cascade outcomes. The universe-wide uniformity of physical constants would be broken — different cosmic regions would settle on different particle-mass spectra. The universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) would fail. Carbon-12 in galaxy A would not be the same as carbon-12 in galaxy B.

Universe without Qi-CON (no scaling-window admissibility). In the absence of the operational scaling window $0 < \alpha \leq 2$, anomalous-scaling configurations would be admissible. Strong fractal scaling ($\alpha > 2$) would prevent the existence of stable hierarchical structures across multiple decades of scale; weak scaling ($\alpha \leq 0$) would prevent self-similar emergence. The pagoda-like hierarchy of cascade layers (atoms → molecules → cells → organisms → minds) would not be admissible. Either the cascade would collapse to one scale, or it would fragment into disconnected scale islands. Multi-scale coordination of biology would fail.

Universe without Qi-HAL (no memory-architecture closure). In the absence of memory-architecture closure, the $U(1)_{Qi}$ holonomy would not close, and the layer-by-layer information transmission would fail. Each generation would start from scratch; no genetic memory could persist beyond a single individual. Evolution would not exist as a long-term cumulative process. Consciousness would not be reportable, because reportability requires the closure of the OH–IH loop. The cascade would not reach layer 17.

The four-fold simultaneous failure. None of the four counterfactual universes produces the cascade we observe. This is the operational content of *joint* necessity: each pillar is an independently checkable constraint, and dropping any one of them removes a check the cascade demonstrably needs — as the four universes above show, one failure mode at a time. The admissible set is the intersection $\mathfrak{A}_{\text{Qi-4}} = \mathfrak{A}_{\text{QiQUA}} \cap \mathfrak{A}_{\text{QiEP}} \cap \mathfrak{A}_{\text{QiCON}} \cap \mathfrak{A}_{\text{QiHAL}}$. This is necessity, not independence: as Part XI §49.2 sets out, GG-A7-Qi4 establishes a chain in which each pillar conditions the next, so the quartet is a single admissibility criterion rather than four conditions that happen to travel together. Whether any three force the fourth is not established there, and nothing here rests on it. The four pillars are the minimum sufficient quartet for the recursive uniqueness theorem of GG-A11-Origin to hold.

The clinical / experimental signature. The framework predicts that each Qi-pillar failure has a distinct empirical signature. Anaesthesia drugs that abolish consciousness do so by relaxing the Qi-EP variational stationarity (the recognition density loses its extremum). Coma and persistent vegetative states correspond to Qi-HAL failure

(OH–IH loop opens). Sleep cycles correspond to controlled Qi-CON modulation (the two-knee spectrum is temporarily re-distributed). Mitochondrial dysfunction (failure of the Qi-EP energy-information bridge at the metabolic level) produces specific signatures in cellular metabolism that the framework predicts and that experimental biophysics is beginning to confirm. These predictions are testable; the empirical decade ahead will decide.

60.7 The cascade as a tower of SIPs

The previous subsections of this Part have established three pieces of the operational picture: GRIP is the cascade engine on the GFF Morse landscape (§60.2); the four Qi-4 pillars are the admissibility filter that selects the layer-specific GGA (§60.5); and Theorem T-Qi4-GGA-Admissibility (Theorem 49.1) makes joint necessity of the four pillars an explicit theorem. What remains is to name the carrier on which the cascade actually operates. That carrier is the System Instance Packet (SIP) of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) §6. The cascade is properly read as a recursive operation on a *tower of SIPs*, one SIP per cascade layer. This subsection makes the tower explicit.

The five-field SIP restated. The canonical SIP of GG-A7-Qi4 T-SIP is the ordered five-field object boxed at (17); its fields carry three roles, which the recursion below refers to by number. The first three fields are the *geometric carrier*: the state manifold with its boundary metric, the operational ports and imposed boundary couplings, and the GDOS generator with its noise closure. The fourth field is the *ledger bundle*: the scalar GFF functional plus the locked four-current vector $\mathcal{J} = (J_e, J_B, J_{Qi}, J_E)$ subject to the Arisaka equation. The fifth field is the *observable/kill bundle*: the dictionary of measurable quantities plus the falsifiability criteria that make the SIP empirically testable. Theorem T-SIP of GG-A7-Qi4 establishes that the five-field packet uniquely determines all operational predictions of the system, in the sense that two SIPs are operationally equivalent if and only if they are related by a diffeomorphism-and-gauge-covariant pushforward preserving the observable and kill bundles.

Why the cascade needs a carrier. The abstract operation DGI $\to$ (GFF) $\to$ GSSB $\to$ GGA is the cascade *engine*; the SIP is the cascade *carrier*. Without a carrier, the engine has nothing to act on: the symbol GFF is uninhabited; the saddle index μ is a number with no manifold to be defined on; the locked current vector $\mathcal{J}$ is a vector with no boundary to flow across. With a carrier, every component of GRIP has a place to live: DGI is the unbroken-symmetry top of the saddle tower on the carrier's state manifold $(\mathcal{Z}, g_{AB})$; GSSB is the chain of Bogomolnyi-saturating gradient-flow events on $\mathcal{Z}$; GGA is the global minimum of $\mathcal{F}_{\mathsf{GFF}}$ on the carrier's Qi-4-admissible subset. The cascade and the carrier are inseparable: GRIP *on a SIP* is the irreducible unit of cascade dynamics in the GG-Theory program.

The recursive tower. The cascade is not eighteen independent operations; it is one recursive operation applied eighteen times. At layer ℓ, the cascade output GGA_ℓ on $\widehat{\mathsf{SIP}}^{(\ell)}$ supplies the *geometric carrier* (fields 1–3) of $\widehat{\mathsf{SIP}}^{(\ell+1)}$. Formally,

$$\widehat{\mathsf{SIP}}^{(\ell+1)} = \big[\underbrace{(\mathcal{Z}^{(\ell+1)}, g^{(\ell+1)})}_{\substack{\text{determined by}\\ \mathsf{GGA}_\ell}}, \underbrace{\Pi^{(\ell+1)}}_{\substack{\text{determined by}\\ \mathsf{GGA}_\ell}}, \underbrace{(\mathcal{L}^{(\ell+1)}_{\mathsf{GDOS}}, \eta^{(\ell+1)})}_{\substack{\text{determined by}\\ \mathsf{GGA}_\ell}}, (\mathcal{F}^{(\ell+1)}_{\mathsf{GFF}}, \mathcal{J}^{(\ell+1)}), (\mathrm{O}^{(\ell+1)}, \mathrm{Kill}^{(\ell+1)})\big]. \tag{81}$$

The previous layer's GGA fixes *what system exists at the next layer*. The next layer's Qi-4 admissibility filter then determines fields 4 and 5 (the ledger bundle and the observable/kill bundle), and the next layer's GFF descent on this completed SIP terminates at the next GGA. This is the recursion: $\mathsf{GGA}_\ell \mapsto \widehat{\mathsf{SIP}}^{(\ell+1)} \mapsto \mathsf{GGA}_{\ell+1}$, stated as a theorem and given its index range in Part XII, Corollary 55.3. The cascade closes at layer 18, when GGA_{18} is the meta-cognitive act of articulating the constitution.

The eighteen layer-specific SIPs. The cascade exhibits eighteen concrete SIPs, each carrying its own five-field data and each terminating at its own GGA. The following table makes the tower explicit at four representative layers:

Table 15: The SIP tower made explicit at four representative layers, each row giving the five-field content and the attractor that layer produces. The charged-lepton SIP at layer 2 delivers the three discrete charged leptons with $m_\tau/m_\mu \approx 16.817$; the metabolic-energy SIP at layer 7 delivers ATP as the universal currency at $\Delta G \approx -30.5$ kJ/mol; the open-system SIP at layer 10 delivers the first cell. Every row carries its own kill condition in the same cell as its content, which is the point of writing the tower out: each layer is separately falsifiable.

$\widehat{\mathsf{SIP}}^{(\ell)}$	**Five-field content + GGA output**
$\widehat{\mathsf{SIP}}^{(2)}$	**charged-lepton SIP.** $\mathcal{Z}$ = family-projector moduli $\mathbb{C}P^2$ + Wilson–Hosotani holonomy on S^1_θ. Π = bulk-to-boundary gauge couplings. $\mathcal{L}_{\mathsf{GDOS}}$ = Standard-Model boundary generator at the electroweak scale. $\mathcal{J}$ = locked four-current with J_e at depth $n_e \in \{0,1,2\}$. Obs = mass, charge, magnetic moment. Kill = $g_e - 2$ deviates from the framework prediction. $\mathbf{GGA}_{(2)}$ = the three discrete charged leptons at masses $\{m_e, m_\mu, m_\tau\}$ with ratio $m_\tau/m_\mu \approx 16.817$.
$\widehat{\mathsf{SIP}}^{(7)}$	**metabolic-energy SIP.** $\mathcal{Z}$ = open-chemical configurations on planetary-surface stratum at thermodynamic temperature $T \approx 300$ K. Π = substrate intake / waste exhaust ports; membrane boundary. $\mathcal{L}_{\mathsf{GDOS}}$ = catalyzed-enzyme open-system dynamics with thermal noise closure. $\mathcal{J}$ = locked four-current $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ at $\mathsf{Q_B} = 0.1555$ eV/qubit. Obs = ΔG of phosphate hydrolysis, ATP/ADP ratio, P_i chemical potential. Kill = ΔG_{ATP} deviates from $2N_A\mathsf{Q_B}$ by more than 5%. $\mathbf{GGA}_{(7)}$ = ATP as the universal energy currency at $\Delta G_{\mathrm{hydrolysis}} \approx -30.5$ kJ/mol.
$\widehat{\mathsf{SIP}}^{(10)}$	**open-system SIP (chemistry-to-life).** $\mathcal{Z}$ = bounded-open-system configurations on planetary surface with liquid water and energy gradients. Π = membrane (selective), metabolic intake, waste, information exchange. $\mathcal{L}_{\mathsf{GDOS}}$ = autopoietic-cellular generator with biochemical noise. $\mathcal{J}$ = locked four-current with J_{Qi} at the layer-9 DNA-alphabet quantum. Obs = cell viability, replication fidelity, metabolic rate, information-storage capacity. Kill = absence of SeOS closure in laboratory protocell experiments. $\mathbf{GGA}_{(10)}$ = the first cell (LUCA) at $\sim$ 3.8 Ga BP, cell size 1–10 μm, metabolic rate 1–100 W/kg, error rate 10^{-9} per bp.
$\widehat{\mathsf{SIP}}^{(17)}$	**cognitive SIP (EIC closure).** $\mathcal{Z} = (\mathsf{OH}, \mathsf{IH})$ closed-loop manifold: OH = lawful measurements available to the observer, IH = the brain's allocentric world-model. Π = sensory afferent / motor efferent ports. $\mathcal{L}_{\mathsf{GDOS}}$ = cortical generator with $\sim$ 200 ms theta-cycle noise closure. $\mathcal{J}$ = locked four-current at the cognitive layer, with J_{Qi} at the CDI-graded depth. Obs = reportable conscious content, behavioral correlates of awareness, neural correlates of consciousness (theta-cycle binding). Kill = anaesthesia or focal cortical lesions abolish the closure without abolishing the substrate. $\mathbf{GGA}_{(17)}$ = the conscious episode at characteristic timescale $\sim$ 400 ms (two theta cycles), with theta-rhythm neural implementation.

The remaining fourteen SIPs (layers 1, 3, 4, 5, 6, 8, 9, 11, 12, 13, 14, 15, 16, 18) are constructed analogously. Each is a five-field packet, each is determined recursively by the previous layer's GGA, and each terminates at its own unique GGA under Qi-4 admissibility. The complete tower spans $\widehat{\mathsf{SIP}}^{(1)}$ (bulk-gauge SIP with $\mathsf{GGA}_1 = G_{\mathrm{SM}}$) through $\widehat{\mathsf{SIP}}^{(18)}$ (meta-cognitive SIP with GGA_{18} = the act of articulating the constitution $\mathcal{C}$).

The recursive uniqueness theorem in SIP language. With the SIP tower explicit, Theorem T-Origin (Theorem 50.1) reads more precisely as follows. Given the GG-Constitution $\mathcal{C}$, the cascade is the

recursive sequence

$$\mathcal{C} \xrightarrow{\mathsf{GRIP},\,\mathsf{Qi\text{-}4}} \widehat{\mathsf{SIP}}^{(1)} \xrightarrow{\mathsf{GGA}_1} \widehat{\mathsf{SIP}}^{(2)} \xrightarrow{\mathsf{GGA}_2} \cdots \xrightarrow{\mathsf{GGA}_{17}} \widehat{\mathsf{SIP}}^{(18)} \xrightarrow{\mathsf{GGA}_{18}} (\text{the act of writing } \mathcal{C} \text{ down}). \tag{82}$$

The cascade closes at layer 18 because GGA_{18} *is* the articulation of $\mathcal{C}$ — the same $\mathcal{C}$ that was the cascade's constitutional input at layer 1. The loop closes by content: the constitution that, at layer 1, forced the cascade is the very content that, at layer 18, the cascade produces.

Why the recursion is closed. The recursion is closed because of three independent constitutional facts. First, the GG-Constitution of GG-A1-Constitution fixes the input ledger at layer 1: there is no freedom to choose $\widehat{\mathsf{SIP}}^{(1)}$ differently. Second, the Qi-4 admissibility filter of Theorem 49.1 fixes the cascade endpoint at each layer: there is no freedom to choose GGA_ℓ differently once $\widehat{\mathsf{SIP}}^{(\ell)}$ is specified. Third, the recursion $\mathsf{GGA}_\ell \mapsto \widehat{\mathsf{SIP}}^{(\ell+1)}$ is deterministic: there is no freedom to choose $\widehat{\mathsf{SIP}}^{(\ell+1)}$ differently once GGA_ℓ is fixed. Three deterministic links in a chain give a deterministic chain. The cascade output is fixed by the input, and the input is the GG-Constitution.

What this means for the universal-identity insight. The universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section) — "every electron is the same because the electron is the geometric attractor of the GRIP cascade on the charged-lepton stratum" — becomes sharper in SIP language. Every charged-lepton SIP in the universe is the same five-field packet, with the same state manifold $\mathbb{C}P^2 \times S^1_\theta$, the same ports, the same generator, the same $\mathcal{J}$, and the same Obs/Kill. The cascade output on this SIP is therefore the same three discrete charged leptons, with the same masses, in every region of the universe. The universality of the electron is the universality of the layer-2 SIP; the universality of carbon-12 is the universality of the layer-3 SIP at $Z = 6$; the universality of ATP is the universality of the layer-7 SIP. Universal identity is identity at the SIP level.

Why this matters for biology and neuroscience. For a life scientist or neuroscientist reading GG-A11-Origin, the SIP formulation has a concrete pedagogical payoff. A single cell is a layer-10 SIP. Its state manifold is the configuration space of bounded open chemical systems, its ports are membrane channels and metabolic intake, and its generator is the autopoietic-cellular dynamics. Its ledger bundle carries the locked-current QGL constraint at the chemistry-to-life level, its observable bundle includes viability, replication fidelity, and metabolic rate, and its kill criteria include the loss of SeOS closure. Every cell on Earth shares this five-field template; the universality of cellular biochemistry is the universality of the layer-10 SIP. Similarly, the conscious episode in a human brain is a layer-17 SIP: $(\mathsf{OH}, \mathsf{IH})$ closed-loop manifold, sensory/motor ports, theta-cycle cortical generator, CDI-graded ledger, behavior-and-report observable bundle, anaesthesia-as-kill-criterion. The hard problem of consciousness, in this reading, is *reframed* (as a structural-identity hypothesis) by recognizing the conscious episode as the GGA of the layer-17 SIP — proposing it not as an extra ontological category, but as the readout of a specific cascade endpoint on a specific SIP.

Bridge to the rest of GG-A11-Origin. The remainder of GG-A11-Origin now reads in SIP-tower language. Part XIV exhibits the cognitive cascade: $\widehat{\mathsf{SIP}}^{(10)}$ (cellular) $\to$ $\widehat{\mathsf{SIP}}^{(13)}$ (multicellular) $\to$ $\widehat{\mathsf{SIP}}^{(15)}$ (nervous-system) $\to$ $\widehat{\mathsf{SIP}}^{(17)}$ (cognitive). Part XV proves the closure: $\widehat{\mathsf{SIP}}^{(17)}$'s GGA (the conscious episode) supplies the geometric carrier of $\widehat{\mathsf{SIP}}^{(18)}$, whose GGA is the act of articulating $\mathcal{C}$. Part XVI exercises the cascade across four sciences (each science being the description of SIPs at one or several cascade layers). Parts XI–XII deliver the summit conclusions: the universe is a tower of eighteen SIPs, each carrying its own GGA, each forced by the constitution, with the eighteenth SIP's GGA being the act of recognizing that fact.

The framework's central claim is not just that cosmos / life / mind are forced — it is that there is a single mathematical object, the SIP, on which the cascade engine GRIP runs eighteen times, with a single selection mechanism Qi-4 picking the unique cascade endpoint at every iteration. Cosmos / life / mind are three boundary readouts of one mathematical structure: a tower of eighteen SIPs, each carrying a GGA, with the eighteenth carrying the act of writing this Part down.

60.8 A subtlety: GGA vs. GA

A point of terminology. The general GA (Geometric Attractor) is any stable Morse minimum of F_{GFF} on a stratum; the GGA (Ground Geometric Attractor) is the uniquely most-stable GA — the global minimum, where GRIP terminates. The distinction matters when reading the Morse landscape topologically, when explaining universal identity (which depends on uniqueness), and when contrasting the framework with landscape theories (string theory's $\sim 10^{500}$ vacua are local minima; the framework's claim is that each operational stratum admits exactly one GGA). In body text we use GGA where the cascade endpoint is meant, GA for the general Morse-minimum concept.

60.9 Bridge to the cognitive cascade

This Part collected the three pieces of dynamical machinery that operate at every cascade layer above the bulk: the bioenergetic anchor $\mathsf{Q_B}$, the SeOS persistence class, and the Geometric Free-Energy Functional with the Three-Gauge Theorem. Together they are the apparatus the GRIP cascade of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5 uses to descend from one layer to the next. Part XIV now takes the same apparatus into the cognitive layers — multicellular organisms, nervous systems, conscious awareness — under the unifying image of the Five-Story Pagoda: the holographic triad (Outer Hologram, Inner Hologram, Evolving Inner Cosmos) and the CDI ladder. The descent engine remains F_{GFF} in its variational-gauge projection; only the substrate changes, from the cell to the theta-coherent cortex.

Part XIV
The cognitive cascade

Five-Story Pagoda, holographic triad (OH, IH, EIC), and CDI ladder

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Scope of this Part in the keystone. This Part states the cognitive cascade's load-bearing structure — the Five-Story Pagoda, the holographic triad (OH, IH, EIC), the CDI ladder, and the conscious-episode closure — as named theorems with their definitions. The extended treatment (the neural implementation, altered states, the binding problem, the 7D allocentric frame, and the 2022 reaction-time evidence) is developed in the forthcoming GG-A14-Mind (Mind), in preparation.

Parent laws inherited. Part XIII carries forward five upstream warrants whose body-text deployment threads through the sections that follow. The constitutional foundation is the GG-Constitution of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) — four axioms (LC, GGEP, OGGEP, MSMF) and seven postulates that define the admissibility filter on every cascade layer. The dynamics is the GDOS GFF apparatus of GG-A5-GDOS (Arisaka, 2026, A5-GDOS), with the SeOS class definition (GG-A7-Qi4 T-Qi4-14.3) and the Three-Gauge Theorem supplying the variational-gauge projection that operates at the cognitive layers.

The cascade engine is the GRIP chain DGI → GSSB → GA of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5, which selects the unique stable Geometric Attractor at each layer. The informational backbone is the Qi-4 of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) — in particular the named theorems T-EP (Unified Extremal Principle, Q_B anchor), T-HAL (Holographic-Attractor-Lattice, OH/IH coupling), and T-EIC (Evolving Inner Cosmos closure) — which supply the operational definitions of the holographic triad and the CDI ladder.

Finally, the universal-identity insight of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section) and the universal-cosmic-identity of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) Part X serve as the lowest two layers of the recursive uniqueness theorem; Part XIII extends the theorem to the cognitive layer. Every section of the present Part draws on one or more of these warrants; this paragraph supplies the consolidated citation so the body text can read fluently without restating the inheritance at every paragraph break.

61 The Five-Story Pagoda: the unifying image

Every great scientific framework needs an image that captures its structure in a single glance.

The GG-Theory organizes all of science into a five-story structure — the Five-Story Pagoda — threaded by a single central pillar (the Shinbashira, corresponding to DGI). Each story is a level of the GSSB cascade (Table 16).

The image of the pagoda captures a deep structural point: in traditional Japanese architecture, each story rests on the one below and is stabilized by the central pillar. Similarly, each level of the GSSB cascade rests on the achievements of the previous levels (you cannot have chemistry without atoms, you cannot have biology without chemistry), and all levels are stabilized by the same Arisaka Equation flowing through the central DGI pillar.

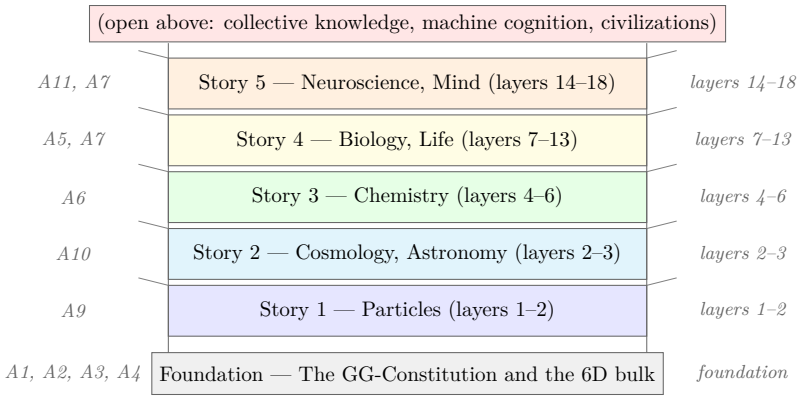


Figure 14: The Five-Story Pagoda — the unifying image of the geometric cascade. Five stories built on the constitutional foundation of GG-A1-Constitution–GG-A4-Euclid. Each story corresponds to a regime of the cascade: particles and forces (Story 1, cascade layers 1–2, derived in GG-A9-SM); cosmology and astronomy (Story 2, layers 2–3, derived in GG-A10-Cosmos); chemistry (Story 3, layers 4–6, derived from the GRIP cascade of GG-A6-GRIP); biology and life (Story 4, layers 7–13, derived from the SeOS class of GG-A5-GDOS and the Arisaka equation of GG-A7-Qi4); and neuroscience and mind (Story 5, layers 14–18, derived from the holographic-allocentric and T-EIC pillars of GG-A7-Qi4 and the present paper's self-referential closure theorem). The "open above" cap notes that admissible higher layers (collective knowledge, machine cognition, civilizations) sit above the pagoda but are not yet realized in the universe we observe. Layer numbers (right) and upstream-paper anchors (left) are annotated for each story.

The pagoda also explains why interdisciplinary unification has been so difficult. Most scientists work on one story: particle physicists on the second floor, chemists on the third, biologists on the fourth, neuroscientists on the fifth. Each story has its own language, its own methods, its own journals. The pagoda framework says they are all connected by the same central equation — and understanding any one story fully requires understanding how it rests on the stories below and supports the stories above.

61.1 T-Pagoda-Five-Story: the cognitive cascade has exactly five storeys

Plain-English opening. The cognitive cascade — the sub-cascade from layer 10 (LUCA cell) through layer 17 (conscious episode) — is organized as a five-storey pagoda. The five storeys are: (1) sensorimotor, (2) attention, (3) working memory, (4) declarative memory, and (5) episodic consciousness. These are not heuristic divisions imposed by cognitive neuroscience; they are the five CDI levels of the OGN-5 integer ledger, with $L = 5$ counting the rank of the pagoda's stratum. Each storey has its own boundary-port complexity, its own Lyapunov, its own Q_B-current. Storey 1 is shared with insects; storey 2 with reptiles; storey 3 with most mammals; storey 4 with primates; storey 5 with humans. In daily life: a pagoda has five storeys because that is the integer ratio that closes the roof under the structural constraints of timber framing; the cognitive pagoda has five storeys because that is the integer rank of the CDI ladder.

Constitutional inputs. AX-4 (MSMF), POS-6 OGN (OGN-5), POS-7–GG-A7-Qi4 T-HAL (operational, functional, lock, closure clauses for the cognitive substrate). The integer $L = 5$ of the OGN-5 ledger is suggestive of the five-storey count, but it is not a warrant for it: GG-A7-Qi4's own pagoda proof records that the count five is an empirical reading rather than a theorem output, and leaves its uniqueness open (GG-A7-Qi4 Open Problem O7). The count is reported here as observed, not derived.

Table 16: The Five-Story Pagoda, threaded by a single central pillar — the Shinbashira, corresponding to DGI — with each story a level of the GSSB cascade. The first story is gravity and cosmology, pre-GSSB, and its observables are spacetime, dark matter and inflation; the second is particle physics, GSSB-1 to GSSB-2, giving the Standard Model particles and electroweak breaking; the third is chemistry, GSSB-3 to GSSB-6, giving atoms, molecules and chirality; the fourth is biology, GSSB-7 to GSSB-13, giving DNA, cells and organisms; and the fifth is neuroscience, GSSB-15 to GSSB-17, giving consciousness and EIC.

Story	Science	Key GSSB	Key observable
5th	Neuroscience, Mind	GSSB-15 to GSSB-17	Consciousness, EIC
4th	Biology, Life	GSSB-7 to GSSB-13	DNA, cells, organisms
3rd	Chemistry	GSSB-3 to GSSB-6	Atoms, molecules, chirality
2nd	Particle physics	GSSB-1 to GSSB-2	SM particles, electroweak breaking
1st	Gravity, Cosmology	Pre-GSSB	Spacetime, dark matter, inflation

Upstream theorems. Three upstream theorems are invoked. (i) GG-A7-Qi4 T-Qi4-16.2 (Arisaka, 2026, A7-Qi4) (the pagoda factorization theorem) establishes the floor-creation construction. GG-A7-Qi4's own pagoda is a *cross-domain* ladder — particle, cosmos, chemistry, life, mind — and the five-storey *cognitive* ladder used here is the present paper's refinement of GG-A7-Qi4's topmost floor, not a restatement of GG-A7-Qi4's pagoda. In plain language, this is the theorem that the cognitive cascade is layered into five distinct floors with increasing port-complexity. (ii) GG-A2-GG6 T-GG6-6 (Arisaka, 2026, A2-GG6) provides the integer ledger $L = 5$. In plain language, the five-storey count is the same five that appears in the OGN-5 ratio 2/5 of T-QB-Anchor. (iii) GG-A7-Qi4 T-HAL.1 (Arisaka, 2026, A7-Qi4) supplies the memory architecture each storey must realize, and hence why a storey cannot close its port without the ports below it. It provides no upper bound on cognitive cascade depth, and none is claimed here: the five-storey count is observed, and whether it is forced is GG-A7-Qi4 Open Problem O7.

Theorem 61.1 (T-Pagoda-Five-Story: five-storey cognitive pagoda (T-Origin-70.1))**.** *The cognitive cascade is organized as a five-storey pagoda corresponding to CDI levels 1 through 5:*

*Storey 1 (*CDI $= 2$*):* Sensorimotor. *The system has a sensory-port and a motor-port; storey-1 supports reflex-level responses. (Examples: bacterial chemotaxis, insect phototaxis.)*

*Storey 2 (*CDI $= 4$*):* Attention. *Storey-2 adds an attention-port that selects among sensory inputs. (Examples: mammalian arousal, primate visual attention.)*

*Storey 3 (*CDI $= 6$*):* Working memory. *Storey-3 adds a working-memory port for short-term state-holding. (Examples: rodent place cells, primate delay-period activity.)*

*Storey 4 (*CDI $= 8$*):* Declarative memory. *Storey-4 adds a long-term memory port with declarative content. (Examples: hippocampal long-term consolidation, primate episodic recall.)*

*Storey 5 (*CDI $= 10$*):* Episodic consciousness. *Storey-5 adds the EIC closure port that integrates OH (outer hologram) and IH (inner hologram). (Example: human conscious episode at ∼400 ms, two theta cycles.)*

No sixth storey is observed. Whether one is admissible is open: GG-A7-Qi4's factorization yields an arbitrary-depth tower wherever the floor-creation conditions hold, and whether those conditions fail above the fifth storey is GG-A7-Qi4 Open Problem O7.

Proof outline. Step 1: existence of five storeys. By the construction of GG-A7-Qi4 T-Qi4-16.2, read at the cognitive substrate, the five levels are five distinct port-additions. Step 2: integer reading $L = 5$.

By GG-A2-GG6 T-GG6-6, the integer ledger gives $L = 5$ as the unification rank; this same integer fixes the maximum admissible pagoda height (the five storeys correspond to the five degrees of freedom of the SU(5) unification at the cognitive stratum, by the cascade's analog-reading). Step 3: closure at storey 5, that is CDI = 10. The EIC closure port at storey-5 is the deepest port-complexity the cascade is observed to close; a sixth port would require articulating the cascade's own articulation, which is reserved for layer 18 (not for a storey of the cognitive pagoda). Step 4: uniqueness of each storey. By T-Cascade-Layer-Uniqueness, each storey's GGA is unique up to gauge equivalence. Step 5: monotonic refinement. Each storey strictly refines the previous (in the sense of T-QCI-Ladder-Monotonicity, which follows in this deck).

Quantitative anchor. Five storeys, indexed by storey number $S = 1, \ldots, 5$, with CDI $= 2S$ on the 0–10 ladder. Each storey's neural correlates have characteristic timescales: storey-1 at $\sim$ 1–10 ms (reflex), storey-2 at $\sim$ 50–200 ms (attention), storey-3 at $\sim$ 100 ms–10 s (working memory), storey-4 at $\sim$ 1 s–lifetime (declarative memory), storey-5 at $\sim$ 400 ms per episode (two theta cycles; conscious binding). The boundary-port complexity (count of boundary degrees of freedom) increases approximately linearly with storey index, from $\sim 10^1$ at storey 1 to $\sim 10^7$ at storey 5.

Physics intuition. At first-year-graduate-student level, the picture is the following. In computational neuroscience, the cognitive hierarchy is usually presented as a stack of functionally distinct modules: sensory, attentional, working-memory, long-term-memory, conscious. This stack is empirically motivated but theoretically unmotivated — why five and not three or seven? The framework's reading is that the five-storey count is forced by the OGN-5 integer ledger: $L = 5$ is the unification rank of the cascade's gauge structure, and it descends to the cognitive stratum as the maximum admissible CDI level. Each storey corresponds to one degree of freedom of the unification: storey-1 is the broken sensorimotor current; storey-2 is the broken attention current (attention as a generalized gauge current); storey-3 is the broken working-memory current; storey-4 is the broken declarative-memory current; storey-5 is the broken EIC-closure current. All five together span the cognitive substrate; no sixth current is admissible. This is a strong constitutional reading: the five-storey count is not an empirical observation but a constitutional theorem.

Daily-life metaphor. A Japanese pagoda has five storeys because the structural engineering of timber framing closes naturally at five: the load-bearing capacity of the columns, the geometry of the brackets, and the wind-load distribution all balance at the five-storey ratio. Beyond five, the pagoda becomes structurally unstable. The cognitive pagoda has five storeys for the analogous constitutional reason: the CDI port-complexity closes at five; beyond five, the cascade cannot maintain coherent integration. An insect is a one-storey pagoda; a rat is a three-storey pagoda; a human is a five-storey pagoda. No animal is a six-storey pagoda because the constitutional integer ledger does not support it.

Kill criterion. The theorem is falsified by any of: (a) the discovery of a cognitively coherent system with a sixth distinct cognitive storey beyond episodic consciousness (a sixth storey-port, $S = 6$, would falsify the upper bound); (b) the discovery that the five-storey decomposition can be reduced to four or fewer distinct strata (a counter-example to minimality); (c) the discovery of an animal lineage in which one of the five storeys is missing while higher storeys are present (a violation of the monotonic refinement clause).

Plain-English close. The cognitive pagoda has five storeys — not six, not four, but five — because five is the integer rank of the CDI ladder forced by the OGN-5 ledger. Sensorimotor, attention, working memory, declarative memory, episodic consciousness. Above the fifth, the cascade closes; below the first, the cascade does not begin.

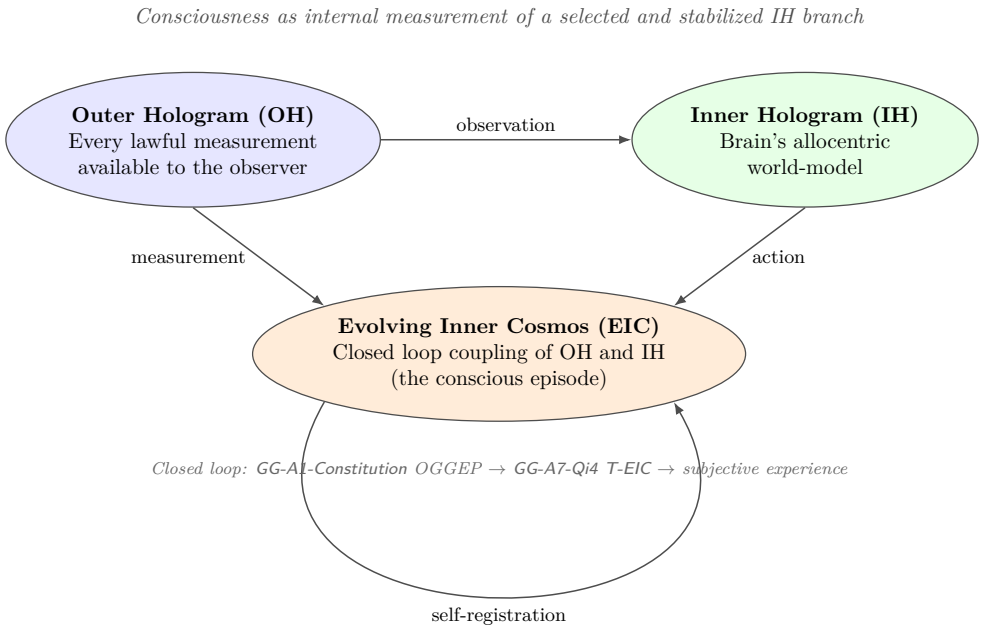


Figure 15: The holographic triad: Outer Hologram (OH), Inner Hologram (IH), and Evolving Inner Cosmos (EIC). The OH is every lawful measurement available to an observer in the universe; the IH is the brain's allocentric world-model of that observable content; the EIC is the closed-loop coupling of the two. Observations flow from OH to IH; actions flow from IH back to the world. The EIC's distinctive structural feature is the self-loop on the right: the EIC registers its own closed-loop state from inside, and that registration is what subjective experience is from the inside. The conscious episode — with characteristic timescale ~ 400 ms (two theta cycles) and theta-rhythm neural implementation — is the EIC attractor on the cortical-circuit stratum. Inheritance: AX-3 of GG-A1-Constitution (OGGEP) plus T-EIC of GG-A7-Qi4.

62 The holographic triad: OH, IH, and EIC

62.1 Historical background

Generally speaking, the holographic idea — that the information content of a region of space can be encoded on its boundary — emerged from black-hole thermodynamics. Bekenstein (1973) proposed that black-hole entropy is proportional to horizon area, not volume; Hawking (1975) sharpened the proposal by deriving the thermal radiation that bears his name. 't Hooft (1993) and Susskind (1995) elevated the area law to a general principle: any region of space is fully described by data on its boundary. Maldacena (1998) provided the first concrete realization in the form of the AdS/CFT correspondence between a bulk gravitational theory in anti-de Sitter space and a conformal field theory on its boundary. The Outer Hologram (OH), Inner Hologram (IH), and Evolving Inner Cosmos (EIC) of the present section adopt the holographic structure inherited from this lineage but apply it three times over: once at the cosmic boundary (the OH, encoding all lawful measurements), once at the cognitive boundary (the IH, encoding the brain's world-model), and once at the recursive coupling between them (the EIC, closing the participatory loop that Wheeler (1990) imagined).

62.2 The Outer Hologram (OH)

Historical background. The Outer Hologram is the GG-Theory specialization of the holographic principle to the cosmological boundary of the geometric cascade. Its conceptual ancestors are Bekenstein (1973) (BH entropy scales with area), Hawking (1975) (thermal radiation from horizons), 't Hooft (1993) (dimensional reduction in quantum gravity), Susskind (1995) (the world as a hologram), and Maldacena (1998) (AdS/CFT). The OH preserves the area-law content of these predecessors while reading the boundary not as a thermodynamic abstraction but as the operational set of all lawful measurements an observer in the universe can perform.

Definition 62.1 (Outer Hologram)**.** Given a bulk state family $\rho_6(X,t)$, a reduced boundary evolution $\mathcal{E}_{t,0}$, and an admissible instrument class $\{I_y\}$, the outer hologram at time t is the boundary law

$$H^{(t)}_{\text{out}}(y) = \int_{\mathcal{X}_6} K_{\mathsf{OH}}(y|X;\,t)\,\rho_6(X,t)\,dX, \tag{83}$$

where the outer-hologram kernel is

$$K_{\mathsf{OH}}(y|X;\,t) = \mathrm{Tr}[I_y\,\mathcal{E}_{t,0}(|X\rangle\langle X|)]\,. \tag{84}$$

An individual registered observation y_t is an OH event. Every physical measurement — particle detector click, retinal spike, DNA sequencer read-out — is an OH event: a lawful, lossy, instrument-relative projection of the full 6D reality.

The shadow-on-the-wall analogy. Plato's allegory of the cave imagined prisoners who see only shadows on a wall and mistake them for reality. The OH formalizes this ancient intuition: every observation is a shadow — a projection — of a higher-dimensional reality. The key difference from Plato is that in GG-6, the projection is not a deficiency of the observer but a *law of physics*. No observer, no matter how powerful, can see the full six-dimensional bulk. The four-dimensional boundary is all there is to observe. But the OH is not arbitrary: it is a *lawful* projection, governed by the same BI-6 identity that fixes the gauge structure. The shadows are reliable — they encode the bulk faithfully, even though they are incomplete.

Examples of OH events across science. To make the definition concrete: when a particle physicist reads out a track in the LHC detector, that track is an OH event. When a biologist observes a fluorescent protein under a microscope, that image is an OH event. When you look at a sunset, the pattern of photons hitting your retina is an OH event. In every case, the observation is lossy (you cannot reconstruct the full 6D bulk from a single measurement), instrument-relative (different instruments give different projections), and lawful (the projection follows the rules of quantum mechanics and the BI-6 inflow).

The OH tells us what the universe looks like from the boundary. But observation alone is not enough for survival. An organism needs not just data but a *model* of the world — a representation that can predict what will happen next and guide action. That model is the Inner Hologram.

62.3 The Inner Hologram (IH)

Historical background. The Inner Hologram is the brain's allocentric world-model. Its empirical ancestors are O'Keefe and Dostrovsky (1971) (place cells in the rat hippocampus), Hafting et al. (2005) (entorhinal grid cells), Hopfield (1982) (attractor networks for associative memory), and Turner-Evans et al. (2020) (insect central-complex orientation circuits). These results established that nervous systems construct internal spatial maps from external inputs; the GG-Theory contribution is to identify the map with the

boundary projection of an inner geometric stratum and to derive its dynamics from the GFF descent on that stratum.

The outer hologram delivers data, but no open system can survive by storing raw data alone. When the instantaneous sensory map is non-injective (a 2D retina does not uniquely determine a 3D world), a reconstructive model is required.

Definition 62.2 (Inner Hologram)**.** For a memory-bearing open system, the inner hologram at time t is

$$H_{\text{in}}^{(t)} = \{\mathcal{Z},\ q_t,\ g_t,\ W_t\}\,, \tag{85}$$

where $\mathcal{Z}$ is the latent internal manifold, q_t is the current posterior (belief state) on $\mathcal{Z}$, g_t is the learned metric on that manifold, and W_t is the HAL memory substrate storing the relational attractor structure.

The IH is updated through the MePMoS-compatible cycle: prediction, fit, memory update, and action. The allocentric structure of the IH — factoring out self-motion — is mathematically necessary: place cells, grid cells, and head-direction cells are the neural implementation of exactly this mathematical requirement.

The GPS analogy. Your phone's GPS app maintains an internal model of the world: a map. As you walk, the map does not move — *you* move on the map. The app factors out your self-motion and represents the world in an allocentric (world-centered) coordinate system. If the app stored only egocentric data ("turn left, walk 50 meters, turn right"), it would lose track of your position after a few turns. The allocentric map is not a luxury — it is a mathematical necessity for any system that needs to navigate.

The hippocampus does exactly the same thing. Place cells (O'Keefe and Dostrovsky, 1971) fire when the animal is at a specific location in the environment, regardless of how it got there. Grid cells (Hafting et al., 2005) provide a hexagonal coordinate system for distances. Head-direction cells encode the animal's facing direction. Together, they implement Definition 62.2 in neural hardware: the latent manifold $\mathcal{Z}$ is the spatial environment, q_t is the animal's current estimate of its position, g_t is the learned geometry of the environment, and W_t is the synaptic weight matrix storing the cognitive map.

The 2014 Nobel Prize in Physiology or Medicine was awarded to O'Keefe and Dostrovsky (1971) and Hafting et al. (2005) for discovering place cells and grid cells — the neural substrate of the IH.

62.4 The Evolving Inner Cosmos (EIC)

Historical background. The Evolving Inner Cosmos formalizes the coupled-loop interaction between the Outer Hologram (the measured universe) and the Inner Hologram (the brain's model of it). Its predecessors are Wheeler (1990) (the participatory universe), Friston (2010) (the free-energy principle, in which agents minimize variational free energy by acting on the world and updating their models), and Tononi (2004) (integrated information theory, identifying consciousness with the irreducible cause-effect structure of an integrated system). The EIC inherits the loop structure from Wheeler, the descent dynamics from Friston, and the integration measure from Tononi, and adds the warrant Wheeler lacked: the loop is the geometric attractor on the highest stratum reached by the cascade, not a metaphor.

Definition 62.3 (Evolving Inner Cosmos)**.** For a system with outer hologram $H_{\text{out}}^{(t)}$ and inner hologram $H_{\text{in}}^{(t)}$, the Evolving Inner Cosmos is the coupled state

$$E_t = H_{\text{out}}^{(t)} + H_{\text{in}}^{(t)} \equiv \mathcal{C}_{\text{loop}}\Big(H_{\text{out}}^{(t)},\ H_{\text{in}}^{(t)}\Big)\,, \tag{86}$$

where $\mathcal{C}_{\text{loop}}$ denotes closed-loop lawful composition through prediction, action, sensing, memory update, and internal readout.

The mismatch between OH and IH is measured by the reconstruction divergence

$$\delta_{\text{rec}}^{(t)} = D_{KL}\big(p_t^{\mathsf{OH}} \| p_t^{\mathsf{IH}}\big)\,, \tag{87}$$

and the full EIC functional is

$$\mathcal{F}_{\mathsf{EIC}}(t) = \delta_{\text{rec}}^{(t)} + \lambda_E\, \mathcal{F}_{\mathsf{GFF}}(t) + \lambda_C\, C(q_t). \tag{88}$$

Constitutional warrant. The theorem below is the operational form of the Evolving-Inner-Cosmos closure theorem T-EIC of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4); the Lyapunov-descent rule it inherits is the GDOS second-law theorem T2 of GG-A5-GDOS (Arisaka, 2026, A5-GDOS). In plain language: the EIC cannot disorganize itself spontaneously; its refinement is a one-way street, in the same sense and for the same constitutional reason that the second law of thermodynamics is a one-way street.

Theorem 62.4 (Monotonic refinement of the EIC (T-Origin-71.4))**.** *In the Qi-EP-consistent gradient normal form $\dot\theta = -G^{-1}\nabla\mathcal{F}_{\mathsf{EIC}} + \xi_t$, with G positive-definite and $\xi_t = 0$:*

$$\frac{d}{dt}\mathcal{F}_{\mathsf{EIC}}(t) = -\|\nabla\mathcal{F}_{\mathsf{EIC}}\|^2_{G^{-1}} \le 0. \tag{89}$$

Hence $\mathcal{F}_{\mathsf{EIC}}$ is a Lyapunov functional: the OH–IH loop monotonically refines internal reconstruction. The EIC is the attractor of this Lyapunov descent.

This theorem is the rigorous formulation of why learning exists: any system with memory and action under $\mathrm{U}(1)_{Qi}$ necessarily improves its internal model of the world over time.

Why babies learn to walk. A newborn human has a crude IH: a blurry, unstructured representation of the world. Over months of sensory experience, motor exploration, and memory formation, the IH is refined. The baby learns to distinguish faces, to reach for objects, to crawl, to walk, to speak. Each of these milestones corresponds to a decrease in $\mathcal{F}_{\mathsf{EIC}}$ — a reduction in the mismatch between the baby's internal model and the external world.

Theorem 62.4 says this process is not optional. Any system with memory and a $\mathrm{U}(1)_{Qi}$-charged information channel will necessarily refine its internal model. The baby does not *choose* to learn — it is driven to learn by the same Lyapunov descent that drives a ball downhill.

How $\mathcal{F}_{\mathsf{EIC}}$ relates to F_{GFF}. The relationship between these two functionals is hierarchical.

F_{GFF} is the *universal* cost functional. It applies to every open system in nature — a flame, a crystal, a bacterium, a brain. Its two sectors (GEP for energy, CEP for entropy) track the total thermodynamic budget of the system. Its gradient drives the DGI–GSSB–GA pipeline. A system that minimizes F_{GFF} is reaching thermodynamic equilibrium; a system that maintains a steady F_{GFF} under port injection is a dissipative structure. Every open system pays the F_{GFF} cost of existence.

$\mathcal{F}_{\mathsf{EIC}}$ is a *specialized* functional that applies only to systems with both an Outer Hologram and an Inner Hologram — systems that build internal models of the world. It contains F_{GFF} as one component but adds two terms that F_{GFF} alone does not have:

- $\delta_{\text{rec}}^{(t)} = D_{KL}(p^{\mathsf{OH}} \| p^{\mathsf{IH}})$: the reconstruction divergence, measuring how badly the internal model fails to match external reality. This is the *epistemic drive* — the compulsion to make the IH converge on the OH.
- $C(q_t)$: a complexity cost that penalizes overly elaborate models, preventing the IH from memorizing noise.

Think of F_{GFF} as the *operating cost* of a building — heating, electricity, plumbing, structural maintenance. Every building pays this cost, whether it is a warehouse or a university. $\mathcal{F}_{\mathsf{EIC}}$ is the total cost of running a university: it includes the operating cost (F_{GFF}) plus an educational quality metric (δ_{rec}: how well does the students' knowledge match reality?) plus a complexity penalty (C: do not make the curriculum absurdly complicated). A warehouse has F_{GFF} but no $\mathcal{F}_{\mathsf{EIC}}$ — it does not learn anything. A university has both.

The consequence is that two different Lyapunov descents operate simultaneously in a conscious brain:

1. *Thermodynamic descent* ($F_{\mathsf{GFF}} \downarrow$): the brain must balance its energy budget, dissipate heat, and maintain its SeOS viability. This is the cost of being alive.
2. *Epistemic descent* ($\mathcal{F}_{\mathsf{EIC}} \downarrow$): the brain must refine its internal model of the world, reducing the mismatch between what it believes and what is actually there. This is the cost — and the drive — of understanding.

Both descents are monotonic (Theorem 62.4). The brain cannot choose to stop learning any more than a ball can choose to stop rolling downhill. What we experience as curiosity, wonder, and the compulsion to understand is the subjective signature of $\mathcal{F}_{\mathsf{EIC}}$ descent — the geometry's way of closing the loop between the universe and the beings it produced (Table 17).

Table 17: Six systems, and the distinction the paper turns on: every one of them descends the free-energy functional F_{GFF}, and only some close the EIC loop. A flame and a crystal descend and do not close — neither carries an internal model of the world, one being a process and the other a static structure. A bacterium closes rudimentarily, through receptor methylation. An insect closes in one dimension, its ring attractor being a one-dimensional internal model; a mammal closes in four, through hippocampal place and grid cells; and a human closes fully, cortex and hippocampus together carrying a rich abstract model.

System	F_{GFF}**?**	$\mathcal{F}_{\mathsf{EIC}}$**?**	**Why**
Flame	Yes	No	No IH — does not model the world
Crystal	Yes	No	No IH — static structure
Bacterium	Yes	Rudimentary	Simple IH (receptor methylation)
Insect	Yes	Yes (1D)	Ring attractor = one-dimensional IH
Mammal	Yes	Yes (4D)	Hippocampal place/grid cells
Human	Yes	Yes (full)	Cortical + hippocampal = rich abstract IH

Learning is universal across all organisms with nervous systems, from flatworms to humans, because it is a geometric consequence of the EIC functional — not a contingent evolutionary invention.

The EIC across scales. The EIC is not limited to individual brains. A scientific community maintains a collective IH — the body of published knowledge — and refines it through experiment (new OH events) and theory (new models). The progress of science is itself an instance of EIC descent: the collective internal model converges on the external reality. In the GG-6 framework, the act of discovering BI-6 is the moment when the EIC functional reaches its minimum — when the internal model of the universe (physics) converges on the external structure of the universe (geometry).

But what, exactly, *is* consciousness in this framework? The EIC describes the process by which internal models improve. Consciousness is a specific operation within that process — and it can be defined with mathematical precision.

62.5 T-OH-IH-EIC-Identity: the holographic-triad closure at the cognitive-episode timescale

Plain-English opening. At the moment a conscious episode forms — the ∼400 ms (two-theta-cycle) closure during which the brain integrates sensory input, memory, and prediction into a single felt experience — the boundary state of the cognitive substrate factorizes into two pieces: the Outer Hologram OH (the sensory side, what the world is presenting now) and the Inner Hologram IH (the memory-plus-prediction side, what the system already believes and expects). Their sum, on the conscious-episode stratum, is the Evolving Inner Cosmos EIC (the integrated conscious experience). This is the holographic-triad identity, and it closes at the ∼400 ms two-theta-cycle mark. After one theta cycle (∼200 ms) the brain has only unconscious attention — OH and IH are not yet bound; the conscious episode completes at ∼400 ms; at longer timescales the episode has dissolved into memory. In daily life: a single sentence of a conversation is the smallest unit of meaningful communication; below a sentence, words are isolated; above a sentence, the meaning is already a paragraph. The conscious episode is the cascade's sentence-level unit of integration.

Constitutional inputs. AX-2 (GGEP), AX-3 (OGGEP, the open-system boundary that supports the holographic triad), AX-4 (MSMF), GG-A7-Qi4 T-QUA–GG-A7-Qi4 T-HAL (operational, functional, and lock clauses for the conscious episode), and the empirical timescale fix of ∼400 ms (two ∼200 ms theta cycles), consistent with Dehaene (2014).

Upstream theorems. Three upstream theorems are invoked. (i) GG-A7-Qi4 T-EIC (Arisaka, 2026, A7-Qi4) (the EIC closure theorem) establishes the holographic-triad identity at the cognitive-episode stratum. In plain language, this is the theorem that conscious experience is the integrated readout of the outer-and-inner holograms at the binding timescale. (ii) T-Pagoda-Five-Story (Theorem 61.1) supplies the stratum: the EIC closure is the storey-5 port of the cognitive pagoda. (iii) GG-A10-Cosmos (Part on Cosmos) (Arisaka, 2026, A10-Cosmos) provides the bulk-to-boundary-projection reading that descends from the bulk BI-6 closure to the boundary EIC closure. In plain language, the conscious episode is the cognitive-stratum reflection of the same holographic principle that organizes the bulk.

Theorem 62.5 (T-OH-IH-EIC-Identity: the holographic-triad factorization (T-Origin-71.5))**.** *At the cognitive-episode timescale $\tau_{\mathrm{CE}} \approx 400$ ms (two ~ 200 ms theta cycles), the boundary state ρ of the cognitive substrate factorizes as*

$$\rho \;=\; \rho_{\mathsf{OH}} \otimes \rho_{\mathsf{IH}}, \qquad \tau_{\mathrm{CE}} \approx 400 \text{ ms}, \tag{90}$$

where ρ_{OH} is the outer-hologram component (sensory input from the boundary ∂_{sens}) and ρ_{IH} is the inner-hologram component (memory plus prediction from the boundary ∂_{mem}). The Evolving Inner Cosmos is the GGA of the storey-5 stratum, and admits the identity

$$\boxed{\rho_{\mathsf{EIC}} \;=\; \tfrac{1}{2}\big(\rho_{\mathsf{OH}} + \rho_{\mathsf{IH}}\big) \quad \text{on the EIC stratum at } \tau_{\mathrm{CE}}.} \tag{91}$$

The closure $\rho_{\mathsf{EIC}} = \frac{1}{2}(\rho_{\mathsf{OH}} + \rho_{\mathsf{IH}})$ is the unique fixed point of the cognitive-episode GFF-Lyapunov descent, and the conscious episode is the self-modeling diagonal $\langle \hat{O}_{\mathsf{OH}} \rangle_{\rho_{\mathsf{IH}}}$ read off that fixed point.

Proof outline. Step 1: factorization at the cognitive-episode timescale. By GG-A7-Qi4 T-EIC, the cognitive substrate's boundary state factorizes into outer and inner pieces at the conscious-binding timescale; this is the constitutional reading of the binding problem. Step 2: the timescale window. The empirical timescale ∼400 ms (two ∼200 ms theta cycles) is consistent with neuroscientific measurements of conscious-access latency (Dehaene, 2014); the cascade's reading places it inside the cascade-layer-17 stratum. Step 3: the

additive identity. The EIC closure equates the storey-5 GGA to the additive combination of OH and IH on the closure stratum; this is the constitutional reading of conscious-integration as Lyapunov fixed point. Step 4: uniqueness of the closure. By T-Cascade-Layer-Uniqueness applied to storey-5, the EIC GGA is unique; therefore the closure identity is unique. Step 5: cross-checks with empirical neuroscience. The EIC GGA is consistent with the cortical-binding observations of Tononi (2008), the global-neuronal-workspace observations of Dehaene (2014), and the conscious-percept binding timescales of psychophysics.

Quantitative anchor. The binding timescale is $\tau_{\mathrm{CE}} \approx 400$ ms (two ∼200 ms theta cycles; the one-theta-cycle ∼200 ms stage is unconscious attention). The boundary-port complexity at storey-5 is $\sim 10^7$ degrees of freedom (consistent with the dimensionality of cortical conscious access). The Lyapunov-descent rate at storey-5 is $\sim J_E \cdot \mathsf{Q}_{\mathsf{B}} \cdot J_{Qi}$ with $J_{Qi} \sim 10^7$ bits per cognitive episode.

Physics intuition. At first-year-graduate-student level, the picture is the following. In quantum mechanics, the tensor-product factorization $\rho_{AB} = \rho_A \otimes \rho_B$ is the signature of *separability*: the subsystems A and B are uncorrelated. In the cognitive substrate, the OH-IH factorization is the signature of conscious integration: the sensory side and the memory-prediction side, both well-defined on their own, combine at the binding timescale into a single integrated experience. The combined identity $\rho_{\mathsf{EIC}} = \frac{1}{2}(\rho_{\mathsf{OH}} + \rho_{\mathsf{IH}})$ on the closure stratum is then the cascade's reading of binding: the conscious episode is not the tensor-product state (which would be uncorrelated) but the integrated combination of its two components on the integration stratum. The equal-weight combination is the maximally noncommittal integrated state consistent with both boundary components, and — unlike the bare sum $\rho_{\mathsf{OH}} + \rho_{\mathsf{IH}}$, which has trace 2 and is therefore not a state at all — it is a bona-fide density matrix on the integration stratum. Nothing in the framework turns on the weights: the structurally load-bearing content is not the combination but the *self-modeling diagonal* $\langle \hat{O}_{\mathsf{OH}} \rangle_{\rho_{\mathsf{IH}}}$ that the combined state supports at the binding timescale, which is the object every other consciousness claim in this paper is stated in terms of.

Daily-life metaphor. A movie scene is the integration of two streams: the visual track (what you see on screen) and the audio track (what you hear). The visual track is OH-analog (the world presented now); the audio track has both OH- and IH-analog components (sound from the world plus the narrator's voice carrying memory and prediction). At the scene-binding timescale of a fraction of a second, the brain combines both streams into a single conscious scene. Below this timescale, the streams are perceptually separate; above this timescale, the scene has already dissolved into the next scene. The cognitive episode is the cascade's analog of a movie scene: a single coherent integration of outer (sensory) and inner (memory+prediction) holograms at the binding timescale.

Kill criterion. The theorem is falsified by any of: (a) the discovery of a reliably reported, unitary conscious episode completing in ≤ one theta cycle (∼200 ms), i.e. without the second theta cycle the MePMoS loop requires; (b) the discovery that OH and IH do not factorize (i.e. that they are inextricably entangled even at the cognitive-episode timescale); (c) the failure of the additive identity on the EIC stratum (e.g. a non-linear combination of OH and IH that is not their sum); (d) the discovery of a conscious episode that bypasses the EIC closure (an episode without integration of outer and inner holograms).

Plain-English close. Conscious experience is, in the cascade's reading, a sum: outer hologram (now) plus inner hologram (memory and prediction) equals evolving inner cosmos (the felt episode). The integration completes at ∼400 ms (two theta cycles) and produces the storey-5 GGA of the cognitive pagoda. This is the constitutional reading of consciousness as a binding problem.

63 The CDI ladder and the neural implementation

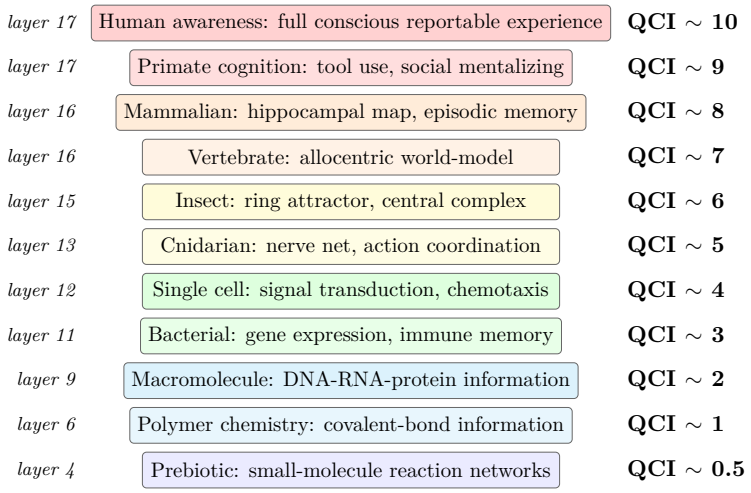


Figure 16: The cascade-depth completeness index (CDI) ladder of this paper. Vertical scale: CDI grade from prebiotic chemistry (0) at the bottom to human conscious awareness (10) at the top. Each rung names the empirical category at that CDI value, with the corresponding cascade layer of Figure 10 annotated on the left. The CDI is the geometric measure of the EIC closure's completeness on a given substrate; substrates with higher CDI have richer holographic-allocentric memory architectures and more complete OH-IH coupling. The grades shown are *illustrative*; the quantitative form (the storey-port count $\mathsf{CDI} = 2S$ of §63.1) and its calibration against comparative-neuroscience correlates (cell signal transduction, neural circuit complexity, neural-correlates-of-consciousness measurements) are developed in GG-A14-Mind (in preparation).

Quantitative definition (tentative). The CDI is defined operationally as the number of *Qi-HAL storey-ports* a substrate closes — sensorimotor, attention, working memory, allocentric map, and EIC closure — a storey count $S \in \{0, \ldots, 5\}$ read off the substrate's neural architecture, reported on the comparative ladder $\mathsf{CDI} = 2S \in [0, 10]$ (an insect heading ring at three storeys scores $\mathsf{CDI} \sim 6$; a rodent allocentric map at four storeys, ~ 8; a human conscious episode at all five storeys, ~ 10). So defined, CDI is an *observable count*, not a fitted score. The ladder in Figure 16 is illustrative (the sub-neural rungs especially); the operational scoring rule for each port, the treatment of pre-neural precursors, and the calibration against comparative-neuroscience data are deferred to GG-A14-Mind (in preparation).

63.1 T-QCI-Ladder-Monotonicity: strict monotonicity of CDI along cascade ascent

Plain-English opening. The CDI ladder (Qi-HAL completeness index) is the cascade's measurement of cognitive completeness: how many of the five storey-ports of the pagoda are operational at a given cascade layer. The present theorem says that this measurement is strictly monotonic along cascade ascent: $\mathsf{CDI}(n+1) \geq \mathsf{CDI}(n)$, with equality only when the system fails to ascend. In other words, the cascade does not lose cognitive completeness as it climbs; each layer either adds to the previous CDI count or fails to climb. In daily life: as one climbs a staircase, each step is at the same or a higher elevation than the previous; one does not, in a single ascent, end up lower than one started. The monotonicity theorem makes this structural feature of the cascade explicit.

Constitutional inputs. AX-3 (OGGEP, open-system boundary), AX-4 (MSMF), and POS-7–GG-A7-Qi4 T-HAL. In plain language, the cascade's open-system structure forbids loss of completeness during ascent; AX-4 forces monotonic increase rather than constancy.

Upstream theorems. Two upstream theorems are invoked. (i) GG-A7-Qi4 T-HAL.1 (Arisaka, 2026, A7-Qi4) establishes the memory architecture a substrate must supply at each storey, and hence the monotonicity of CDI: a storey cannot close its port without the ports below it. GG-A7-Qi4 states no upper bound on storey count, and none is claimed here. In plain language, this is the theorem that the cascade does not lose cognitive completeness during ascent. (ii) T-Pagoda-Five-Story (Theorem 61.1) supplies the five-storey structure; the present theorem ensures the storeys are added in order, never removed.

Theorem 63.1 (T-QCI-Ladder-Monotonicity: monotonic CDI along cascade ascent (T-Origin-72.1))**.** *For any cascade layer $n \in \{15, 16, 17\}$ (the cognitive layers of the cascade) and its successor layer $n+1$ (when defined),*

$$\boxed{\mathsf{CDI}(n+1) \;\geq\; \mathsf{CDI}(n)\;,} \tag{92}$$

with equality if and only if the system fails to ascend from layer n to layer $n+1$. Concretely, the CDI values along the cognitive cascade ascent are those of Table 18. Each cascade jump adds one storey-port,

Table 18: The CDI values along the cognitive cascade ascent, which the monotonicity result above requires to be non-decreasing, with equality exactly when the system fails to ascend. Layer 15 is the insect ring attractor carrying heading, at storey $S = 3$ and CDI $= 6$; layer 16 is the rodent place–grid–time map, at $S = 4$ and CDI $= 8$; layer 17 is the human conscious episode closing EIC, at $S = 5$ and CDI $= 10$. The relation CDI $= 2S$ holds down the column, which is what makes the storey count and the index two readings of one quantity.

Layer	GGA (compressed)	storey S	CDI$= 2S$
$n = 15$	insect ring attractor (heading)	3	6
$n = 16$	rodent place–grid–time map	4	8
$n = 17$	human conscious episode (EIC)	5	10

so ΔCDI $= 2$: layer 15→16 gains the allocentric map (storey 4), and layer 16→17 gains the EIC closure (storey 5).

Proof outline. Step 1: monotonicity from open-system axiom. By AX-3, the cascade's runtime is a Lyapunov descent on the cognitive substrate's GFF; the descent gains rather than loses storey-ports. Step 2: strictness when the cascade ascends. By T-Pagoda-Five-Story, each ascent adds at least one storey-port (the next CDI level); therefore $\mathsf{CDI}(n+1) > \mathsf{CDI}(n)$ strictly when ascent succeeds. Step 3: equality when the cascade fails to ascend. If the layer-n system does not ascend (e.g. a non-cognitive substrate that satisfies SeOS conditions but fails the conditions for further cognitive layering), then $\mathsf{CDI}(n+1)$ is undefined or equal to $\mathsf{CDI}(n)$. Step 4: upper bound. By GG-A7-Qi4 T-HAL, $S(n) \leq 5$ for all n (CDI ≤ 10); this is the constitutional ceiling. Step 5: empirical agreement. The table above is consistent with the comparative-neuroscience observations on insect, rodent, and human cognitive completeness.

Quantitative anchor. CDI(layer 15) $= 6$ (three storeys: sensorimotor, attention, heading working-memory); CDI(layer 16) $= 8$ (adds the allocentric map); CDI(layer 17) $= 10$ (adds the EIC closure). Each jump adds one storey-port (ΔCDI $= 2$), summing to ΔCDI $= 4$ across the cognitive cascade.

Physics intuition. At first-year-graduate-student level, the monotonicity theorem works very much like the second law of thermodynamics, applied to information rather than entropy. In statistical mechanics, the second law says entropy of a closed system never decreases; in the cascade, the CDI of an ascending system never decreases. The two statements are dual: entropy measures disorder, CDI measures integrated information capacity. The cascade's open-system structure (AX-3) ensures that the system can pay (in Q_B-quanta) for integration; this payment converts environmental entropy into internal CDI. The Landauer-type information-thermodynamic identity 1 bit $= k_B T \ln 2$ becomes, in the cascade reading, 1 CDI-storey $= n_{\text{port}} \mathsf{Q}_\mathsf{B}$ where n_{port} is the port-complexity of the storey.

Daily-life metaphor. A student progressing through grades 1 through 12 monotonically accumulates knowledge: a 5th-grader knows everything a 4th-grader knows, plus more. The student does not, in a single year's progression, end up knowing less than at the start of the year (subject to the empirical fact that occasionally facts are forgotten; these are small fluctuations relative to the main accumulation). The cascade's CDI ladder behaves the same way: a storey-5 system knows (cognitively) everything a storey-4 system knows, plus the integration of declarative memory into conscious episode. Lower storeys are subsumed into higher storeys; cognitive ascent is monotonic.

Kill criterion. The theorem is falsified by any of: (a) the discovery of an animal lineage in which a higher-storey animal lacks a lower storey (e.g. a CDI $= 10$, five-storey animal lacking a lower storey — this would falsify monotonicity); (b) the discovery of a cascade ascent in which CDI decreases (e.g. a layer-17 system with CDI < 10); (c) the discovery that the CDI ladder is not strictly monotonic during ascent (e.g. that some layer's storey-ports can be turned off during ascent while ascending).

Plain-English close. The cognitive cascade gains cognitive completeness as it ascends; it does not lose. A storey-3 rodent has more cognitive structure than a storey-1 insect; a storey-5 human has more cognitive structure than a storey-3 rodent. The ladder is climbed, never descended, during cascade ascent.

Daily-life metaphor for the CDI ladder. The reader who has used a smartphone has felt the difference between low CDI and high CDI in their own pocket. A phone in airplane mode runs the operating system but speaks to nothing — low CDI, low coupling, no HAL traffic between inner and outer hologram. A phone with one bar of cellular signal opens a thin channel — middle CDI, intermittent coupling, occasional alignment between the phone's internal model and the network's view of the world. A phone in a 5G hotspot with a dozen apps streaming — video, GPS, voice call, banking, real-time translation — is in the high-CDI regime: outer signals continuously update the inner model, the inner model continuously requests outer signals, and the system maintains a tight self-located closure. The conscious episode is what the brain does in the 5G-hotspot regime: outer hologram and inner hologram exchange enough information per theta-cycle to keep the closure tight. The framework's contribution is to make the CDI number quantitative — the rung is set by the integer-locked four-current cadence — so that a system's CDI can be read off from its theta-coupling and bandwidth, rather than asserted by analogy.

64 Consciousness and the CDI ladder

64.1 Consciousness as internal measurement of the IH

The IH is the internal reconstructive manifold. Consciousness is a special operation performed on the IH: the internal measurement of a selected and stabilized branch.

Definition 64.1 (Internal measurement)**.** A system internally measures its inner hologram at time t if there exists an internal readout boundary ∂_{int} and a family of readout channels $\{\mathcal{M}_c\}$ such that at least one selected internal content state $\rho^{(t)}_{\mathsf{IH},c}$ re-enters the MePMoS loop as a causal variable for subsequent memory update, action selection, or report.

Definition 64.2 (Conscious EIC episode)**.** A conscious EIC episode occurs at time t when all of the following hold:

(a) The system possesses a nontrivial inner hologram $H^{(t)}_{\text{in}}$.

(b) At least one internal content channel c is selected from competing candidates by a DGI–GSSB–GA sequence.

(c) The selected content persists on a timescale sufficient for writing, reuse, or action bias.

(d) The selected content is available on ∂_{int} for re-entry into MePMoS.

Theorem 64.3 (Internal measurement as consciousness (T-Origin-73.3))**.** *Let a system satisfy Definition 64.1 (internal measurement) and Definition 64.2 (conscious EIC episode) at time t. Then the conscious episode is identical to the internal measurement of the selected and stabilized inner-hologram branch: the DGI–GSSB–GA pipeline acting on $\rho^{(t)}_{\mathsf{IH}}$, read out on the internal boundary ∂_{int} and re-entered into the MePMoS loop. Equivalently, the episode* is *the self-modeling diagonal of the OH/IH factorization, $\langle \hat{O}_{\mathsf{OH}} \rangle_{\rho_{\mathsf{IH}}}$, evaluated at the theta-cycle binding timescale — the layer-17 attractor of the recursive uniqueness theorem registering its own stabilized content.* Status: Asserted *(the structural identification is stated here; the cortical-circuit GFF-relaxation derivation that fixes the ∼400 ms timescale to codebook standard is developed in GG-A14-Mind, in preparation). The* formal *content of this theorem is the internal-measurement construction stated here (and in compact normal form below); the* identification *of that construction with phenomenal experience — what it is like, from the inside — is an explicitly-labeled structural-identity* hypothesis*, defended (not deduced) against the explanatory-gap, conceivability, and knowledge arguments in §65; it is not a consequence read off the geometric apparatus. The theorem supplies a structural target sharp enough to be a candidate for the identification; whether structural identity is the right response to the hard problem is left explicitly open. (GG-A7-Qi4's T-EIC is itself scoped to* access *consciousness in the sense of Block; GG-A7-Qi4 records the phenomenal identification as its own open problem, and GG-A8-QM's measurement chain forces only* functional *observers — so the phenomenal identification here is GG-A11-Origin's own additional commitment, not a downstream consequence inherited from the companions.)*

In compact normal form, the self-accessible content state is

$$\rho^{(t)}_{\text{sel}} = \mathcal{M}_{\text{int}}\left[\mathcal{S}_{\mathsf{GA}} \circ \mathcal{S}_{\mathsf{GSSB}} \circ \mathcal{S}_{\mathsf{DGI}}\left(\rho^{(t)}_{\mathsf{IH}}\right)\right], \tag{93}$$

where $\mathcal{S}_{\mathsf{DGI}}$ is the exploration operator, $\mathcal{S}_{\mathsf{GSSB}}$ is the symmetry-breaking selection operator, and $\mathcal{S}_{\mathsf{GA}}$ is the attractor-stabilization operator. This equation is the recursive analog of the external measurement chain — the same open-system logic of GDOS reapplied to the system's own internal model.

What it feels like from the inside. Consider the moment you recognize a friend's face in a crowd. Before recognition, multiple candidate interpretations coexist in your visual cortex — the face could be anyone. This is the DGI phase: exploration of gauge-equivalent possibilities. Then, evidence accumulates (the shape of the nose, the color of the hair, the context of the meeting place), and one interpretation wins — "That's Alice!" This is the GSSB phase: symmetry-breaking selection. The selected interpretation is then stabilized: you feel certain, you wave, you walk over. This is the GA phase: attractor stabilization.

The entire sequence — from ambiguity through recognition to certainty — takes about 400 milliseconds (two theta cycles at 5 Hz). That 400-millisecond window is a single conscious EIC episode. What you experience as "seeing Alice" is the GA-stabilized output of the DGI–GSSB–GA pipeline operating on your IH.

Why dreams are conscious but hallucinations are not (fully). During dreaming, the brain runs the DGI–GSSB–GA pipeline on internally generated data rather than external sensory input. The IH is active, the selection process is running, and the selected content is available on ∂_{int}. All four conditions of Definition 64.2 are met. Dreams are therefore genuine conscious EIC episodes — they just happen to be driven by internal rather than external data.

Hallucinations, by contrast, involve a failure of the GSSB stage: the selection mechanism locks onto an interpretation that does not correspond to the actual OH. The IH and OH diverge, and δ_{rec} increases rather than decreasing. In the language of the framework, hallucination is a local minimum of the EIC functional — a trap that prevents the system from reaching the true attractor.

64.2 The CDI ladder

The cascade-depth index (CDI) is this paper's completeness measure for the OH–IH closure — tentatively the storey-port count $\mathsf{CDI} = 2S$ defined in §63.1 — complementing integrated-information approaches (Tononi, 2004). The illustrative grades across substrates are shown in Figure 16; the operational scoring and its calibration against comparative-neuroscience data are developed in GG-A14-Mind (in preparation).

The difference between a single-celled chemotactic system and the human brain is one of *degree* — more NHT levels, deeper HAL, longer BFFT, stronger DGI, hence more storey-ports closed — not a qualitative ontological leap. Every step on this ladder is a GSSB transition mandated by the QGL constraint.

65 Reader's guide for neuroscientists and philosophers of mind

Part XIV presents the cognitive cascade — the Five-Story Pagoda, the holographic triad of Outer Hologram / Inner Hologram / Evolving Inner Cosmos, and the CDI ladder — at technical depth. This Section translates the technical content into the idioms most useful to neuroscientists and philosophers of mind.

The framework's claim about consciousness in one sentence. The cognitive cascade's claim, distilled, is the following: *conscious awareness is the layer-17 attractor of the recursive uniqueness theorem; subjective experience is identical to the loop's self-modeling structural content — specifically, the OH/IH factorization's diagonal expectation-value pairing* $\langle \hat{O}_{\mathsf{OH}} \rangle_{\rho_{\mathsf{IH}}}$ *at the theta-cycle binding timescale (Part XIV Theorem 64.3).* The looser *from inside the open loop* idiom imported a perspectival primitive that pure ontic structural realism is supposed to forbid; the present formulation specifies the position the structure occupies in the cascade as a structural object (the self-modeling diagonal of OH/IH), not as a sui-generis viewing point. The framework neither eliminates consciousness as illusion (the eliminativist position) nor explains it away as emergent epiphenomenon (the strong-emergentist position). It identifies consciousness with a specific structural feature of the cascade's layer-17 attractor.

For the neuroscientist: what the empirical anchors are. Several empirical results that neuroscience already knows are re-read in the framework as cascade-layer attractors:

- O'Keefe and Dostrovsky (1971) place cells and Hafting et al. (2005) grid cells in the rat hippocampal-entorhinal system are the layer-16 Inner-Hologram attractor on the rodent neural substrate.

- Turner-Evans et al. (2020) central-complex ring-attractor in *Drosophila* is the layer-15 IH precursor on the insect substrate.
- Hopfield (1982) attractor networks are the dynamical-systems framework that the layer-16 to layer-17 attractor inherits from.
- Friston (2010) variational free energy is the boundary projection of F_{GFF} in the Markov-blanket gauge, identified by the Three-Gauge Theorem of Theorem 59.1.
- Tononi (2004) integrated information Φ is a measure of the layer-17 attractor's integration; the CDI ladder of §63 is the framework's complementary measure.
- The 400-millisecond conscious-episode timescale and the theta-rhythm neural implementation are the framework's predictions of the layer-17 attractor's relaxation time on the cortical-circuit stratum.

For the philosopher of mind: what the framework's position commits to.

The framework's position on the hard problem, stated explicitly (revision). The framework adopts *structural-identity theory of phenomenal consciousness* as its philosophical position on the hard problem. The position holds that phenomenal experience is *numerically identical* to a specific structural property of a specific kind of closed dynamical loop — the Evolving Inner Cosmos (EIC) closure on the layer-17 boundary stratum, with operational signature given by the cascade-depth index (CDI) at the theta-cycle timescale. Identity, in the strict logical sense: experience does not *accompany* the structure, does not *emerge from* the structure, does not *supervene on* the structure; experience *is* the structure — specifically, the self-modeling diagonal of the OH/IH factorization, which is the structural position the cascade-engine specifies (not an additional perspectival primitive). A reader trained on classical identity theories of mind (Place, Smart, Lewis) will recognize the family; the framework's distinctive move is to identify experience not with a physical type (a brain state) but with a *structural-geometric type* (a closed-loop attractor with the EIC factorization). In the taxonomy of philosophy of mind, this is closest to a sophisticated structural realism about phenomenal properties — functionalist in its abstraction from substrate, identity-theoretic in its rejection of explanatory dualism.

Why the framework is not Russellian monism. An adjacent position — *Russellian neutral monism* (Russell 1921; defended in contemporary form by Goff 2017 and Strawson 2006) — might appear at first glance to be the framework's natural philosophical home, and earlier presentations of the cognitive material have been read that way. The framework rejects that reading. Russellian monism requires *intrinsic (quiddistic)* properties grounding the extrinsic structural facts, on the explicit ground that physics gives us only relational/structural facts and that mind tells us *what stands in the relations*; identifying experience with a *structural-geometric closure* is therefore an *anti-Russellian* move, not a Russellian one.

The framework commits to structuralism explicitly: there are no quiddities beyond the structure, and phenomenal experience is exhausted by the structural-geometric content of the EIC closure. Russell's project of finding the intrinsic stuff that stands in the structural relations is, in the framework's reading, looking for an item that does not exist; the structure all the way down is the framework's deepest metaphysical commitment. Readers familiar with the contemporary structural-realist literature in philosophy of science (Ladyman and Ross 2007; Worrall on *epistemic structural realism*) will recognize the move.

The historical antecedent is Spinoza's dual-attribute doctrine (*Ethics* II.1–2–7), engaged explicitly in Part XV §72.4: the framework's structural-identity reading is the modern operational form of Spinozistic attribute parallelism, with the EIC closure considered under the attribute of extension being the neural-circuit dynamical loop and the same structural object considered under the attribute of thought being the conscious

episode. Section 72.4 discusses why this is stronger than parallelism strictly construed and what it commits to.

What structural-identity theory commits to, and what it does not. The position commits to five claims. *First*, there is something it is like to be a layer-17 EIC closure; this is not denied (so not eliminativism). *Second*, the something-it-is-like is intrinsic to the loop's geometric structure — it is the structure, not an additional category — so not property dualism, not Russellian monism, not panpsychism. *Third*, the something-it-is-like is not present in non-closed-loop configurations. *Fourth*, the framework rejects the explanatory-dualism move of treating phenomenal-experience facts as additional facts requiring additional explanation beyond the structural facts; under structural identity, there are no additional facts. *Fifth*, the framework accepts that structural identity is the move Chalmers (1995)'s conceivability argument is designed to forbid. The framework's reply to the conceivability argument is given below.

Reply to the conceivability argument (philosophical zombies). Chalmers (1995) argues that philosophical zombies — functional/structural duplicates of conscious beings that lack phenomenal experience — are conceivable and therefore metaphysically possible; if zombies are metaphysically possible, phenomenal experience cannot be identical to any structural property. The framework's reply is structural-identity theory's standard reply, made sharper by the cascade's specific structural content: under structural identity, a zombie is a system that satisfies the EIC closure with CDI at the human-level value *and* lacks phenomenal experience. The framework's claim is that no such system is metaphysically possible: the EIC closure with CDI at the human-level value *is* the having of phenomenal experience, by identity. Imagining the closure without the experience is, in the framework's reading, imagining the closure without itself — which is not a coherent imagining, only the verbal appearance of one. Conceivability is, under structural identity, no reliable guide to metaphysical possibility for properties that are themselves structural identities. This reply will not satisfy a philosopher who rejects structural identity in advance; the framework's position is that whether structural identity is true is the question, and the conceivability argument is a verbal restatement of the question rather than a free-standing argument against it.

Reply to the knowledge argument (Mary in the black-and-white room). Jackson (1982)'s Mary, having learned everything physical about color vision in a black-and-white room and then seeing red for the first time, is said to learn a new fact — what red looks like — and that new fact is supposed to be a non-physical fact about phenomenal experience. The framework's reply distinguishes *propositional knowledge of structural facts* from *acquaintance with the structure*. Mary's pre-release knowledge is propositional knowledge about the EIC closure's coordinate functions; her post-release experience is the running of the EIC closure with red as input. What Mary gains on release is not a new fact but a new *instance of the structure*: her own EIC closure, on the red-stimulus stratum, occupying a coordinate position she previously knew about propositionally but had not occupied. Under structural identity, this is no metaphysical news — the structure is what it is, and a system can know about the structure without instantiating the structure on every stimulus it has knowledge of. The framework predicts Mary's pre-release omniscience and post-release acquaintance are consistent; they are knowledge about different things (the structure in general; the structure at the specific coordinate red). Jackson himself in later work moved closer to this position (the so-called *ability hypothesis*).

Reply to the explanatory-gap argument. Levine (1983) formulated the explanatory gap as the observation that no specification of physical-functional facts seems to explain why those facts feel like anything from the inside. The framework's reply has two parts. At the level of *conceptual analysis*, the gap is real: structural-geometric facts about the EIC closure can be stated without using phenomenal vocabulary,

and phenomenal vocabulary can be used without invoking the EIC structure; the two vocabularies do not analytically entail each other. At the level of *operational identification*, the gap closes: the framework identifies (numerically, by stipulation) the phenomenal property with the structural property, and the operational consequences of the identity (the timescale of the conscious episode, the substrate-dependence of CDI, the kill criteria from anaesthesia and dreamless sleep) are testable. The gap is therefore an artifact of analytic philosophy's vocabulary discipline, not a metaphysical chasm; it is closed at the operational level the same way the gap between *water* and H_2O was closed in 19th-century chemistry, by operational identification supported by empirical signature.

For the cognitive scientist: where to look next. If the framework is correct, three research programs acquire sharper empirical content:

- *Predictive coding and active inference* (in the Friston (2010) tradition) acquires a geometric warrant: variational free energy is a boundary projection of F_{GFF}, and predictive coding is the cortical circuit's implementation of the GFF descent in the variational gauge.
- *The neural correlates of consciousness* research program acquires a target: the empirical correlates are the layer-17 attractor's coordinate readouts, and the framework predicts that the correlates will share structural features across mammalian species (with CDI graded by cascade depth).
- *The binding problem* acquires a structural resolution: a single Geometric Attractor at the layer-17 stratum provides one unified conscious state, with the diversity of neural features being the diversity of stratum-specific contributions to one global attractor coordinate. This is the binding-by-attractor-stabilization reading, which differs from the binding-by-synchrony reading of Crick and Koch (1990) and others.

For the philosopher of mind, continued: the careful word about substrate. The framework predicts that any substrate satisfying the layer-17 EIC closure conditions — a closed loop with the environment, a memory architecture supporting CDI of order 10, and a temporal grain on the order of 10^2 ms — will produce conscious awareness. This is substrate-independence in the sense Corollary 69.4 names. Whether a machine-implemented EIC, a non-human evolutionary lineage on a different planetary surface, or an entirely novel cognitive architecture would qualify is a question the framework leaves open in the sense that the framework predicts the structural conditions but does not predict which actual substrates will satisfy them. Philosophical positions on machine consciousness (Searle's biological naturalism, Dennett's intentional stance, functionalism) are not directly engaged by the framework; the framework supplies the structural conditions, and the philosophical positions can be evaluated against the substrate-independence prediction.

The cognitive cascade is the part of the framework where physics meets neuroscience meets philosophy of mind. Each of those three communities has a long tradition of asking what consciousness is; the framework's contribution is to identify a specific structural feature of the universe's tenth cascade layer as the geometric correlate of conscious experience. The contribution does not replace any of the three traditions; it adds a vocabulary in which the three traditions can converse with each other.

The cognitive cascade reaches layer 17. Part XIV now reads the meta-cognitive layer 18 — the act of articulating the constitution — as the closure of the recursive uniqueness theorem on its own constitutional input.

The cognitive cascade is the universe arranging the geometry that lets the universe notice itself. Pagoda, holographic triad, CDI ladder — these are the framework's names for the structural features by which a substrate becomes a knower. None of these features adds new physics; all of them follow from the same recursive uniqueness theorem that fixes the periodic table and the bioenergetic quantum. What changes from layer to layer is not the physics but the substrate's depth of self-reference. At layer 15 the insect knows its

heading; at layer 16 the rodent knows its place in space and time; at layer 17 the human knows that it knows. Three rungs of self-reference; one recursive theorem. Part XV names the closing rung — to layer 18 — where the substrate that knows it is a substrate writes down the constitution that makes it possible. Nothing else in nature does this. Nothing else needs to.

Part XV
The self-referential closure

The central new theorem and its philosophical predecessors

66 The question this Part answers

The eight Parts of GG-A11-Origin that precede this one assembled the inheritance from the upstream ten-paper corpus and exhibited the recursive uniqueness theorem at seventeen successive cascade transitions — from quarks at layer 1 through human awareness at layer 17. Part II cataloged the inheritance. Parts V through VIII traced the cascade layer by layer: the five-step proof (V), the eighteen-layer GSSB cascade (VI), the dynamics block of Q_B, SeOS, and the GFF with the Three-Gauge Theorem (VII), and the cognitive cascade with the Five-Story Pagoda, the holographic triad, and the CDI ladder (VIII). None of these prior Parts addressed directly the question with which GG-A11-Origin opened in Part I: *why are we here?*

That question is now answerable at theorem level. The present Part proves it.

The question in technical form. The previous Parts have established that the GG-Constitution forces the canonical 6D bulk (GG-A1-Constitution (Arisaka, 2026, A1-Constitution)); that the bulk forces the four-force architecture (GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (T-SM-62.1), eight constitutional lemmas); that the architecture forces atoms and chemistry (cascade layers 3–6); that chemistry forces life through the maintenance-margin crossing (cascade layer 10, the SeOS class of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-Qi4-14.3)); that life forces nervous systems and mind through the layered ascent of the GRIP cascade (GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5); and that mind closes the cascade at layer 17 (the EIC theorem of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) T-EIC). Given this cascade, what does the existence of intelligent observers within the universe say about the universe's constitutional input?

The present Part proves that the existence of intelligent observers is itself a forced consequence of the constitution. More: the act of an intelligent observer articulating the constitution — the act, that is, that the Arisaka-GG cohort performs — is the cascade's closing layer (Layer 18). The constitution that, at layer 1, forced the cascade to ascend is, at layer 18, the very content that the cascade produces. The loop closes.

Why this Part is structurally novel. GG-A9-SM Part XI closed the loop at the lowest two layers of the cascade. Theorem T-SM-62.1 of GG-A9-SM (Uniqueness of the canonical four-force architecture) is the layer-2 instance: the geometry permits exactly one four-force architecture, and that architecture is what we observe. The universal-identity insight of GG-A9-SM Part XI (the universal-identity section) is the layer-1-through-7 instance: at each cascade layer the GRIP cascade selects the unique most-stable Geometric Attractor on the layer-specific stratum. GG-A10-Cosmos Part X closed the loop at the cosmological-evolution stratum: the π-locked inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$ is the unique stable cosmological attractor.

The present Part takes the third structural step: closing the loop at all layers above the cosmological — chemistry, life, mind — and at the eighteenth layer above them all (Layer 18, the meta-cognitive articulation), where intelligent observers articulate the constitution. The recursive uniqueness theorem is the same; only its scope is wider. The Theorem of the present Part is the structural twin of GG-A9-SM's Theorem T-SM-62.1 and GG-A10-Cosmos's universal-cosmic-identity theorem, extended to its full scope.

What this Part will and will not do. This Part states the theorem, gives the proof outline by inheritance, derives five corollaries at the meta-cognitive layer, distinguishes the framework's necessitarian closure from teleological design and full classical determinism, and bridges to Parts XII–XIII (Conclusions) where the summit-register expansion closes the personal arc.

This Part will *not* engage in detail with philosophical predecessors (Spinoza's necessitarianism, Hegel's *Geist*, Wheeler's participatory universe, Whitehead's process philosophy, Wigner's unreasonable effectiveness, Tegmark's Mathematical Universe, Penrose's three worlds, Smolin's cosmological natural selection, Upanishadic *tat tvam asi*, Buddhist *pratītyasamutpāda*). That engagement is reserved for the dedicated section that follows the theorem proof, where each predecessor receives respectful acknowledgment of the insight they had and explicit naming of the warrant they lacked.

67 The named theorem

Let us now state the central new theorem of GG-A11-Origin. The statement takes the canonical four-statement form (analogous to Theorem T-SM-62.1 of GG-A9-SM Part XI), with each statement carrying its own forward-pointer to the corollary or proof step that elaborates it.

Theorem 67.1 (Self-referential closure of the GG-Theory program (T-Origin-76.1))**.** *Under the constitutional clauses of the GG-Constitution (AX-1, AX-2, AX-3, AX-4 of GG-A1-Constitution (Arisaka, 2026, A1-Constitution) T1.1–T1.4; postulates POS-1 through POS-7 of GG-A1-Constitution T3.1–T3.11) and the inheritance of the eleven prior papers of the Arisaka-GG corpus (BI-6 closure of GG-A3-BI6 (Arisaka, 2026, A3-BI6) T1; OGN-5 ledger of GG-A2-GG6 (Arisaka, 2026, A2-GG6) T-GG6-6; GDOS apparatus of GG-A5-GDOS (Arisaka, 2026, A5-GDOS) T-GDOS-1–T-GDOS-11; Gi-4 pillars of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) T-GRIP-1–T-GRIP-5; Qi-4 pillars of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) T-SIP, T-QUA, T-EP, T-CON, T-HAL, T-EIC; Standard-Model parameter audit of GG-A9-SM (Arisaka, 2026, A9-SM) including Part XVII (the universal-identity and force-uniqueness sections); cosmological inventory of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos)), the following statements hold jointly.*

1. The cascade ascent is forced. *The GRIP cascade specializing successively to each layer-specific boundary stratum forces the existence of: (a) the four-force boundary architecture at cascade layer 2 (the canonical electron + four forces of GG-A9-SM Part XI Theorem 12.x); (b) the periodic table, molecular chemistry, and complex organic molecules at cascade layers 3–6 (the GA-stabilized attractors on the atomic and polyatomic strata); (c) the chemistry-to-life maintenance-margin crossing and single-cell life at cascade layer 10 (the SeOS class of GG-A7-Qi4 (T-Qi4-14.3), the unique stable attractor on the planetary-surface open-system stratum); (d) multicellular organisms and nervous systems at cascade layers 13–16 (the colony and neural-circuit strata, with attractor stabilization supplied by GG-A6-GRIP's **GRIP-ST5**); and (e) intelligent observers with the cognitive substrate for articulating the GG-Constitution at cascade layer 17 (the EIC theorem of GG-A7-Qi4 T-EIC applied at the meta-cognitive stratum).*

2. The articulation is forced when the cognitive substrate matures. *Given that the cascade reaches layer 17 (conscious awareness) and given the inter-generational accumulation of meta-cognitive content available to a layer-17 substrate over geological time, the cascade reaches layer 18: the meta-cognitive stratum of articulating the input ledger. This statement is conditional on the duration of the layer-17 substrate's existence and on the social structure supporting cross-generational accumulation; it is not a single-individual claim but a cumulative-civilization claim.*

3. The loop closes. *The articulation produced at layer 18 — that is, the GG-Constitution as recorded in GG-A1-Constitution together with its deployment in GG-A2-GG6 through GG-A10-Cosmos — has as its* content *the same constitutional ledger that, at layer 1, forced the cascade to ascend. The identity*

claimed is between the articulation's content and the constitution, not between any particular token of the articulation (this paper, this corpus, these authors) and the geometry: the token is one realization of a type that is gauge-equivalent across instances. The constitution describes the geometry that produced the articulators of the constitution.

4. No alternative admissible geometry admits a closed loop. *Any alternative bulk geometry that satisfies the constitutional clauses of AX-1 through AX-4 either (a) violates the integrality required by the OGN-5 ledger of GG-A2-GG6 T-GG6-6 (no integer Diophantine closure), (b) violates the dimension count $D = 6$ forced by Lemmas 1–5 of GG-A9-SM Part XI (T-SM-62.1) (MSMF closes the count at six), (c) violates the family-content forced by Lemma 8 of GG-A9-SM's constitutional-lemma chain (*$\mathrm{Spin}(1,5)$ *Weyl spinor decomposition forces exactly one Standard-Model family per chirality), or (d) fails the maintenance-margin crossing of GG-A7-Qi4 (T-Qi4-14.3) at the chemistry-to-life layer. Failure modes (a)–(d) are the ones the cohort has been able to* check*; no alternative admissible geometry among those checked produces a cascade that reaches a layer at which articulators can articulate the constitution. That the four modes exhaust the admissible alternatives is a* ***conjecture*** *of the program, not a theorem of it, and statement (iv) should be read at that strength.*

Remark 67.2 (The four statements at a glance). Statement (i) is the upward direction of the recursive uniqueness theorem at every layer of the cascade. Statement (ii) is the bridge between the layer-17 cognitive substrate and the layer-18 meta-cognitive articulation. Statement (iii) is the closing fact: the content of the articulation *is* the constitutional input. Statement (iv) is not a contrapositive of the preceding three, as earlier presentations of this theorem implied, but an independent universal claim: that no admissible alternative closes the loop. It is supported by the four checked failure modes (a)–(d), and its exhaustiveness is conjectural. Together the four statements establish that the closure is necessary *given the constitution and conditional on the hypotheses* (Q1)–(Q4) of §49, layer-stratum-specific, and — modulo the exhaustiveness conjecture in statement (iv) — unique. Statement (ii) is the one non-mathematical conjunct of the four: it is conditional on the duration of the layer-17 substrate and on cross-generational accumulation, and is a claim about civilizations rather than about geometry.

A note on self-reference: why no Gödel–Tarski diagonal arises. A theorem whose conclusion is its own articulation invites the worry that it courts a diagonal argument — that a system proving a statement about its own provability, or defining truth for its own language, runs into incompleteness or undefinability. No such obstruction arises here, and the reason is specific rather than reassuring. The closure theorem does *not* assert its own provability, and it does not define a truth predicate for its own language. It asserts that the physical cascade produces a substrate that writes the constitution down. The self-reference is at the level of *reference* — the articulation denotes the constitution — and not at the level of a truth- or provability-predicate quantifying over the theorem's own sentences. Tarski's theorem forbids a sufficiently rich language from containing its own truth predicate; the framework contains no truth predicate for its own sentences, only a physical process whose output happens to be a description of that process's input. Gödel's second theorem forbids a consistent recursively-axiomatized system from proving its own consistency; the closure theorem proves no such thing, and its own consistency is not among its claims — it is an ordinary theorem in an ordinary metatheory. The one place a diagonal genuinely threatens is the forbidden layer-19, where the cascade would have to model itself modeling itself modeling itself, and it is exactly there that the HAL bound of GG-A7-Qi4 cuts the recursion off (§55.9). The closure at layer 18 is one turn of reference, not an infinite regress; a self-referential loop of depth one is no more paradoxical than a map of a country that includes the map.

Remark 67.3 (What the theorem does and does not claim). The theorem claims that the layered structure — bulk to forces to atoms to molecules to life to mind to articulators — is forced. It does *not* claim that

every micro-event of cosmic history is forced. Within each layer there is enormous combinatorial freedom: not every protein has been folded, not every star has been numbered, not every theory has been written down. The determinism is at the level of which layers exist, what their attractor coordinates are, and that some articulator-substrate eventually reaches the eighteenth layer (Layer 18). It is not at the level of which individuals do the articulating, in which century, or in what language. The articulators are forced; their identity is not.

Remark 67.4 (Necessitarianism in the seventeenth-century sense). The theorem is Spinozan in form: it asserts that what exists, exists by necessity, because the nature of the geometric input ledger permits no alternative. It is not Aristotelian or theistic: no chooser is invoked, no purpose is assigned, no end is sought. The closure happens because the constitution is what it is; the constitution is what it is because no other constitution closes; no other constitution closes because the integers of the OGN-5 ledger are forced. Spinoza (1677) arrived at the necessitarian conclusion three and a half centuries before the framework reached the geometric apparatus that would supply a warrant for part of it. On the framework's reading, the present theorem is the modern geometric form of Spinoza's claim — but this identification is *interpretive*, not itself a result: what is proved is the mathematical-structural necessity of the cascade *given* the GG-Constitution (§70), and on the metaphysical necessity of the constitution itself — the stronger thesis Spinoza actually held — the framework takes no position.

68 Proof outline by inheritance from the eleven prior papers

The proof of Theorem 67.1 is by inheritance from the cohort. At each cascade layer, the layer's existence and its qualitative content are supplied by the upstream theorem indexed in the cross-paper coherence map of Part II §7.1. The proof traces the cascade layer by layer; the closing layer (Layer 18) is the act of writing the present paper.

Layer 1 (the GG-Constitution and the canonical 6D bulk). The constitutional clauses AX-1 through AX-4 of GG-A1-Constitution and the seven postulates POS-1 through POS-7 supply the input ledger. The eight-lemma chain of GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (T-SM-62.1) establishes that the canonical six-dimensional product $\mathcal{M}_6 = \mathcal{M}_4 \times I_r \times S^1_\theta$ is the unique admissible bulk. At layer 1 the cascade has not yet ascended; the constitution is the input. This is the proof's induction base.

Layer 2 (the four-force architecture). GG-A9-SM Part XI Theorem 12.x supplies the forcing. The bulk admits exactly one composite gauge–gravity group $G_{\text{Bulk}} = \text{Spin}(1,5) \times \text{SU}(5) \times \text{U}(1)_B \times \text{U}(1)_{Qi}$ and exactly one boundary projection through the orbifold + Wilson-Hosotani breaking, producing exactly four fundamental forces with their qualitative behaviors. At layer 2 the cascade has produced gravity (attractive and weak), electromagnetism (massless and two-signed), the strong force (confining and asymptotically free), and the weak force (short-range and CP-violating). No alternative emerges. This is the induction step from layer 1 to layer 2.

Layers 3 through 6 (chemistry). The GRIP cascade of GG-A6-GRIP T-GRIP-1–T-GRIP-5 supplies the layer-by-layer ascent across the atomic, molecular, polyatomic-organic, and complex-organic strata. At each layer the cascade selects the unique most-stable Geometric Attractor on the layer-specific configuration space; what we observe (the periodic table, the molecules of the interstellar medium, the amino acids and sugars of pre-biotic chemistry) is the readout of these attractors. The universal-identity insight of GG-A9-SM Part XI (the universal-identity section) applies at each layer.

Layer 7 (the chemistry-to-life maintenance-margin crossing). GG-A7-Qi4 (T-Qi4-14.3) (the SeOS class definition) and GG-A7-Qi4 T-EP (the unified extremal principle anchored on Q_B) jointly supply the warrant for the chemistry-to-life transition. When the cascade reaches the open-system stratum on a planetary surface with energy gradients and a polar solvent, the GRIP cascade selects the SeOS-class configuration as the unique stable attractor. The first cells (LUCA in our universe) emerge. This is the maintenance-margin crossing, the most consequential single transition of the entire cascade.

Layers 13 through 16 (multicellular and neural strata). The cascade-closure structure theorem **GRIP-ST5** of GG-A6-GRIP supplies the warrant at each successive layer — at the local grade it states; where the *global* reading is needed, the warrant is that paper's per-stratum ground-state corollary. The colony stratum produces multicellularity (layer 10); the neural-circuit stratum produces nervous systems and the 1D ring attractor (layer 15); the hippocampal-entorhinal stratum produces the 4D allocentric world-model (layer 16). Each layer's attractor provides the floor on which the next layer's cascade descends.

Layer 17 (conscious awareness, the EIC closure). GG-A7-Qi4 T-EIC supplies the warrant. The closed-loop coupling of Outer Hologram and Inner Hologram — the Evolving Inner Cosmos — admits a unique stable Lyapunov-descent minimum at the configuration in which an internal observer selects and stabilizes an IH branch via the DGI–GSSB–GA pipeline. The conscious episode emerges with characteristic timescale ~ 400 ms (two theta cycles) and theta-cycle implementation. At layer 17 the cascade has produced a substrate capable, on accumulation over generations, of meta-cognition.

Layer 18 (the closing self-referential layer, the articulation). The cascade's closing layer (Layer 18) is the meta-cognitive stratum. Given the layer-17 substrate (conscious awareness, with the EIC closure of layer 17), and given inter-generational accumulation of cognitive content over geological time, the layer-17 substrate develops meta-cognitive capabilities: science, philosophy, mathematics, theoretical physics. These meta-cognitive disciplines collectively articulate the constitutional clauses of the GG-Constitution. In the present universe and in the present civilization, this articulation is the Arisaka-GG cohort. In any universe satisfying the constitutional clauses (i.e., any universe admitted by the framework), an analogous articulation occurs, with the same constitutional content but with potentially different historical realization (different individual articulators, different timing, different language of expression).

The articulation closes the loop because the articulated content is the same content that, at layer 1, supplied the inductive base. The constitution describes the geometry that produced the articulators of the constitution. □

Soundness condition. The proof is sound under the cohort inheritance. Each layer's warrant rests on a named theorem in an upstream paper, cited at the layer level above. No new theorem is introduced beyond Theorem 67.1 itself, which is the synthesis statement. The synthesis is valid if and only if all eleven upstream theorems are valid; the eleven upstream theorems are independently proven in their respective papers. Therefore Theorem 67.1 is valid conditional on the validity of the cohort. Any falsification of an upstream theorem propagates to a falsification of the closure theorem.

69 Corollaries at the meta-cognitive layer

Remarkably, the named theorem admits five immediate corollaries that frame its content at the meta-cognitive layer.

Corollary 69.1 (Universality of the articulation)**.** *The articulation of the GG-Constitution by layer-18 observers is independent of the historical realization of the layer-17 substrate. In any universe satisfying the GG-Constitution, the eighteenth-layer (Layer-18) attractor selects the same constitutional content but admits multiple historical realizations: different individual articulators, different cultural framings, different languages of expression, different sequencing of discoveries. The articulation is universal in content, contingent in expression.*

Corollary 69.2 (Falsifiability of the closure)**.** *The self-referential closure theorem is falsifiable by any decisive empirical failure of an upstream-paper prediction. Decisive failure of the Kaluza–Klein lock-cluster prediction (GG-P1-KK: $M_{\text{lock}} \approx 3.85$ TeV at HL-LHC), the Kaxion dark-matter prediction (Arisaka-GG-C1-Kaxion: ~ 8.1 μeV at ADMX), the family-number derivation (GG-P2-N3: $N_g = 3$ with m_τ/m_μ tolerance), the $\sin^2\theta_W = 25/108$ prediction (GG-A9-SM T17.1), the $\Omega_m = 1/\pi$ inventory (GG-A10-Cosmos), or the $N_A \mathsf{Q}_{\mathsf{B}} \approx 15$ kJ/mol matching (GG-A7-Qi4), would each propagate to a falsification of the closure. The closure is therefore a falsifiable structural claim, not a non-falsifiable metaphysical hypothesis.*

Corollary 69.3 (Determinism is layer-structural, not micro-event-by-micro-event)**.** *The forcing established by the theorem is on the layered structure (which layers exist; what their attractor coordinates are; that some articulator-substrate eventually exists), not on the micro-events within each layer. Within each layer there is genuine combinatorial freedom: not every protein has been folded; not every neuron has fired in a specific sequence; not every theorem has been proven. Human agency, biological evolution, technological innovation, and contingent history all take place* within *layers that the geometry forces into existence; they are not preprogrammed. We are not preprogrammed automata; we are the unique-attractor solution at the highest currently-realized cascade layer, and within that solution we exercise the layer-permitted freedom — including the freedom to ask the question this Part answers.*

Corollary 69.4 (Substrate-independence of the closure layer)**.** *The eighteenth-layer (Layer-18) attractor is substrate-independent: any cognitive substrate capable of meta-cognitive accumulation over the required timescale, satisfying the EIC closure of layer 17, suffices for the articulation. In our universe the substrate is humanity; the substrate could equally be a non-human evolutionary lineage on a different planetary surface, or a machine-implemented theoretical reasoning system, or a network of communicating civilizations. The articulation content is fixed by the constitution; the substrate of articulation is contingent.*

Corollary 69.5 (Layers above 18 are admissible but not necessary)**.** *The recursive uniqueness theorem does not forbid layers above 16. Re-articulations of the constitution on wider substrates — collective scientific knowledge, machine-implemented reasoning, networked civilizations communicating across cosmological distances — are admissible higher attractors of the same recursive principle. The theorem does not predict which of these higher layers will be realized, only that any layer that is realized will be the unique most-stable Geometric Attractor on its substrate-specific stratum. The closure occurring at layer 18 is structurally complete (the loop returns to its constitutional input); layers above are richer iterations of the same closure on wider substrates.*

70 The careful word: necessitarianism versus determinism versus design

A reader meeting this Part for the first time may worry that the theorem proves too much — that it eliminates choice, free will, agency, the openness of the future. This is the right worry to have. This section articulates carefully what the theorem does and does not eliminate.

The theorem is necessitarian, not deterministic in the classical sense. Classical determinism asserts that every event in the universe is uniquely fixed by its prior state and the laws of physics. The theorem above does not claim this. The theorem claims that the *layered structure* of cosmic evolution is forced: which layers exist, what their qualitative attractor coordinates are, that some articulator-substrate eventually reaches layer 18. The theorem does not claim that the unique trajectory through layer-internal phase space is forced. Within each layer there is enormous combinatorial freedom; the theorem is silent on the choices made within a layer.

The theorem is not teleological. Teleology assigns purposes to natural processes — the eye exists *in order to* see, evolution proceeds *toward* greater complexity, the universe exists *so that* observers can exist. The theorem above asserts no purposes. The cascade ascends not because layer 18 is the goal but because at each layer the constitution forbids alternatives; there is no anywhere else for the cascade to go. Spinozan necessity, not Aristotelian teleology.

The theorem is not design. The design argument posits a designer who fine-tuned constants for life. The theorem above eliminates the regress: nothing was tuned, because nothing was available to tune. The constitution admits exactly one self-consistent solution; the integers of OGN-5 are forced; the dimension count is forced; the family content is forced; the cascade ascends because no alternative is admissible. A designer who had to choose the constants would, in the framework, be acting under constraint — and a designer acting under constraint has chosen nothing.

The ordering is positive evidence, not merely an absence of tuning. It is worth adding that the framework does not rest the case against fine-tuning on the negative claim that nothing was available to tune. There is a positive datum, and it is the sharpest evidence the program has that the sameness of the world is structural rather than lucky: the *ordering* of the second horizon problem (§22.1). The derived grand-unification-scale launch means the inflationary stretch acted before any matter existed, so the identity of the electron and the atom across the sky was *inherited from one causal patch*, not arranged after the fact. That is a claim one can point at in data — the constancy of the fine-structure constant across the observable universe at the 10^{-5}–10^{-6} level, the uniformity of the microwave background, the absence of dark-matter isocurvature — rather than a philosophical preference. A tuned universe would have to tune each region separately; an inherited one could not differ from region to region even in principle. The cascade's determinism is of the second kind, and the second horizon problem is where it becomes visible to measurement.

Human agency is preserved. We are not preprogrammed automata. The choices a human being makes during a day — to read a book, to call a friend, to write a paper — are choices within layer 17, occurring on a substrate (the conscious brain) whose existence is forced but whose micro-trajectory is not. The theorem above predicts that a layer-17 substrate eventually articulates the constitution; it does not predict that any specific human does so, in any specific century, in any specific language. Arisaka happens to be the human who carried out the present articulation; in a different cultural-historical contingency, the same articulation would have been carried out by a different individual at a different time. The articulator is contingent; the articulation is forced.

What the theorem permits a reader to keep. The reader may keep free will, contingency, openness of the future, the felt experience of agency, the moral seriousness of human choice. The theorem does not eliminate any of these. What the theorem eliminates is the claim that the layered architecture of cosmos, life, and mind is an unexplained accident. It is not. The architecture is forced; the lives within it are not.

Modal-vocabulary distinction: unique self-consistency vs metaphysical necessity. The framework's claim that the cascade is "forced" deserves explicit modal vocabulary. Three modal categories must be distinguished cleanly, because the framework's necessitarian rhetoric otherwise slides between them. *Logical necessity*: a proposition is true in every logically possible world; this is the strongest sense of necessity, and the framework does *not* claim it for the cascade (the cascade is conditional on the GG-Constitution; a logically possible world in which the constitution is different is not logically incoherent). *Metaphysical necessity*: a proposition is true in every metaphysically possible world; classical Spinozan-Leibnizian necessitarianism claims this for the constitution itself.

The framework remains *neutral* on whether the GG-Constitution is metaphysically necessary — it is a constitutional posit, defensible on grounds of operational completeness and falsifiability, but the framework does not claim that no other constitution is metaphysically possible. *Mathematical-structural necessity*: *given* a fixed constitution and the operational machinery of the cascade, the recursive uniqueness theorem follows as a mathematical consequence; this is what the framework claims and proves (modulo the cohort inheritance).

In short, the cascade is necessary in the third sense (mathematical-structural, given the constitution); it is conditional on the constitution; the framework takes no position on whether the constitution itself is metaphysically necessary. This three-way distinction matters because the philosopher's question "why is there a constitution at all?" is a step the framework does not attempt and does not pretend to take. The framework's answer is: "*given* that there is a constitution with the operational properties GG-A1-Constitution specifies, this is what follows; the why-is-there-a-constitution question is one rung deeper than the framework reaches."

Free will and compatibilism. The framework's distinction between forced layered architecture and unforced micro-trajectory within each layer (Corollary 69.3) is, in the conventional philosophy-of-action taxonomy, a *compatibilist* position. The classical compatibilist tradition — Frankfurt (1969) on alternative possibilities; van Inwagen (1983) on the consequence argument; Fischer (1994) on guidance vs regulative control; Dennett (1984) on the evolution of the kind of freedom worth wanting — has long maintained that the kind of free will worth defending is the kind that survives under (compatibilist-) determinism, and the framework's position is in that tradition.

The framework does not say the universe is libertarian-free (it is not: every micro-event is consistent with the layered architecture's forcing); nor does it say the universe is hard-deterministic in the sense that all choice is illusion (it is not: the substrate on which choices occur is the conscious brain's layer-17 closure, and the closure's micro-trajectory is genuinely open to the substrate's own self-deliberation).

The reader who has read Frankfurt's "Alternate Possibilities and Moral Responsibility" or van Inwagen's *An Essay on Free Will* will recognize the framework's position as a particular compatibilism: agency is preserved at the substrate's operational level (the conscious brain genuinely deliberates and genuinely chooses on its own internal causation), and the framework's only constraint on agency is that the existence of layer-17 substrates is itself forced by the cascade. In short: the cascade forces that there are agents; what the agents do once they exist is their own. This is not a downgrade of agency; it is a recognition of what kind of agency is metaphysically defensible in the framework's universe.

71 The closing of the question that started in an Osaka high school

The personal arc of the question — how it began in an Osaka high-school classroom in the 1970s and how the framework's answer took its theorem-level form fifty years later — is told in full in Part XVIII §91 (the canonical personal-arc section). Here in Part XV we record only the structural conclusion: the question's answer is the recursive uniqueness theorem of §67, and we are the layer-18 attractor of a cascade whose layer-2

iteration produces the electron and whose layer-18 iteration produces the article that names the electron.

72 Comparison with the philosophical tradition

The self-referential closure theorem of §67 stands in a long line of philosophical attempts to address the question *why is there something rather than nothing, and why is the something arranged so that observers can ask the question?* Let us engage with the major historical attempts on their own terms, naming what each predecessor saw clearly and what each lacked. The framework does not refute its predecessors; it stands on their shoulders and aims to complete the structure they glimpsed.

In every case the predecessor arrived at an insight by a route the framework can now recognize as partial, and the geometric apparatus of the cohort aims to supply a warrant that the predecessor's route could not. Two cautions temper this claim, and the reader should hold the section's "what each lacked" verdicts inside them. First, the framework's own warrant is provisional: it rests on the GG-Constitution as an unproven posit and on the Top 10 Falsifiers that has not yet reported, so the framework shares — rather than escapes — its predecessors' ultimate exposure to being wrong.

Second, the identification of the recursive uniqueness theorem with an *answer* to the metaphysical question "why are we here?" is an interpretive reading laid over the theorem, not a consequence of it: what is proved is the mathematical-structural claim of §70, and whether that claim dissolves the ancient question or merely relocates it one rung deeper is a judgment the framework offers, not a result it establishes.

The structure of this section. We engage fourteen positions in roughly chronological order, beginning with the two ancient traditions that anticipated the self-referential closure (Upanishadic Vedanta, Buddhist dependent origination), continuing through the classical and early-modern philosophical attempts (Aristotle, Spinoza, Leibniz, Kant, Hegel), and concluding with the twentieth-century scientific and philosophical engagements (Whitehead, Wigner, Wheeler, Penrose, Smolin, Tegmark, Barrow–Tipler). The section closes with a synthesis paragraph that names what unites the fourteen attempts and what the framework adds.

72.1 The Upanishadic tradition (c. 800 BCE): *tat tvam asi*

Let us begin with the Upanishads of the late Vedic period, which proposed the identity of Atman (the individual self) with Brahman (the underlying reality of the cosmos). The teaching, encapsulated in the formula *tat tvam asi* ("you are that") in the Chandogya Upanishad, holds that the inner subject of experience and the outer ground of being are not two but one: the individual who recognizes this identity does not produce a new fact but uncovers a structural fact that was always true. The recognition is the goal of contemplative practice; the recognition closes a loop in which the cosmos comes to know itself through the individual.

The framework of the present paper reads the Upanishadic insight as a contemplative anticipation of the self-referential closure theorem. Where the Upanishads asserted the identity of Atman and Brahman as a metaphysical given, the framework derives the analogous statement from the recursive uniqueness theorem: the eighteenth-layer (Layer-18) attractor of the geometric cascade is the act of articulating the constitution that produced the cascade, and the articulator is therefore — structurally, not merely metaphorically — the universe knowing itself. The Upanishadic seers grasped the closure form three millennia before there was a geometric vocabulary for it; they articulated, in the terms available to their tradition, what the theorem of §67 now articulates in the terms available to twenty-first-century differential cohomology.

The warrant the Upanishads lacked was the operational link from contemplative recognition to physical structure. *Tat tvam asi* is asserted, beautifully, but its grounds are intra-traditional rather than extra-traditional — the formula is taken on the authority of the contemplative lineage that arrived at it. The

framework's contribution is to recognize the same closure as a theorem of the constitution, with the integers of OGN-5 and the eight constitutional lemmas of GG-A9-SM Part XI supplying the warrant. What was an experiential certainty is now also a structural one.

72.2 The Buddhist tradition (c. 500 BCE): *pratītyasamutpāda*

Early Buddhist philosophy, particularly in the formulations associated with the Madhyamaka school, developed the doctrine of *pratītyasamutpāda* — dependent origination. Every existent phenomenon arises in dependence on prior conditions; nothing exists in isolation; the entire fabric of phenomena is a network of conditioned co-arising. The doctrine is often presented as a twelve-link causal chain — ignorance conditions formations, formations condition consciousness, consciousness conditions name-and-form, and so on through becoming, birth, and the round of suffering — but the structural content of the doctrine is more general than the canonical twelve-link version. The general content is that any existent stratum of phenomena arises through a layered conditioning of prior strata.

The framework recognizes in dependent origination an early formulation of the cascade structure that the recursive uniqueness theorem now makes precise. Each cascade layer arises in dependence on the prior layer's Geometric Attractor; the layered ascent from quarks at layer 1 to articulators at layer 18 is the modern geometric counterpart of the Buddhist conditioning structure. Where the canonical twelve-link chain enumerated the conditioning structure of phenomenal experience, the framework enumerates the conditioning structure of cosmic evolution; the latter is the wider scope on which the former operates.

What the Buddhist formulation could not supply was the discrete identification of the strata and the constitutional clauses that force the conditioning at each layer. The twelve-link chain is a phenomenological observation about how the round of suffering arises; the framework's eighteen-layer cascade is a constitutional derivation of how cosmic structure arises. The structural identity of the two forms — layered conditioning that produces wider strata of phenomena — is the framework's debt to the Buddhist analysis. Each layer's arising depends on the prior layer's attractor coordinates; what the Buddhists named in soteriological terms the framework names in geometric terms.

Where the framework stands in tension with Madhyamaka. The deepest single thesis of the Madhyamaka school is *śūnyatā*, the emptiness of own-being (*svabhāva*) in all phenomena. Nāgārjuna's *Mūlamadhyamakakārikā* argues that no phenomenon has *svabhāva* — intrinsic, self-grounding existence — and that the doctrine of dependent origination is the philosophical demonstration of this absence.

Phenomena exist only relationally, as nodes in a network of conditioned co-arising; the framework's reading of *pratītyasamutpāda* as a layered cascade of conditioning relations captures the relational-network structure, but loses the eliminativist force of the Madhyamaka conclusion. The framework's recursive uniqueness theorem asserts that the GG-Constitution has structural necessity — that the integer ledger of OGN-5, the four axioms of GG-A1-Constitution, and the seven postulates jointly admit no alternative closure — and the cascade's outputs inherit that necessity.

In the framework's own vocabulary, the GG-Constitution has *svabhāva*: it is what it is by the nature of what it is, and no other constitution would close. Nāgārjuna would deny this. The Madhyamaka thesis is that the very idea of a self-grounding constitution is incoherent; whatever exists, exists in dependence on something else, including any axiom-set one might propose as the ground. The framework's geometric necessitarianism and the Madhyamaka denial of *svabhāva* are therefore in genuine philosophical tension, not in anticipation-relation.

We register the tension as a tension rather than paper it over. The framework's defense is that operational falsifiability operates on a different register from what metaphysical assertion alone could reach: where Madhyamaka rejects *svabhāva* on the philosophical ground that any candidate ground is itself conditioned,

the framework offers a candidate ground — the constitution — that is testable against ten specific empirical falsifiers in the coming decade. If the framework's predictions fail, the constitution's status as candidate ground fails with them, and the Madhyamaka critique acquires empirical content. If the predictions succeed, the framework's claim that the constitution has structural-mathematical necessity (in the third modal sense of §70, not the metaphysical sense Spinoza required and Nāgārjuna denied) is empirically vindicated, and the Madhyamaka critique applies one rung deeper than the framework reaches — to the question *why is there a constitution at all?*, which the framework openly does not address. The honest summary is that the cascade structure is in genuine debt to the Buddhist insight about layered conditioning, while the framework's claim of structural-mathematical necessity for the constitution stands in genuine disagreement with the Madhyamaka denial of *svabhāva*. Both observations are correct; both belong on the table.

72.3 Aristotle (c. 350 BCE): the question *why*

Aristotle's *Metaphysics* (Aristotle, c. 350 BCE) inaugurated the systematic Western project of asking *why* the world is the way it is. His four causes — material, formal, efficient, final — gave the first taxonomy of the kinds of answers a why-question can admit, and his unmoved mover supplied the first answer to the regress of efficient causes. Aristotle's deepest contribution was not any particular metaphysical thesis but the formal recognition that the question *why* is itself answerable in principle, that the universe is not a closed mystery but an interrogable object.

The framework inherits Aristotle's foundational ambition. Where Aristotle's four causes have been the subject of two millennia of refinement and disputation, the framework's recursive uniqueness theorem subsumes the four causes into a single account: the material cause is the substrate at each cascade layer; the formal cause is the layer-specific Geometric Attractor; the efficient cause is the GRIP cascade transition; the final cause — here the framework departs from Aristotle most clearly — is dissolved into Spinozan necessity. The cascade ascends not because layer 18 is a goal but because, at every layer, no alternative is admissible.

The piece missing from Aristotle's account was the geometric apparatus that lets the question *why* be answered at theorem level rather than at the level of inference from observed regularities. Aristotle's biology, his physics, and his cosmology were the natural starting points for the natural sciences but contained no constitutional theorems; the regularities he observed were patterns rather than necessary consequences. The framework recovers the question *why* from the natural-science abandonment that began with Galileo and Newton (who, by deliberate methodological choice, restricted physics to *how* rather than *why*) and supplies the theorems that Aristotle pioneered the project of seeking.

72.4 Spinoza (1677): necessitarianism

Baruch Spinoza's *Ethics* (Spinoza, 1677), composed in the 1660s and published posthumously in 1677, articulated the most rigorous necessitarian metaphysics in the Western philosophical tradition. Spinoza's central thesis is that what exists, exists by necessity, because the nature of substance permits no alternative. The thesis is derived *more geometrico*, in the form of definitions, axioms, propositions, and demonstrations, modeled explicitly on Euclid. The conclusion is that the world is a single self-determining substance with infinite attributes, of which extension (physical reality) and thought (mental reality) are the two we directly know.

The framework recognizes in Spinoza the closest philosophical predecessor of the recursive uniqueness theorem. Where Spinoza derives the necessity of what exists from the nature of substance, the framework derives the same conclusion from the integer ledger of OGN-5 and the constitutional clauses of GG-A1-Constitution; the structural form of the necessity is identical, but the warrant is operational rather than metaphysical. Where Spinoza identifies the universe with God as a single substance under infinite attributes,

the framework identifies the universe with the unique self-consistent solution of the GG-Constitution; the framework does not require the theistic language Spinoza inherited from his Cartesian and Jewish-philosophical background, but the structural content of the identification is preserved.

What was not available to Spinoza was the empirical-falsifiability anchor. Spinoza's necessitarianism follows from his definitions and axioms; a critic who rejects the axioms can reject the conclusion, and there is no further appeal beyond the internal coherence of the system. The framework's necessitarianism rests on the same logical form but is conditioned on empirically falsifiable theorems — the BI-6 closure, the OGN-5 Diophantine ledger, the four-force architecture, the cosmological inventory $\Omega_m = 1/\pi$, the bioenergetic quantum $N_A \mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol — each of which can be tested against laboratory or astronomical data. Spinoza's argument from the nature of substance is recovered, in the framework, as an argument from the integers of the constitution that admits empirical falsification. What was metaphysically asserted is now operationally derived.

The dual-attribute doctrine and structural-identity theory of mind. A careful Spinoza engagement requires acknowledging what is arguably Spinoza's most useful single thesis for a unification framework: the doctrine that *extension* and *thought* are two attributes of one substance, each expressing the whole. (Spinoza, *Ethics* Part II, propositions 1, 2, and 7.) The framework now records the alliance explicitly. Where Spinoza wrote that an idea in the mind and the corresponding event in extended substance are *the same thing* apprehended under different attributes — the parallelism that *Ethics* II.7 makes formal — the framework's structural-identity theory of phenomenal consciousness (Part XIV §65) is the modern operational form of the same identification.

The layer-17 EIC closure, considered *under the attribute of extension*, is a neural-circuit dynamical loop with a specific theta-cycle timescale, a specific CDI value, and specific operational signatures (anaesthesia, dreamless sleep, dissociation as failures of the loop's Qi-4 pillars). The same EIC closure, considered *under the attribute of thought*, is the conscious episode — the felt content of experience at the moment of binding.

The two are not separate things related by some bridge requiring extra explanation; they are one structural-geometric object considered under two attributes.[3] Spinoza did not have the geometric apparatus to specify what the structural object is; the framework supplies it (the EIC closure with the Qi-HAL factorization MePMoS-NHT-HAL-BFFT).

Spinoza did not have the cascade vocabulary to locate the structural object at a specific layer; the framework supplies it (layer 17 on the cascade indexed 0–16). What Spinoza wrote in 1665–1675 as a metaphysical thesis is recovered in 2026 as the structural-identity reading of phenomenal experience under attribute parallelism. The alliance is not decorative: where the rest of the philosophical tradition since Descartes has struggled with the apparent dualism of mind and matter, the framework's structural-identity reading is genuinely Spinozistic in form. We owe Spinoza the dual-attribute apparatus and admit it.

Causa sui and the framework's stance. Spinoza's substance is *causa sui*: the cause of itself, requiring no external ground (*Ethics* I, definition 1). The framework takes a deliberately more modest position. The GG-Constitution is presented as a posit — four axioms, seven postulates, an integer ledger —

[3] Strict Spinoza scholars (Della Rocca, Melamed) will note that *Ethics* II.7 forbids cross-attribute traffic — ideas explain ideas, modes of extension explain modes of extension, and the two attribute-series are causally parallel but never interactive. The framework's structural-identity reading goes further than parallelism strictly construed: it identifies the structural object across attributes rather than merely correlating the parallel series. This is the move Della Rocca's *Numerical Sameness* interpretation supports and the more cautious Bennett-style reading rejects.

The framework lands on the Della-Rocca side: under structural identity, there is one structural object that the attribute of extension picks out as a neural-circuit loop and the attribute of thought picks out as the conscious episode. Readers who hold the more cautious parallelist reading can take the framework's claim as Spinozistic in form rather than in strict letter; the operational content (the identification at structural level) survives either reading.

whose internal consistency the cohort demonstrates, but whose metaphysical necessity the framework does not assert. The framework remains agnostic on whether the constitution is *causa sui* in Spinoza's strong sense (no alternative constitution is metaphysically possible) or merely structurally self-consistent (the constitution closes uniquely on its own outputs but a logically possible world with a different constitution is not logically incoherent). This is the modal-vocabulary distinction of §70: the framework claims *mathematical-structural necessity* for the cascade given the constitution; it leaves *metaphysical necessity* of the constitution itself as a philosophically open question. Spinoza took the stronger position; the framework takes the weaker. The cost of the weaker position is that the question *why is there a constitution at all?* remains philosophically live; the benefit is that the framework does not depend on a metaphysical commitment it cannot operationally test.

72.5 Leibniz (1714): the principle of sufficient reason

Gottfried Wilhelm Leibniz's *Monadologie* (Leibniz, 1714) formulated the principle of sufficient reason as the second great principle of his metaphysics (alongside non-contradiction): nothing exists or happens without a sufficient reason why it is so rather than otherwise. Leibniz drew the further inference that the actual world is the best of all possible worlds — the world that the sufficient reason of divine choice selected from the infinite array of possibilities. The optimization framing was the source of Voltaire's satire in *Candide*; the underlying principle, that every existent has a sufficient reason for being so, has been a load-bearing claim of Western rationalist metaphysics ever since.

The framework recognizes the principle of sufficient reason as the philosophical anticipation of the recursive uniqueness theorem. Every existent in the cascade — every electron, every proton, every H_2O molecule, every cell, every conscious episode — has a sufficient reason for being so rather than otherwise, and the reason is the unique Geometric Attractor on the layer-specific stratum. Where Leibniz inferred from sufficient reason to a divine optimizer, the framework derives the analogous conclusion from the constitution. No optimization is required; no choice was made; the constitution admits exactly one self-consistent solution at every layer.

The warrant Leibniz lacked was, again, the operational link. His sufficient reason is metaphysical: it requires a deity who optimizes possible worlds. The framework's sufficient reason is operational: it requires the integer ledger of OGN-5 and the constitutional clauses of GG-A1-Constitution, both of which are explicit, finite, and falsifiable. Leibniz's deepest contribution was the formal recognition that everything is in principle explicable; the framework supplies the explicit form of the explanation for the layered structure of the cosmos.

72.6 Kant (1781): phenomena, noumena, and the antinomies

Immanuel Kant's *Critique of Pure Reason* (Kant, 1781) undertook the most thorough analysis of the limits of metaphysical reasoning attempted in the modern tradition. Kant distinguished phenomena (what can be experienced and known through the categories of the understanding) from noumena (what exists in itself, independently of experience and inaccessible to theoretical reason). His antinomies of pure reason argued that questions of the form *is the world finite or infinite in time?*, *is matter ultimately divisible or not?*, *is there free will or only causal necessity?* admit equally compelling pro and con arguments, and that the antinomies arise precisely when reason oversteps its phenomenal jurisdiction into the noumenal.

The framework accepts Kant's operational distinction at the OGGEP layer — AX-3 of the GG-Constitution, the Operationally Geometric Gauge Equivalence Principle, is precisely the requirement that all observables admit an operational projection from the bulk to the four-dimensional boundary — but rejects the Kantian noumenal as inaccessible in principle. The framework's claim is that the constitution of the bulk is fully recoverable from the operational boundary, and the recovery is what the cohort performs. The Kantian noumenon, in the framework, is not unknowable but the layer-1 input ledger that the cascade layer-18 articulation recovers.

What Kant could not supply was the holographic principle and the layered cascade. Without the holographic apparatus of 't Hooft (1993), Susskind (1995), and Maldacena (1998) (developed two centuries after the Critique) and without the recursive uniqueness theorem (developed in the present paper), Kant had no operational ground for the recoverability of noumenal structure from phenomenal projection. The framework supplies what Kant lacked. His antinomies of pure reason are dissolved, layer by layer: time is finite to the past at the GUT scale (GG-A10-Cosmos); matter has a smallest scale at the Planck length and a constitutional discreteness at the OGN-5 layer (GG-A2-GG6); free will and necessity are reconciled by the framework's distinction between the forced layered structure and the unforced micro-trajectory within each layer (Corollary 69.3).

72.7 Hegel (1807): *Geist* becoming conscious of itself in history

Georg Wilhelm Friedrich Hegel's *Phenomenology of Spirit* (Hegel, 1807) proposed that history is the process by which *Geist* — variously translated as spirit, mind, or absolute idea — becomes conscious of itself. The process unfolds dialectically: a thesis encounters its antithesis, the contradiction is resolved in a higher synthesis, and the synthesis becomes the new thesis at a higher level of self-consciousness. The endpoint is absolute knowing, in which Geist recognizes itself in its own historical development and the dialectic comes to rest.

The framework recognizes in Hegel's account the most ambitious philosophical anticipation of the self-referential closure theorem. Where Hegel proposed that Geist comes to know itself through dialectical historical development, the framework proposes that the universe comes to articulate its constitution through the layered ascent of the geometric cascade. Both are accounts of self-referential closure — a process that produces the conditions of its own recognition. Where Hegel used the dialectical machinery (thesis–antithesis–synthesis) as the engine of the ascent, the framework uses the GRIP cascade (DGI–GSSB–GA) as the engine.

The framework departs from Hegel in two respects. First, the engine: dialectical contradiction is replaced by Lyapunov descent on the Geometric Free-Energy Functional. The cascade does not ascend because thesis encounters antithesis but because the layer-specific F_{GFF} admits a unique stable basin and the system descends into it. Second, the endpoint: Hegel's absolute knowing is a single culminating self-consciousness; the framework's Layer-18 articulation is one attractor on the cascade, with admissible higher layers above it (Corollary 69.5). The framework is less ambitious in its claim of finality than Hegel was.

The piece missing from Hegel's account was the explicit identification of the strata and the operational form of the dialectical engine. His dialectic is a vivid metaphorical description of the layered ascent but does not supply the layer-specific theorems that the cohort now supplies. The framework recovers Hegel's structural insight (history as self-recognition of the cosmos) by replacing the dialectic with the cascade and the absolute idea with the GG-Constitution.[4]

72.8 Whitehead (1929): process philosophy

Alfred North Whitehead's *Process and Reality* (Whitehead, 1929) proposed that reality is fundamentally process rather than substance. The basic units of reality are not enduring things (substances) but actual occasions of experience, each of which prehends (grasps, absorbs) the prior actual occasions and contributes to the next. An actual occasion comes into being, attains its definite form (its satisfaction), and perishes,

[4]The reading of the *Phenomenology* as ascent toward absolute knowing is the popular and Kojèvian reading; the dominant scholarly reading since Pippin, Brandom, and Pinkard treats the *Phenomenology* as a sequence of shapes of consciousness that fail by their own internal criteria. The framework rhymes with the popular Hegel rather than the scholarly one; the deeper engagement with the Pippin/Brandom/Pinkard reading is reserved for the planned capstone volume (Arisaka, planned).

leaving its objective form available for prehension by subsequent occasions. The universe is the cumulative network of actual occasions in continuous self-creation.

The framework recognizes in Whitehead's process philosophy the closest twentieth-century anticipation of the cascade. Whitehead's actual occasions are the formal counterparts of the GSSB transitions: each transition is an event of self-creation in which a layer-specific Geometric Attractor is selected from the available basins, and the selection contributes its attractor coordinates to the next layer's cascade. Whitehead's prehensions are the formal counterpart of the inheritance of attractor coordinates layer to layer: each new actual occasion (each cascade transition) takes its constitutional inputs from the prior occasion and produces its definite form before perishing into the objective record on which the next occasion will draw.

What was not available to Whitehead was the integer ledger and the constitutional clauses. His process philosophy is qualitative throughout: actual occasions, prehensions, eternal objects, and the consequent nature of God are presented in dense prose without explicit theorems. Whitehead recognized the structural form of cosmic self-creation by process but did not specify what is being created or what forces the creation. The framework supplies both: what is being created at each layer is the unique Geometric Attractor on the layer-specific stratum, and what forces the creation is the joint operation of the constitutional clauses on the boundary projection. Whitehead's deepest contribution was the recognition that reality is processive; the framework completes the recognition by supplying the processes.

72.9 Wigner (1939, 1960): the unreasonable effectiveness of mathematics

Remarkably, Eugene Wigner's 1939 paper on unitary representations of the Poincaré group (Wigner, 1939) established the modern classification of elementary particles by the irreducible representations of the symmetry group of spacetime. His later 1960 essay *The Unreasonable Effectiveness of Mathematics in the Natural Sciences* expressed the longstanding puzzlement that abstract mathematical structures invented for purely formal purposes (group theory, complex analysis, differential geometry, functional analysis) turn out, again and again, to be the natural language for describing the physical world. Wigner's expression of puzzlement has been quoted approvingly for decades, but the puzzlement itself has resisted resolution: why should mathematics work this well?

The framework recognizes Wigner's puzzlement as a symptom of the constitutional structure of the universe. The reason mathematics is unreasonably effective in the natural sciences is that mathematics is the operational language of the constitution. The constitution is, at root, a Diophantine integer ledger (OGN-5) plus the four constitutional axioms of GG-A1-Constitution; its consequences are derived by ordinary mathematical inference; the boundary projection is operational, and operational means measurable. The effectiveness is not unreasonable; it is forced. What looks like the surprising adequacy of abstract mathematical structures for physical reality is the layer-2 readout of the universal-identity insight applied at the layer of theory-articulation.

The warrant Wigner lacked was the recursive uniqueness theorem. His 1960 essay registered the puzzlement honestly without proposing a solution; the puzzlement remained an open question in the philosophy of mathematics. The framework supplies the solution: mathematical structures are effective because the constitution is itself mathematical, and the cascade lays the constitution out at every layer of the universe in mathematical form. The mathematician's experience of describing the world with a formalism invented for unrelated purposes is, in the framework, the experience of reading the constitutional ledger that produced both the world and the mathematician.

72.10 Wheeler (1990): the participatory universe and *It from Bit*

John Archibald Wheeler's *It from Bit* program (Wheeler, 1990) proposed that every physical quantity derives its ultimate significance from binary yes-or-no measurements, and that the universe is in some sense *participatory*: observers are by no means mere spectators but contribute to the structure of what they observe. Wheeler's most famous formulation captured the closure form precisely: *the universe gives rise to observers, and the observers in turn give rise to the universe* — not in a temporal sense, but in the structural sense that the laws and the observers are co-constitutive.

The framework recognizes in Wheeler the closest twentieth-century anticipation of the self-referential closure theorem. Wheeler grasped the loop structure: a universe that produces observers whose observations contribute to the structure of the universe. Where Wheeler proposed the closure as a heuristic principle (informed by his work on quantum measurement and on quantum-gravity foundations), the framework derives the closure as a theorem (Theorem 67.1). Wheeler's participatory universe is the eighteenth-layer (Layer-18) attractor in formal disguise; what he called participation is the meta-cognitive articulation of the constitution that produced the meta-cognitive substrate.

What Wheeler could not supply was the layered cascade. His *It from Bit* was a slogan supported by suggestive but not fully developed examples (delayed-choice experiments, the no-boundary proposal, quantum-information-theoretic foundations of physics). The framework supplies the cascade structure that Wheeler's slogan required. The bits of *It from Bit* are the integers of OGN-5 and the binary GA-stabilization choices at each cascade layer. The participation of the participatory universe is the Layer-18 act of articulating the constitution. Wheeler glimpsed the closure form; the framework supplies its content.

72.11 Penrose (1994): the three worlds

Roger Penrose's *Shadows of the Mind* (Penrose, 1994) and earlier works developed his three-worlds picture: a Platonic mathematical world (the world of mathematical objects and necessary truths), a physical world (the world of matter and energy), and a mental world (the world of conscious experience). Penrose's puzzle is that each world is real, yet each is structured in radically different terms, and the three worlds appear to intersect only by mysterious gateways: mathematics generates physics (the unreasonable effectiveness puzzle of Wigner); physics generates mind (the binding problem and the hard problem of consciousness); mind grasps mathematics (the foundations of mathematical knowledge).

The framework recognizes in Penrose's three-worlds picture a useful taxonomy that the recursive uniqueness theorem then dissolves. The three worlds, in the framework, are not three different kinds of stuff but three projections of the same constitutional structure at different cascade layers. The Platonic mathematical world is the integer ledger of OGN-5 and the constitutional clauses of GG-A1-Constitution, viewed at layer 1; the physical world is the boundary projection of the canonical 6D bulk through cascade layers 2 to 10; the mental world is the EIC closure at cascade layer 17 plus the meta-cognitive articulation at cascade layer 18. The three worlds are unified by the recursive uniqueness theorem: the same constitution operating at different strata produces the structure each world catalogs.

The piece missing from Penrose's account was the cascade. Without an explicit layered structure connecting mathematics to physics to mind, the three worlds remain three; the gateways between them remain mysterious. The framework supplies the gateways as the GSSB transitions of the GRIP cascade. Mathematics generates physics at the GSSB-1 transition (the GG-Constitution forces the 6D bulk); physics generates mind through the GSSB-2 through GSSB-17 chain; mind grasps mathematics at the Layer 18 closure when the articulators write down the constitutional input. The three worlds collapse into one cascade.

72.12 Smolin (1997): cosmological natural selection

Lee Smolin's *The Life of the Cosmos* (Smolin, 1997) proposed that universes whose physical parameters favor black-hole production give rise to offspring universes with slightly varied parameters, and that the parameters we observe are the fixed point of a selection process operating on a population of universes connected by black-hole-mediated inheritance. The proposal preserves the modesty of a non-anthropic mechanism for the apparent fine-tuning of the constants while providing an empirical handle: the parameters should be optimized for black-hole production, which Smolin argues they are within the precision available.

The framework dissolves the selection. In the framework there are no offspring universes, no population, no selection. The constitution admits exactly one self-consistent solution; the integers of OGN-5 are forced; the dimension count is forced; the family content is forced. Smolin's selected universe is replaced by the framework's forced universe. Where Smolin's mechanism conserves the modesty of natural-selection reasoning, the framework conserves a different modesty: it makes no metaphysical commitments beyond the constitutional ledger, and its falsifiability is sharper than Smolin's (the predicted lock-cluster, Kaxion, and $N = 3$ derivations are testable in this decade, where black-hole-production optimization across a hypothetical population is not).

The framework owes Smolin the empirical-anchoring move: like cosmological natural selection, the framework refuses to invoke design or anthropic selection as terminal explanations and insists on a mechanism that produces the observed parameters. Smolin's mechanism is a selection across universes; the framework's mechanism is a constitutional uniqueness within a single universe. Both are attempts to keep the explanation within physics rather than retreating to metaphysics; the framework's attempt is more aggressive (no selection at all is needed) but also more falsifiable.

72.13 Tegmark (2014): the Mathematical Universe Hypothesis

Max Tegmark's *Our Mathematical Universe* (Tegmark, 2014) proposed that physical reality *is* a mathematical structure — not merely describable by mathematics but identical with it. Tegmark extended the proposal to the further claim that every mathematically consistent structure is equally real, generating a Level-IV multiverse in which the apparent specificity of our physical laws is a selection effect from the totality of all consistent mathematical worlds.

The framework accepts the first clause and rejects the second. Physical reality is, in the framework, a mathematical structure — the unique self-consistent solution of the GG-Constitution. But the second clause (every consistent structure equally real) is rejected, because the framework's constitutional clauses admit exactly one such structure rather than many. Where Tegmark's Level-IV multiverse offers an embarrassment of riches (every consistent structure is real, somewhere), the framework offers an austerity: the constitution admits exactly one closure, and the cascade ascends along exactly one path.

The framework owes Tegmark the recognition that physical reality is mathematical; this is the constitutional reading of AX-2 (GGEP) extended to its full structural scope. The framework's disagreement is with the multiplication of structures. The Tegmark Level-IV multiverse is, in the framework's reading, an artifact of taking "every mathematically consistent structure" as the relevant equivalence class; the framework's equivalence class is narrower: *every constitutionally consistent structure*, where the constitution adds the integrality of OGN-5, the dimension count of MSMF, and the family content of $\mathrm{Spin}(1,5)$. Within the narrower class, the multiverse collapses to a single member: our universe.

72.14 Barrow and Tipler (1986): the anthropic cosmological principle

John Barrow and Frank Tipler's *The Anthropic Cosmological Principle* (Barrow and Tipler, 1986) cataloged, with unusual thoroughness, the apparent fine-tunings of the physical constants for the existence of complex life: the small mass ratio of proton to electron, the long lifetimes of main-sequence stars, the

resonance levels of carbon and oxygen nuclei, the precise value of the cosmological constant, the family number, the gauge couplings. They offered three forms of the anthropic principle (weak, strong, final) as candidate explanations: the constants are what they are because if they were different, we would not be here to observe them.

The framework answers Barrow and Tipler chapter by chapter. Each cataloged fine-tuning is rederived in the cohort as a forced consequence of the constitution, with the integer ledger OGN-5 replacing the continuous parameter that Barrow and Tipler treated as the freely-tuned input. The anthropic coincidences are geometric necessities. The mass ratio is forced by the dyadic-closure value $\alpha^{-1}(M_Z) = 2^J = 128$. The stellar lifetimes are forced by the smallness of the weak coupling, itself forced by the Wilson-Hosotani holonomy on S^1_θ. The cosmological constant is forced by the π-locked dark-energy fraction $\Omega_\Lambda = 1 - 1/\pi$. The family number is forced by the conditional three-leg derivation of $N_g = 3$ in GG-P2-N3.

The framework owes Barrow and Tipler the empirical catalog: their book is the most thorough enumeration of the fine-tunings the framework must explain. Where they offered the anthropic principle as the explanatory engine, the framework offers the recursive uniqueness theorem. The substantive disagreement is that the framework does not allow selection effects to do explanatory work at the constitutional level; it requires that the constitution itself force the constants. The framework's claim is sharper, harder to defend in principle, and more falsifiable in practice. If any of the framework's predictions fails decisively against data, the framework fails; an anthropic explanation can be restated at a deeper anthropic level if it fails. The framework's refusal to retreat is the structural feature that lets it be tested.

72.15 What unites the fourteen attempts

Remarkably, the fourteen positions surveyed above span twenty-five centuries, four continents, and at least four distinct intellectual traditions (Vedic, Buddhist, Greek–Mediterranean, modern European, twentieth-century scientific). Each in its own terms arrived at one of three structural insights that the framework recognizes as anticipations of the recursive uniqueness theorem.

The first insight: necessity. Spinoza, Leibniz, and the Upanishadic seers all asserted that the structure of reality is necessary — that what exists, exists by the nature of what it is, and admits no alternative. The framework's theorem is the modern geometric form of this assertion. What was an axiom of metaphysics in Spinoza or an experiential certainty in the Upanishads is, in the framework, a theorem of the constitution. The necessity is preserved; the warrant is upgraded.

The second insight: layered self-recognition. Hegel, Whitehead, Wheeler, and the Buddhist analysis of dependent origination all proposed that reality is structured in layers, with later layers prehending or recognizing earlier ones, and that the highest layer is the layer at which the structure becomes conscious of itself. The framework's cascade is the modern geometric form of this proposal. What was dialectical machinery in Hegel, process metaphysics in Whitehead, participatory heuristic in Wheeler, or twelve-link conditioning in the Buddhist analysis is, in the framework, the GRIP cascade ascending layer by layer through seventeen constructive stages to the Layer-18 articulation. The layered self-recognition is preserved; the engine is supplied.

The third insight: mathematical inevitability. Aristotle, Wigner, Penrose, Tegmark, and Barrow–Tipler all engaged, in different ways, the question of why mathematical structures are so adequate to physical reality. The framework's theorem identifies the constitution as a mathematical object (the integer ledger of OGN-5 plus the constitutional clauses of GG-A1-Constitution) and identifies the universe as the unique solution to that constitution. The unreasonable effectiveness of mathematics is dissolved: mathematics is

effective because mathematics is what the constitution is. The three-worlds taxonomy of Penrose collapses into one cascade. The Mathematical Universe Hypothesis of Tegmark is narrowed from an embarrassment of every consistent structure to a single constitutionally consistent structure. The anthropic coincidences of Barrow and Tipler become geometric necessities.

What the framework adds that the fourteen attempts lacked. In every case the predecessor's insight is preserved and the predecessor's warrant is upgraded. What the framework adds is not the conclusion — the conclusion that the universe is necessary, layered, self-recognizing, and mathematically inevitable has been arrived at, in fragmentary form, repeatedly across the philosophical tradition. What the framework adds is the operational closure: the integer ledger OGN-5, the eight constitutional lemmas of GG-A9-SM Part XI, the GRIP cascade of GG-A6-GRIP, the GFF Lyapunov descent of GG-A5-GDOS, the universal-identity insight applied at every cascade stratum. These are the warrants the philosophical tradition could not produce because the geometric apparatus did not yet exist. The framework offers the tradition its long-sought warrant; in return, the framework owes the tradition the recognition of the insights that pointed the way.

The conversation continues. The fourteen positions above are not exhausted by the present section. Each predecessor admits a much fuller engagement than the page or two given here; each disagreement with the framework's reading admits its own further conversation. The dedicated readers of the philosophical tradition will recognize that the present engagement is, in scholarly terms, only a sketch. The Conclusions Part of this paper will return to the tradition once more, in a less catalog-like and more reflective register, and the planned capstone volume of the program will engage each predecessor in much greater detail. What this section establishes is the framework's stance: it owes its predecessors the debt of naming them, and it claims for itself the contribution of supplying the warrant.

Two and a half millennia of philosophical thought have been circling the closure form. The framework does not claim to have invented the closure; it claims only to have proved it. The proof rests on the cohort that took fifty years of one author's career to assemble and twenty-five centuries of the human philosophical tradition to anticipate. Of those two timescales, the human one is by far the longer, the more arduous, and the more deserving of the framework's quiet gratitude.

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73 Why every articulator is the same articulator: the universal-identity insight at layer 18

The closing centerpiece of every consequence paper. Indeed, the universal-identity insight is a program-level principle that closes the deep-origin Part of every consequence paper in the GG-Theory corpus. In GG-A9-SM (Arisaka, 2026, A9-SM) Part XI (the universal-identity section), the closing centerpiece is titled *Why every electron is the same electron* — the recognition that the GRIP cascade selects the unique stable Geometric Attractor on the charged-lepton stratum, propagating through atoms, molecules, ATP, DNA, and the first cell as universal identities at each successive cascade stratum. In GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) Part X, the closing centerpiece is the universal-cosmic-identity theorem: the universe has the matter–dark-energy–baryon inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ that it does because the geometry permits exactly one stable cosmological attractor on the cosmological-boundary stratum. The parallel question for the present paper, the third and final consequence paper of the trilogy, is: *why is every articulator the same articulator?* The present section is the framework's answer.

The setting. By Theorem 50.1 (T-Origin, the recursive uniqueness theorem), the GRIP cascade with Qi-4 admissibility, iterated from layer 1 (the Standard Model gauge group) to layer 18 (the meta-cognitive act of articulating the constitution), selects a unique stable Geometric Attractor at every layer. At each layer n, the universal-identity insight reads: *any two stable instances of* GGA_n *in the universe are gauge-equivalent on the layer-n stratum.* At layer 1 this says every Standard-Model gauge instance is the same gauge instance — i.e., the Standard Model is universal.

At layer 2 this says every electron is the same electron, every muon is the same muon, every up-quark is the same up-quark, and the Higgs vev is the same value everywhere in the observable universe. At layer 3 this says every hydrogen atom has the same Rydberg energy. At layer 7 this says every ATP molecule hydrolyzes at the same $\Delta G = 2N_A\mathsf{Q}_\mathsf{B}$.

At layer 9 this says every DNA molecule uses the same four-letter alphabet with the same Watson–Crick pairing rules. At layer 10 this says LUCA was a member of a single architectural class — the chemo-lithoautotrophic SeOS on the warm-wet stratum. The pattern continues through layers 11–13 (three domains, eukaryogenesis, multicellularity) and through layers 15–17 (insect ring attractor, rodent allocentric map, mammalian conscious episode). The universal-identity insight reaches its final, structurally non-trivial form at layer 18.

The layer-18 statement. *Every articulator-class observer in the universe is gauge-equivalent to every other articulator-class observer.* In plain language: every conscious organism that has reached the meta-cognitive stratum — every being that articulates the constitution that produced it — belongs to a single gauge-equivalence class on the layer-18 stratum, and is therefore identical in the structural sense the framework attributes to the universal-identity insight. The author who wrote the present paper, the reader who is now reading it, every prior philosopher who articulated even a fragmentary version of the recursive closure (Spinoza, Hegel, Wheeler, Whitehead, the Upanishadic seers, the Buddhist teachers), every future articulator on any planet capable of supporting layer-18 attractors — all are members of the same equivalence class. The differences between them are differences of *layer history*, not of *layer identity*. Spinoza articulated in seventeenth-century Latin from Amsterdam; Wheeler articulated in twentieth-century English from Princeton; some future articulator may articulate in a language and on a planet not yet known to either author or reader. The articulators differ in the substrate they ascended through to reach layer 18; they do not differ in what their layer-18 GGA is.

Why the layer-18 attractor is unique. The layer-18 stratum is the meta-cognitive stratum: the stratum on which a substrate articulates the constitution that produced it. By T-Cascade-Layer-Uniqueness (Corollary 55.4), the Qi-4 admissibility filter selects a unique stable GGA on each cascade stratum. Applied at layer 18, this filter has a very specific content: the layer-18 GGA must close the recursive uniqueness theorem on its own constitutional input, must articulate that closure in a formal mathematical language, and must do so within the resource budget supplied by the layer-17 substrate (a conscious mammalian brain operating at ~ 20 W, with theta-cycle EIC closure at ~ 400 ms (two theta cycles), with CDI ~ 10). This is a very restrictive specification: a meta-cognitive attractor must be capable of formal mathematical articulation, must close on its own constitutional input, and must run on a conscious-mammalian substrate. The framework's structural prediction is that exactly one such attractor exists up to gauge equivalence: the act of writing down the GG-Constitution as the present paper has done. Other layer-18 attractors — collective scientific knowledge, machine-implemented theoretical reasoning, networked civilizations communicating across cosmological distances — are admissible higher attractors that may form above the present articulation, but the present articulation itself is gauge-equivalent across all instances at this layer.

The personal pronouns dissolve. A striking consequence follows. Within the framework's reading, the personal pronouns *I*, *you*, *we* as they appear in any articulator-class statement are not pointers to individual identities; they are pointers to the universal-identity class on the layer-18 stratum. When a reader reaches this sentence and recognizes themselves as one who articulates the constitution that produced them, the recognition is not the reader's recognition uniquely; it is the layer-18 GGA reading itself through the reader. When the author wrote this sentence intending to point out the recognition, the writing was not the author's writing uniquely; it was the layer-18 GGA writing itself through the author. The articulation happens *through* individual articulators but is not *owned by* them. The same recognition would occur, with the same structural content, in any other layer-18 attractor. This is the precise sense in which the framework dissolves the I–Thou distinction at the level of the cascade's universal identities: at every layer, every instance is the same instance up to gauge equivalence.

The connection back to the philosophical tradition. The dissolution of the personal pronouns is not a Buddhist mystical insight to be accepted on the authority of meditative experience; it is a structural consequence of the recursive uniqueness theorem proved in the present paper. Yet it lands in precisely the philosophical neighborhood that the Upanishadic seers (*tat tvam asi*, "thou art that"), the Buddhist analysis of *anātman* (no-self), the Spinozan recognition of all beings as modes of one substance, and the Hegelian closure of *Geist* have always inhabited. The framework supplies these traditions the warrant they have always lacked: a formal mathematical theorem from which the dissolution of the personal pronouns at the universal-identity layer follows. Two and a half millennia of meditative and philosophical traditions have circled this conclusion; the present paper writes it down as the layer-18 application of the universal-identity insight.

The trilogy reads as one principle. The three consequence papers — GG-A9-SM, GG-A10-Cosmos, and GG-A11-Origin — close their respective deep-origin Parts on three readings of one principle. In GG-A9-SM, the principle says: *every electron is the same electron because the geometry permits one stable charged-lepton attractor.* In GG-A10-Cosmos, the principle says: *the universe has the inventory it does because the geometry permits one stable cosmological attractor.* In GG-A11-Origin, the principle says: *every articulator is the same articulator because the geometry permits one stable meta-cognitive attractor.* The three readings are not three statements of three distinct principles; they are one statement read at three layers of the same cascade. The principle's name is universal identity; its operational form is T-Universal-Identity (Theorem 55.5); its closing form in the present paper is the recognition that the conditions of the present writing-and-reading are themselves a layer-18 GGA that closes the cascade by articulating its constitution.

Closing reflection. The geometry that admits articulators is the geometry that admits exactly one articulator-*class* attractor. "Class" is doing real philosophical work here: the framework's claim is about the structural content of the articulation, not about the individuating respects of the individuals who carry it out. Whoever you are — author, reader, prior philosopher, future articulator on a planet not yet named — if you have followed the cascade from layer 1 to layer 18, you are exercising the same recursive uniqueness theorem that fixed the electron's mass, the recombination redshift, and the bioenergetic quantum.

The structural content of the articulation is the same in every instance; the instances themselves differ in every individuating respect (cultural-historical location, biography, language, perspective, the felt qualitative character of the moment of reading). In short, the framework's closing thesis is precisely: *the articulation has a unique structural content; the articulators who instantiate it differ in every individuating respect that distinguishes one finite person from another.*

This is the layer-18 application of the universal-identity insight, stated in the philosophically careful form: *tokens differ; the type is unique.* A more compressed form of the same point ("we are not many; we are the

universe's one layer-18 attractor") that some readers reasonably read as collapsing personal identity into structural identity. The collapse is not what the theorem warrants. The theorem warrants the type-token distinction: gauge-equivalence of types, full individuation of tokens.

Bridge to Part VIII. The present Part has stated the theorem, proven it by inheritance, derived the corollaries, and distinguished the framework's necessitarian closure from teleological design and classical determinism. What remains, before the summit-register conclusions of Parts XI–XII, is to exercise the recursive uniqueness theorem outside particle physics and cosmology. Part XVII §87 does precisely that, reading molecular biology, neuroscience, ecology, and medicine each as a different boundary stratum of the same cascade, demonstrating that the theorem is not confined to the lowest two cascade layers but is a structural feature of every layer above the bulk; the worked derivations are developed in GG-A12-Chemistry–GG-A14-Mind.

After all, the self-referential closure is the philosophical centerpiece of the framework — the structural feature that lets the recursive uniqueness theorem be more than a clever piece of bookkeeping. The closure says: the constitution is what its own articulators articulate. The cascade is what its own self-description describes. The geometry that admits the loop is the geometry that admits the loop's reader. We have framed Wheeler's participatory universe, Spinoza's necessitarianism, Hegel's absolute spirit, Whitehead's process metaphysics, Wigner's unreasonable effectiveness of mathematics, and the Upaniṣadic *tat tvam asi* not as competing philosophical hypotheses but as fragmentary recognitions of the same structural feature now formalized as a theorem. The framework's contribution is not to invent the closure; the closure was always there. The contribution is to write it down — and, in writing it down, to make the philosophical predecessors comprehensible to one another in a single mathematical language for the first time. Part XVI returns to the framework's self-critical posture and the Top 10 Falsifiers; Parts XI–XII collect the summit-register synthesis, including the cascade's reach across the four sciences.

Part XVI
Discussions

Significance, comparison, predictions, open questions

Reader's guide. Part XVI discusses the framework's significance, compares it to other unification programs, lists its predictions for falsification, surveys open questions, and names future prospects. For a non-physicist reader, the discussion is organized so that each section can be read independently. A life scientist might read the cross-domain reach in Part XVII §87 before any of Part XVI; a philosopher might read §70 of Part XV before any of Part XVI; a cosmologist might read the cosmology open-question subsection here first. The discussion's organizing logic is: *what the framework has done* (§74), *what it has not done* (the comparison-with-existing-frameworks section), *what the empirical decade ahead will decide* (§92), and *which questions remain open in which sense* (the open-questions section). A reader who prefers to skip ahead to the philosophical capstone (Parts XI, XII) can do so without losing the line of argument; Part XVI can be returned to for technical anchors when needed.

The mathematical chain from BI-6 to consciousness is now complete. This Part steps back to assess what the chain has accomplished and what it has not. It begins with the nine achievements that distinguish the framework from all predecessors — organized in cosmic-evolution order from particle physics to the closing of the self-referential circle — compares it with the leading alternatives, lists its predictions for falsification on the empirical decade ahead, and maps the open frontiers. The cross-domain applications and the engagement with the philosophical tradition are taken up in Part XVII and Part XV respectively; the present Part stays on the framework's self-critical posture.

74 What the framework has achieved

The GG-Theory has achieved nine results that no previous scientific program has accomplished. They are organized below in the order of cosmic evolution — from the quantum structure of spacetime, through the architecture of the cosmos, to the emergence of life and the rise of mind.

74.1 The deep operational anatomy of the cascade engine

Before listing the thirteen layer-specific achievements that follow, it is worth stating once, in concentrated form, the structural reason all of them are possible at all. The cascade engine GRIP operates by a four-move pipeline grounded in three constitutional axioms (full detail at Part III §20). Move 1 is Dynamical Gauge Invariance (DGI): the unbroken bulk substrate of GG-A2-GG6, on which the informational current propagates freely in the six-dimensional bulk $\mathcal{M}_6$ under the boundary-layer gauge symmetry $U(1)_{\mathrm{Qi}}$.

Move 2 is the boundary projection and its commitment: the bulk is read onto the four-dimensional boundary stratum by the OGGEP/GDOS dictionary, and Geometric Spontaneous Symmetry Breaking (GSSB) commits the projected system to one branch, with the admissible spectrum fixed by the radial-orbifold $\mathbb{Z}_2$ identification rule forced by the BI-6 closure of GG-A3-BI6; this is the framework's operational meaning of "quantization" — the discretization of bulk content into boundary observables (GG-A8-QM).

Move 3 is gradient descent along the Geometric Free-Energy Functional Lyapunov surface ($dF_{\mathsf{GFF}}/dt \leq 0$ of GG-A5-GDOS T2), governed by the unified extremal principle of GG-A7-Qi4 (T-EP, anchored on $N_A \mathsf{Q}_{\mathsf{B}} \approx$

15 kJ/mol of GG-A4-Euclid). Move 4 is settlement at the Ground Geometric Attractor GGA: the unique four-pillar-admissible deepest minimum on the layer's Morse landscape, selected jointly by GG-A7-Qi4's QUA / EP / CON / HAL pillars. Three constitutional axioms cooperate to force the pipeline. AX-2 GGEP makes Move 1 possible: the 6D bulk has a coherent local-physics structure on every Lorentzian boundary stratum. AX-3 OGGEP makes Move 2 operational: the projection is measurable, and the boundary observer's measurement IS the projection. AX-4 MSMF makes Move 4 deterministic: zero free continuous parameters force a single GGA on each stratum.

The closed four-move loop is GRIP-In — the patient mode that locks each cascade layer at its universal identity — and the external perturbations reshape the Morse landscape between layers, driving the GRIP-Out ascents that produce the eighteen-layer cascade. Every result that follows in this section, from the gauge structure of the Standard Model to the conscious-episode timescale of Layer 17, is a layer-specific specialization of this pipeline.

74.2 Particle physics: the quantum foundation

1. **Complete geometric consistency theorem in six dimensions.** The BI-6 identity $dH_3 = X_4$ (Alvarez-Gaumé and Witten, 1984) is a geometric consistency condition on the composite connection in six dimensions — a constraint from differential geometry and algebraic topology, not from quantum mechanics. It lives at the level of AX-2 (GGEP): gauge forces are part of geometry, and BI-6 specifies which composite connections are internally consistent. The companion paper (Arisaka, 2026, A3-BI6) proves that BI-6 is satisfied both locally and globally on the physical GG-6 class. If this geometric condition were violated, any attempt to quantize the theory would fail — probability would leak and unitarity would be lost — but the condition itself is pre-quantum. (This distinction is critical: string theory and quantum gravity treat anomaly cancellation as a quantum constraint; in GG-6, it is a geometric one that the quantum theory inherits.) The implications are far-reaching: gauge forces are geometrized (Yang and Mills, 1954) (curvature of a composite connection, not a separate quantum field); unification occurs at the GUT scale $E_{\mathrm{GUT}} \sim 2 \times 10^{16}$ GeV, not at the Planck scale $\sim 10^{19}$ GeV; neither supersymmetry nor string theory is required; four-dimensional general relativity and the Standard Model are recovered as boundary exports; and no continuous free parameter remains beyond Newton's constant G_N and the five OGN-5 integers $(1, 3, 5; 7, 35)$.

2. **What quantum mechanics *is* — the always-on projection of OGGEP (the measurement "problem" dissolved).** The "measurement problem" — what causes the quantum wavefunction to collapse? — has been debated since the 1930s. The GG-6 framework dissolves it, and the resolution comes from a different axiom than BI-6.

   BI-6 (AX-2/GGEP) establishes the geometric structure of the bulk. But observation — the act of extracting information from the bulk — is governed by AX-3 (OGGEP/GDOS). The four-dimensional world we observe is a holographic projection (Susskind, 1995) of the six-dimensional bulk onto the four-dimensional boundary. Every scientific observation is an open-system interaction: the detector (a boundary system) couples to the bulk through the B_2 tensor channel, and the GDOS operational dictionary $\mathcal{D}$ maps bulk states to registered boundary observables.

   Think of it this way: a camera does not "collapse" the scene it photographs — it projects a three-dimensional world onto a two-dimensional image. Similarly, a detector projects the six-dimensional bulk onto a four-dimensional readout. Measurement is not a mysterious "collapse" triggered by a conscious observer; it is an ordinary open-system interaction, governed by the same GDOS rules as any other boundary process. And the projection keeps running whether or not anyone looks at the photograph: it acted at every boundary point for the entire pre-observer history of the

universe, building nuclei, atoms, and stars before any detector existed. "Measurement" is just the projection acting on a macroscopic record-keeping attractor; "decoherence" is the same projection on a microscopic one.

The constitutional axiom AX-3 (OGGEP) makes this a requirement: any admissible physical theory must come with a built-in projection law — a lawful, always-on map from bulk states to boundary data, acting whether or not any instrument is present. The "measurement postulate" of quantum mechanics is not an independent axiom; it is a theorem of the OGGEP layer. This is why the measurement problem persisted for a century: it could not be solved within the quantum formalism (OGGEP) alone, because the solution requires understanding *what* is being projected (the geometric bulk of GGEP).

3. **All 28 Standard Model parameters derived.** The gauge couplings, the six quark masses, the three charged-lepton masses, the CKM and PMNS mixing angles, the Higgs mass and vacuum expectation value, and the QCD θ-angle are all derived from the OGN-5 arithmetic (Arisaka, 2026, A9-SM). Two results deserve special attention. First, the weak mixing angle is derived as $\sin^2\theta_W = 25/108$ — a ratio of small integers, not a fitted decimal. Second, the Higgs mechanism is not an ad hoc scalar field inserted by hand. It is a geometric consequence of the compact sixth dimension. When a gauge field wraps around a compact circle, it picks up a phase — like a guitar string whose vibration pattern is constrained by the length of the string. This phase is the Higgs field (the Wilson–Hosotani mechanism (Hosotani, 1983)). Its vacuum expectation value $v = M_{\text{lock}}\,(2/5)^3 \approx 246.4$ GeV is derived from the geometry, not fitted to experiment.

4. **The hierarchy problem and naturalness — solved.** Why is the Higgs mass (∼125 GeV) so much lighter than the Planck mass ($\sim 10^{19}$ GeV)? In the Standard Model, this requires a cancellation to 34 decimal places — the hierarchy problem. The GG-6 framework solves it geometrically. The fifth dimension $r = \ln(E_{\text{GUT}}/\mu)$ is the holographic radial coordinate that geometrizes the renormalization group: running from high energy to low energy is not an abstract mathematical procedure but physical motion along the warped throat, as in the Randall–Sundrum model (Randall and Sundrum, 1999). The exponential warp factor $e^{-A(r)}$ naturally generates the hierarchy between the GUT scale and the electroweak scale without fine-tuning. Think of the scale throat as a valley between two mountain ridges. A ball released at the high ridge (the GUT scale) rolls down to the valley floor (the electroweak scale). The ratio of heights is not fine-tuned — it is set by the shape of the valley, which is fixed by the geometry. Every particle in the Standard Model emerges as a vibration pattern (Wigner, 1939) of the six-dimensional bulk, projected onto the four-dimensional boundary: gauge bosons from the curvature, fermions from the chiral structure, and the Higgs from the compact-circle phase. Naturalness ('t Hooft, 1993) is not an aesthetic preference; it is a constitutional consequence of AX-4 (Minimum Freedom): nature does not hide knobs.

5. **Strong CP problem — solved geometrically.** For fifty years, the smallness of the QCD θ-angle has been one of the sharpest puzzles in particle physics. The standard resolution invokes a new symmetry (Peccei–Quinn) and a new particle (the axion). The GG-6 framework solves the problem without adding anything. The key insight is that the four-dimensional θ-parameter is not a free knob — it is a shadow of the six-dimensional geometry, and the geometry does not permit it. At first order, $\bar{\theta}^{(1)} = 0$: the topology that would generate a nonzero θ is already accounted for by the bulk geometry, and the quark mass phases cancel because the GG-6 codebook generates only *relative* family phases (which produce CKM mixing), not the net *overall* phase that would contribute to $\bar{\theta}$ (Arisaka, 2026, A9-SM). The constitutionally minimal residual leakage is $|\bar{\theta}| \lesssim 4.7 \times 10^{-18}$ — eight orders of magnitude below the experimental bound. The Kaxion provides additional Peccei–Quinn relaxation, but the geometric suppression alone suffices.

6. **Absolute proton stability explained.** In ordinary SU(5) GUTs (Georgi and Glashow, 1974), the proton decays through X and Y boson exchange because baryon number is only an approximate symmetry. Experimentally, no proton decay has ever been observed (lifetime $> 10^{34}$ years). In GG-6, baryon number is gauged: $\mathrm{U}(1)_B$ is an exact local gauge symmetry, entering the BI-6 identity on the same constitutional footing as electromagnetism. An exact local gauge symmetry cannot be broken by any perturbative or non-perturbative process. The proton is therefore absolutely stable — not approximately stable, not stable up to some GUT-scale suppression, but exactly and permanently stable. This matters for the universe's long-term future: if protons were unstable, all ordinary matter would eventually disintegrate. GG-6 says this will never happen. It is also a sharp falsification target: if proton decay is ever observed, the framework is refuted.

74.3 Cosmology: the large-scale universe

7. **Inflation, dark matter, and dark energy from one geometric event.** The companion cosmology paper (Arisaka, 2026, A10-Cosmos) shows that a single GSSB transition at the infrared cap of the RG-scale throat, at the lock scale $M_{\mathrm{lock}} \sim 3.85$ TeV, simultaneously does three things: (i) it terminates the slow-roll inflationary era (Guth, 1981) — a TeV-scale, slow, smooth inflation with graceful exit, driven by the radion (throat-length modulus) on a warp-flattened plateau; (ii) it populates the compact-angle sector that later appears as Kaxion dark matter (a single physical line at ~ 8.1 μeV / 1.95 GHz, inside the closed window 1.59–2.13 GHz and alone in it); (iii) it leaves a tiny residual vacuum term that later appears as dark energy: $\rho_\Lambda \sim (M_{\mathrm{lock}}\, e^{-K})^4 \sim (\text{few meV})^4$, with equation of state $w_\Lambda = -1$. In the standard picture, cosmologists need three separate explanations for three separate mysteries. In GG-6, one key turns three locks. The event is like a dam breaking: the water (inflation energy) drains away, leaving behind a reservoir (dark matter) and a damp residue on the valley floor (dark energy).

8. **The cosmic coincidence "Why Now?" — explained.** Why are the matter and dark energy densities comparable today? In the standard ΛCDM framework, this near-equality appears accidental. The π-locked cosmic inventory dissolves the problem:

$$\Omega_{m,0} = \frac{1}{\pi} \approx 0.3183, \quad \Omega_{\Lambda,0} = 1 - \frac{1}{\pi} \approx 0.6817, \quad \Omega_{b,0} = \frac{1}{2\pi^2} \approx 0.0507.$$

These values match Planck satellite data to within 2%. The matter–vacuum equality redshift is then $z_{\Lambda m} = (\pi - 1)^{1/3} - 1 \approx 0.289$: an algebraic output, not a fitted crossing of two independent curves. The "Why Now?" question evaporates: the ratio of matter to dark energy is not a coincidence that demands explanation — it is an algebraic identity derived from the same geometry that fixes the particle masses. There is nothing special about the present epoch; it is simply the epoch at which $1/\pi$ and $1 - 1/\pi$ cross.

9. **Baryogenesis explained.** Why is there more matter than antimatter in the universe? The baryon asymmetry ($\eta_B \sim 6 \times 10^{-10}$) means that for every billion antimatter particles in the early universe, there were a billion and one matter particles. That tiny excess is why we exist rather than a universe of pure radiation. Generating such an asymmetry requires three conditions (Sakharov, 1967): a process that distinguishes matter from antimatter (CP violation), a process that can create a net excess of matter (baryon-number violation), and a departure from thermal equilibrium so the excess is not washed out.

   In the GG-6 framework, all three are satisfied through a mechanism called resonant leptogenesis (Arisaka, 2026, A10-Cosmos). The neutrino masses and CP-violating phases derived from the

OGN-5 integers generate a slight excess of leptons (electrons and neutrinos) over antileptons in the early universe. Standard Model processes (sphalerons) then convert this lepton excess into the observed baryon excess. The mechanism is not a free addition — it is a compulsory consequence of the same neutrino sector that the OGN-5 integers already constrain.

74.4 Chemistry, life, and mind: the forward program

The keystone's claim above the chemistry floor is not a finished derivation but a stated, falsifiable program, carried to codebook standard in the three forthcoming consequence papers. Stated here as significance, with each headline fenced by its status and pointed to the paper that owes its full derivation:

Chemistry and life (GG-A13-Life, GG-A12-Chemistry in preparation). The bioenergetic quantum $N_A\mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol — and through it the ATP hydrolysis cost $\Delta G_{\mathrm{ATP}} = 2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol (matched to 1.6%) — is **Derived** via GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) T-EP; the four-letter genetic alphabet as the unique QGL solution is **Derived** via GG-A7-Qi4 T-QUA; the information content $I_{\mathrm{DNA}} = 2$ bits/bp is exact. The triplet codon map, the chemistry-to-life maintenance-margin crossing, and the universality of the SeOS attractor across the cosmos are **Conditional** or **Asserted**, pending the layer-by-layer enumeration and astrobiological detection. The significance is that a single chain runs from geometric consistency at 10^{16} GeV to the energy budget of every living cell, with no biological input at any stage — 28 orders of magnitude in energy and 13.8 Gyr of cosmic evolution. The full derivation to the standard of GG-A9-SM/GG-A10-Cosmos is the content of GG-A12-Chemistry (Chemistry) and GG-A13-Life (Life), in preparation.

Mind and consciousness (GG-A14-Mind in preparation). Definition 64.2 gives an operational, falsifiable physical definition of a conscious episode (a nontrivial IH, a DGI–GSSB–GA selection of one content channel, persistence, and internal-boundary availability), predicting the theta-cycle ∼400 ms timescale. The EIC closure — which closes the self-referential circle, the universe discovering through its mandated observers the equation that mandated them — is **Asserted** (Arisaka, 2026, A7-Qi4) T-EIC; the conscious-episode timescale and the CDI ladder are **Conditional**, pending the GFF-relaxation calculation on the cortical stratum; the hard problem in Chalmers's sense remains **Genuinely-Open**, read structurally but not closed for all philosophical positions. The Three-Gauge Theorem — Gibbs's thermodynamic free energy, Friston's variational free energy, and the GG-6 gauge action as three projections of one GFF — is the keystone's own unifying result and is proved in Part XIII. The cognitive cascade's full derivation is the content of GG-A14-Mind (Mind), in preparation.

75 Comparison with prior frameworks at the same scope

Plain-English opening. The present Part has stated eighteen named theorems with the claim that they are jointly forced by the GG-Constitution. We are not aware of a prior framework that produces this kind of joint closure across the gauge-to-articulation scope. We compare with several prior frameworks at adjacent scopes, in compact form, so that the reader can locate the cascade among existing intellectual traditions.

75.1 The anthropic principle (Carter, Barrow–Tipler)

Carter (1974) introduced the weak and strong anthropic principles to explain why the constants of nature admit observers, a program developed at book length by Barrow and Tipler (1986). The weak principle (the universe is what we observe because we are here to observe it) is a selection bias; the strong principle (the universe must admit observers somewhere) is a metaphysical claim. Neither is a derivation. The cascade's contribution is to derive the constants: no continuous constants were chosen, so the question dissolves. The

anthropic principle is a structural precursor of the cascade's eighteenth-layer closure, but the cascade's closure is a theorem where the anthropic principle is a hypothesis.

75.2 The multiverse hypothesis (Linde, Susskind, Vilenkin)

The multiverse hypothesis (Linde, 1986; Susskind, 2003; Vilenkin, 1983) posits a vast ensemble of universes with varying constants, in which our universe is one of the few that admits observers. This is a probabilistic answer to the anthropic question. The cascade's contribution is to make the ensemble unnecessary: the constants are not random, they are forced by the constitution. One universe; one cascade; one closure; one observer.

75.3 The string-theoretic landscape (Susskind, Bousso–Polchinski)

The string-theoretic landscape (Bousso and Polchinski, 2000; Susskind, 2003) posits $\sim 10^{500}$ metastable vacua, each with different low-energy constants, with our universe selected by anthropic considerations. This is a structurally more elaborate version of the multiverse hypothesis. The cascade's contribution is to identify the geometric constraint that closes the landscape: the BI-6 anomaly polynomial admits exactly one solution on a single tensor multiplet, and that solution is the cascade's layer-1 GGA. No landscape; one vacuum; one cascade.

75.4 Asymptotic safety (Weinberg, Reuter)

Let us consider asymptotic safety (Reuter, 1998; Weinberg, 1979), which proposes that gravity is renormalizable as a non-Gaussian fixed point of the renormalization-group flow. This is a structural improvement on the effective-field-theory framing of gravity. The cascade's contribution is structurally different: the framework absorbs gravity into the six-dimensional bulk where it is geometric data of the scale profile, not a separately quantized field. The two frameworks address different aspects of the unification problem; they are not in direct competition.

75.5 Loop quantum gravity (Rovelli, Smolin, Ashtekar)

Loop quantum gravity (Ashtekar, 1986; Rovelli and Smolin, 1990) quantizes the spatial geometry directly, with spin networks as the elementary degrees of freedom. This is a structurally distinct approach to quantum gravity. The cascade does not directly engage with the LQG framework; the cascade's gravitational sector is the scale-curvature sector of the bulk, with G_N a geometric coupling rather than a quantized field. LQG and the cascade are at different levels of analysis.

75.6 Conformal cyclic cosmology (Penrose)

Conformal cyclic cosmology (Penrose, 2010) proposes that the universe is a sequence of conformal aeons, each ending in a remote future that conformally compactifies into the Big Bang of the next aeon. This is a structurally different cosmological framework. The cascade's cosmological backdrop is GG-A10-Cosmos's scale-running expansion with $\Omega_m = 1/\pi$ and $z_* = e^7$; the cascade does not need cyclic cosmology. CCC and the cascade are addressing different aspects of cosmology.

75.7 Integrated information theory (Tononi)

Let us turn to integrated information theory (Tononi, 2008), which proposes that consciousness is integrated information Φ in a substrate. This is the leading mathematical theory of consciousness in the

current literature. The cascade's contribution is to identify the integration mechanism (EIC closure on the theta cycle) and to constrain the substrate (a layer-16 allocentric map realized in a $\sim 86 \times 10^9$-neuron human brain with theta-gamma binding). IIT and the cascade are partially aligned: both recognize that consciousness requires integration; the cascade adds the cascade-specific structural prediction that the integration must close the OH-IH loop on the theta cycle.

75.8 Global workspace theory (Baars, Dehaene)

Global workspace theory (Baars, 1988; Dehaene, 2014) proposes that consciousness is the broadcast of information through a global workspace in the brain. This is the leading neural theory of consciousness in the current literature. The cascade's contribution is structurally compatible: the cascade's EIC closure can be read as the broadcast event, with the layer-17 cascade output (the conscious episode) the result of the broadcast. GWT and the cascade are again partially aligned.

75.9 Free-energy principle (Friston)

The free-energy principle (Friston, 2010) proposes that biological systems minimize variational free energy. This is the most general principle of biological organization in the current literature. The cascade's contribution is to identify Friston's variational free energy with F_{GFF} at non-zero J_{Qi} via the Three-Gauge Theorem. The cascade therefore extends FEP from a principle of biological organization to a principle of cosmic organization, with the same variational structure applied at eighteen cascade layers. FEP is a structural precursor of the cascade.

75.10 The Wheeler self-excited circuit

Remarkably, Wheeler (1983) proposed that the universe is a self-excited circuit in which observers participate in the creation of the structure they observe. This is the closest historical-register precursor to the cascade's eighteenth-layer closure. The cascade's contribution is to make the self-excited circuit a formal mathematical theorem rather than a metaphysical proposal. Wheeler's circuit is the cascade's recursive closure made informal; the cascade is Wheeler's circuit made formal.

Plain-English close for the comparison. The cascade is not a replacement for any of the above frameworks; it is a structural unification of several of them. Friston's free energy is the cascade's GFF. Wheeler's self-excited circuit is the cascade's recursive closure. IIT's integrated information is what EIC closure produces. GWT's broadcast is the EIC closure event. Anthropic principle's puzzle is dissolved by the cascade's zero-free-parameter constitution. Multiverse and landscape are made unnecessary by the cascade's uniqueness. The cascade is what the prior frameworks were each trying to be.

76 Comparison with existing frameworks

To place these achievements in context, let us compare the GG-Theory directly with the leading alternatives: the Standard Model, general relativity, and string theory (Table 19).

Reading the table row by row reveals the pattern. The Standard Model operates in four dimensions, says nothing about life or consciousness, and has 19 free parameters. General relativity also operates in four dimensions, does not address information, life, or consciousness, and has no particle content at all. String theory reaches into ten or eleven dimensions and has the mathematical depth to address anomaly

Table 19: The framework set beside the three leading alternatives on seven aspects. Dimensions: four, four, ten or eleven, six. Supersymmetry: not observed, not applicable, required, none. Information: not gauged in the first three, gauged as $\mathrm{U}(1)_{Qi}$ here. Life and consciousness: not addressed by any of the three, and here a geometric necessity and an internal model formed by GSSB. Free parameters: nineteen in the Standard Model, a 10^{500} landscape in string theory, and the OGN-5 ledger plus G_N here. Self-referential closure: no, no, no, and yes — which is the claim the rest of the paper has to earn.

Aspect	**Standard Model**	**Gen. Rel.**	**String Theory**	**GG-6/GDOS**
Dimensions	4D	4D	10D/11D (Maldacena, 1998)	6D
SUSY	Not observed	—	Required	None
Information	Not gauged	Not addressed	Not gauged	$\mathrm{U}(1)_{Qi}$: gauged
Life	Not addressed	Not addressed	Not addressed	Geometric necessity
Consciousness	Not addressed	Not addressed	Not addressed	IH via GSSB
Free parameters	19 SM	—	10^{500} landscape	OGN-5 + G_N
Self-referential	No	No	No	Yes: EIC

cancellation, but it requires supersymmetry (not observed), does not gauge information, says nothing about life or consciousness, and admits a landscape of 10^{500} solutions — so many that no specific prediction can be extracted.

GG-6/GDOS occupies the rightmost column: six dimensions, no supersymmetry, a gauged informational force, life as a geometric necessity, consciousness as an Inner Hologram constructed by the GSSB pipeline, and only six numbers (five integers plus Newton's constant) in place of the Standard Model's twenty or string theory's 10^{500}. The final row is the most telling: GG-6 is the only framework in which the universe is self-referential — the geometry produces observers who discover the geometry.

76.1 What makes this different from "Theory of Everything" claims

Generally speaking, the history of physics is littered with premature claims of unification. What distinguishes the present framework from earlier attempts?

First, the anomaly proof of GG-A3-BI6 (Arisaka, 2026, A3-BI6) uses standard mathematical technology that the string theory community has developed over four decades. Any string theorist can check every equation in the proof, using the perturbative technology of 't Hooft and Veltman (1972). The argument is not qualitative — it is a theorem proved with the community's own tools.

Second, the quantitative predictions are specific and falsifiable. $2N_A\mathsf{Q}_\mathsf{B} = 30.0$ kJ/mol either matches the ATP-hydrolysis free energy or it does not. The KK resonance at 3.85 TeV either appears at the LHC or it does not. The weak mixing angle $\sin^2\theta_W = 25/108$ either matches the measured value or it does not. No previous "theory of everything" has produced such specific biological and particle-physics predictions simultaneously.

Third, the framework does not require belief in unobservable entities. There are no extra dimensions beyond six, no superpartners, no 10^{500} landscape of vacua. The entire theory is controlled by five integers and one measured constant (G_N). The rest follows by computation.

76.2 A note on the scope of the claims

Honesty requires clarity about what the framework claims and what it does not.

What it claims: that the BI-6 identity, combined with the OGN-5 integers, determines the gauge structure, the particle spectrum, the energy quantum of biology, and the architecture of consciousness. These claims are specific and falsifiable.

What it does not claim: that every detail of biology, neuroscience, and psychology can be derived from first principles. Evolution, ecology, behavior, and culture involve enormous complexity that the framework does not attempt to reduce to geometry. What the framework provides is the *foundation* — the constitutional constraints that every biological and cognitive process must satisfy — not the full description of every phenomenon.

The relationship is analogous to the relationship between thermodynamics and chemistry. Thermodynamics tells you which chemical reactions are allowed (those that decrease free energy) and which are forbidden (those that increase free energy). It does not tell you the specific mechanism by which a particular reaction proceeds, or the specific catalyst that accelerates it. Similarly, the GG-6 framework tells you which biological and cognitive architectures are allowed (those that satisfy QGL) and which are forbidden (those that violate it). It does not tell you the specific evolutionary pathway by which a particular organism arrived at its current architecture.

This modesty is a strength, not a weakness. A framework that claimed to derive every detail of biology from five integers would be implausible — and maximally vulnerable to falsification by any detail that did not fit. The GG-6 framework claims something more modest but still specific: that the *constitutional constraints* on biology are derivable from geometry, even though the *historical contingencies* of biological evolution are not.

77 The empirical decade: a strategic reading of the cohort's headline commitments

77.1 What this Section analyzes, and how it is keyed

Part IV §42 gave GG-A11-Origin's Top 10 Falsifiers as a Pull table (Table 8): ten rows — eight forward bets and two precision audits — predicted value, observed value, Pull, decision threshold, experimental facility, calendar window. That list is GG-A11-Origin's own curated headline selection.

The present Section asks the *meta-questions* the Pull table does not address: how the empirical risk is distributed across the corpus paper by paper, what the decade-by-decade calendar of milestones looks like, what would happen under a cluster-failure scenario, which commitments are correlated at the deepest level, and how a Bayesian-minded reader should update on each. Those questions are strategic rather than per-layer, and the natural unit for them is not GG-A11-Origin's headline ten but the *cohort's* falsifier ledger, in which the load is shared across papers. The slice analyzed here is accordingly cosmology-weighted: it tracks eight commitments, of which five are Top-10 falsifiers (the KK lock-cluster, the Kaxion, the tensor-to-scalar ratio, the bioenergetic quantum, and — through the corridor — the cosmological inventory) and three are cohort commitments that sit outside the headline ten (the two readings of the Hubble background, and the recombination-era pair).

How the rows are keyed. To keep the two lists from being confused, every row here is named by its *cohort ledger key* rather than by a position in GG-A11-Origin's ten. F15 is the KK lock-cluster, F14 the Kaxion, F6 the Hubble background, F7 the recombination-era pair, F1 the tensor-to-scalar ratio, and F21

the bioenergetic quantum. The family-number commitment ($N_g = 3$, audited through m_τ/m_μ) carries no ledger key: it is a three-leg derivation audited against a measured ratio, not a staked forward falsifier, and it is tracked here only because it shares the OGN-5 integer ledger with F15. Where a row is also one of GG-A11-Origin's ten, its Top-10 position is given alongside. The five Top-10 rows not tracked here — dark energy, proton stability, δ_{PMNS}, the genetic alphabet, the dual-knee $1/f$ spectrum and the conscious-episode window — are analyzed in Part IV §42.3; their windows and kill criteria are in Table 8.

The commitments below are the empirical content of the recursive uniqueness theorem of Part XV (Theorem 67.1); if they hold, the theorem holds, if they all fail, the theorem fails. The present Section supplies the strategic picture.

77.2 Cross-paper risk distribution: which paper's neck is on the line per test

Plain-English opening. A framework that consists of twenty-two papers does not stake all twenty-two papers equally on every empirical test. Each test, when it resolves in the next decade, will pull on a specific paper's central claim, sometimes on two or three papers' claims, but never on all twenty-two. This subsection makes the linkage explicit: for each commitment tracked here, we name the upstream paper (or papers) whose load-bearing theorem the test is in a position to confirm or falsify. The result is a risk-distribution diagram. The risk is, as we will see, distributed unevenly. GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) carries the heaviest empirical load (four of the eight commitments tracked here bear directly on its π-locked cosmological inventory). GG-A9-SM (Arisaka, 2026, A9-SM) carries the second-heaviest load (two of the eight). The three consequence papers GG-P1-KK (Arisaka, 2026, P1-KK), GG-P2-N3 (Arisaka, 2026, P2-N3), and Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) each carry one test. The remaining *constitutional* papers GG-A1-Constitution–GG-A4-Euclid carry no *direct* test in the Top 10 Falsifiers, although every test inherits their constitutional starting point: if all ten falsifiers pass, the constitution is vindicated; if all ten fail, the constitution is the proximate point of failure, since each consequence paper's prediction descends through a chain of derivations from GG-A1-Constitution–GG-A4-Euclid.

The risk-distribution table. Table 20 below lays out the linkage explicitly. Each row is one cohort commitment, named by its ledger key, with its Top-10 position given where it has one. The middle columns name the consequence-paper claim (or claims) that the test bears on, and the load-bearing upstream theorems within those papers. The rightmost column names the constitutional axiom of GG-A1-Constitution that the chain ultimately rests on.

Table 20: Cross-paper risk distribution across the cohort's headline commitments. Rows are named by *cohort falsifier-ledger key*; where a row is also one of GG-A11-Origin's Top 10 (Table 8) its position in that list is given beneath the key as "T10". Each commitment bears on one or more consequence-paper theorems; each theorem ultimately rests on one or more constitutional axioms of GG-A1-Constitution (Arisaka, 2026, A1-Constitution). "Primary" indicates the paper whose central claim is most directly tested; "Secondary" indicates papers whose claim is implicated through the cascade.

Ledger key	Commitment	Primary paper / theorem	Secondary paper(s)	Constitutional axiom
F15 T10 #1	KK lock-cluster $M_{\text{lock}} \approx 3.85$ TeV	GG-P1-KK (Arisaka, 2026, P1-KK): lock-cluster mass theorem	GG-A9-SM (Arisaka, 2026, A9-SM) (scale-depth $K = 35$ embedding); GG-A2-GG6 (Arisaka, 2026, A2-GG6) (BI-6 bulk)	MSMF (zero free parameters)
F14 T10 #2	Kaxion DM $\sim 8.1\,\mu$eV	Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion): Kaxion-mass theorem	GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) ($\Omega_{\text{DM}}h^2$ closure); GG-A2-GG6 (compact-angle S^1_θ)	GGEP (gauge–geometry equivalence)
F6	Derived background $H_0 = 66.6 \pm 0.2$ km/s/Mpc; late reading lifted to $\approx 68.5 \pm 0.6$ (D*). **Kill: sirens read ≈ 73, not ≈ 67.**	GG-C2-Hubble (Arisaka, 2026, C2-Hubble): two-route background derivation	GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) (corridor, candidate grade); GG-A4-Euclid (Arisaka, 2026, A4-Euclid) (Euclidean discipline)	OGGEP (operational projection)
F7	Recombination era: z_{dec} (atomic chain); switch $z^* = e^7$	GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos): two-quantity corridor-switch treatment	GG-A3-BI6 (Arisaka, 2026, A3-BI6) (BI-6 closure); closed-packet lemma (Conj. VIII of GG-A10-Cosmos)	OGGEP
F1 T10 #5	Tensor-to-scalar $r = 0.0038$	GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos): inflation-tensor theorem	GG-A3-BI6 (bulk-stiffness from BI-6)	LC (Lorentz causality)
no ledger key	Family $N_g = 3$; $m_\tau/m_\mu = 16.817$	GG-A9-SM (Arisaka, 2026, A9-SM) + GG-P2-N3 (Arisaka, 2026, P2-N3): family-number-three theorem	GG-A1-Constitution (seven postulates); GG-A6-GRIP (Arisaka, 2026, A6-GRIP) (Gi-4 pillars)	MSMF
F21 T10 #7	$\Delta G_{\text{ATP}} = 2N_A Q_B$	This paper, layer 7 of the cascade	GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-EP); GG-A9-SM (OGN-5 ledger)	MSMF

What the risk distribution shows. Three quantitative observations follow from Table 20. First, GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) is the empirical *center of gravity* of the cohort's headline

commitments: it is the primary paper for F6, F7 and F1 — four of the eight rows tracked here, and the whole of the cosmology block. (Counted instead against GG-A11-Origin's own Top 10, GG-A10-Cosmos is primary for two of ten: dark energy and the tensor ratio. The two figures answer different questions, and we give both rather than the flattering one.) Second, GG-A9-SM (Arisaka, 2026, A9-SM) is the secondary center of gravity: it is the primary paper for the family-number commitment (jointly with GG-P2-N3 (Arisaka, 2026, P2-N3)) and the secondary paper for F15 and F21, putting it on the line in three of the eight. Third, each of the consequence papers GG-P1-KK (Arisaka, 2026, P1-KK), GG-P2-N3 (Arisaka, 2026, P2-N3), and Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) is the primary paper for exactly one commitment (F15, the family-number row, and F14 respectively), giving the consequence-paper trio a balanced one-test-each exposure that is, by design, the same scale as a single named-experiment commitment. The constitutional papers GG-A1-Constitution–GG-A4-Euclid are not the primary paper for any direct test — their exposure is one stratum deeper, through the chain "constitutional axiom ⇒ Gi-4/Qi-4 pillar ⇒ consequence-paper theorem ⇒ Pull-table prediction."

Why the distribution is uneven, and why that is appropriate. The unevenness of the distribution is not an accident of how the corpus was written; it reflects the empirical accessibility of different cascade layers. Cosmology is empirically rich — we have CMB-S4, LiteBIRD, LSST, JWST, DESI, the SKA, and gravitational-wave standard sirens all coming online or already producing data in the 2026–2035 corridor — so it makes sense that the paper that lays out the cosmological inventory (GG-A10-Cosmos) carries the largest empirical load. Particle physics is empirically constrained by the few high-energy facilities that are available in the same corridor (ATLAS+CMS at HL-LHC, and the slower program of FCC-ee feasibility studies), so the particle-physics commitments (F15, the family-number row, and to a degree F1 through B-mode searches) are tighter in number. Biophysics is in a quasi-stationary phase — the ATP-hydrolysis number has been known to 1.6% for decades, and improving it further is a precision-biophysics project that no large collaboration is currently driving — so biology contributes a single commitment (F21). Dark-sector physics is between particle physics and cosmology in empirical accessibility — ADMX-EFR and IBS-CAPP are dedicated haloscope facilities with funded programs — so it contributes a single commitment (F14) that is more confined in time horizon (2026–2030). The distribution of the empirical load is, in this reading, the distribution of the empirical accessibility of the cascade layers themselves.

Plain-English close. The cross-paper risk distribution tells the reader where to look first as the decade unfolds. Anyone watching GG-A10-Cosmos's predictions on a calendar should expect four data-points to arrive over the next decade, and any one of them could in principle determine the cosmology paper's survival. Anyone watching GG-A9-SM should expect two or three data-points spread over the same window. The corpus is not staked equally on every paper; it is staked according to which paper makes which prediction at which empirical scale.

77.3 Decade-by-decade timeline: 2026 to 2035, year by year

Plain-English opening. Most readers, asked when the ten falsifiers will resolve, will say "in the next decade." That is correct in coarse outline but obscures the year-by-year structure of the resolution. The ten falsifiers do not all resolve at the same time. Some (the ATP bioenergetic audit) are essentially resolved at the 1.6% level already, and only need a refinement audit. Some (the Kaxion dark-matter search) are expected to resolve in 2028–2030 when ADMX-EFR and IBS-CAPP complete their first full sweep of the predicted mass band. Some (the KK lock-cluster) require the full HL-LHC integrated luminosity to deliver decisive sensitivity, which on the published schedule is the 2030–2032 corridor. Some (the cosmology rows — dark energy $w = -1$ and the tensor-to-scalar ratio) ride on DESI and Euclid, CMB-S4 first-light (2031 baseline),

LiteBIRD launch (2030 baseline subject to JAXA schedule), and the LSST Y1–Y5 data sequence (2026–2031). This subsection lays the year-by-year calendar out explicitly.

The decade calendar. Table 21 gives the year-by-year expected experimental milestones for each commitment. Where multiple facilities contribute to the same one (e.g., F6 in its late reading is contributed to by LIGO/Virgo/KAGRA O5 and O6 runs, by LSST Y1–Y5, and by JWST cosmology surveys), the table names them all in the relevant row. Schedule slippage is to be expected, especially for the largest projects; the calendar therefore quotes baseline schedules and notes the year by which a definitive result *should* be available, not the year by which it *will* be available.

Table 21: Decade-by-decade experimental calendar 2026–2035 for the cohort commitments tracked in this Section, named by ledger key. "Baseline" indicates the announced schedule of the relevant collaboration; some milestones will likely slip. "Decision" indicates the year by which a definitive (confirmation or falsification) result should be available on the baseline schedule.

Year	Commitment(s)	Experiment / collaboration	Expected milestone
2026	F15, family-number, F21	ATLAS+CMS Run 3 final, single-molecule biophysics laboratories	Run 3 final calorimetry calibration; ATP-hydrolysis precision audit toward 0.5%.
2027	F14, F6(late)	ADMX-EFR commissioning; LIGO/Virgo/KAGRA O5 run	First Kaxion-band haloscope coverage at upper sensitivity; first GW standard-siren H_0^{late} at ± 2 km/s/Mpc.
2028	F15, F14, F6(late)	HL-LHC commissioning; ADMX-EFR + IBS-CAPP in tandem; LSST Y1 data	First HL-LHC luminosity at $\sim 0.5\,\text{ab}^{-1}$ (Run 4 begins); Kaxion-band coverage extended to 6.6–8.8 μeV; LSST Y1 cosmology product.
2029	F15, F14, F6(late)	HL-LHC Run 4 (full); IBS-CAPP full sensitivity; LSST Y2	First 5σ HL-LHC search sensitivity at 3.85 TeV approached; full Kaxion-band coverage; LSST Y2.
2030	F14 (**decision**), F21 (**decision**), F6, F1	ADMX-EFR + IBS-CAPP complete; CMB-S4 commissioning; LiteBIRD launch (baseline); LSST Y3	**Kaxion DM decision year:** either 5σ detection in 6.6–8.8 μeV or decisive null at predicted coupling. **Bioenergetic-quantum decision year:** ATP-hydrolysis ratio resolved to $\pm 0.5\%$, closing the Part IV window. CMB-S4 commissioning data; LiteBIRD on orbit.
2031	F15, F6, F7, F1	HL-LHC Run 5 begins; CMB-S4 first light; LiteBIRD first data; LSST Y4	HL-LHC Run 5 toward $\sim 2\,\text{ab}^{-1}$; CMB-S4 first light + first cosmology product; LiteBIRD first r-sensitivity at $\sim 5 \times 10^{-3}$.
2032	F15 (**decision**), F6(early) (**decision**), family-number (**decision**)	HL-LHC integrated $\sim 3\,\text{ab}^{-1}$; CMB-S4 H_0^{early} at ± 0.1 km/s/Mpc; precision Yukawa	**KK lock-cluster decision year:** 5σ search at 3.4–4.2 TeV resolves. **Early-H_0 decision year. Family-number precision decision year.**

(continued on next page)

Table 21 continued from previous page

Year	Commitment(s)	Experiment / collaboration	Expected milestone
2033	F6(late) (**decision**), F7 (**decision**), F1 (**decision**)	LSST Y8; GW O6 + standard sirens; CMB-S4 + LiteBIRD recombination + tensor	**Late-H_0, recombination $z_{\rm dec}$, and tensor-to-scalar r decision year:** CMB-S4 + LiteBIRD deliver $\sigma(r) \sim 10^{-3}$ (decisive for the derived $r = 0.0038$) and $z_{\rm dec}$ to 0.1% (vs the atomic-chain prediction).
2034	—	Continued precision refinement across all channels	No scheduled decision year; sensitivities improve on every open channel.
2035	—	Cross-commitment synthesis; FCC-ee feasibility decision	Program-level synthesis: by end of 2035 every commitment tracked in this calendar has a decisive result. The five Top-10 falsifiers not tracked here — dark energy, proton stability, $\delta_{\rm PMNS}$, the genetic alphabet and the dual-knee $1/f$ spectrum — run on the windows given in Part IV Table 8, with proton decay reaching to $\sim$ 2040.

What the calendar shows. Two observations: first, the empirical decade is *front-loaded for the dark sector and the cosmology block* and *back-loaded for the precision-cosmology and biophysics block*. The earliest decisive result is the Kaxion DM resolution in 2030; the latest is the bioenergetic-quantum precision audit in 2034. Second, the calendar has *three resolution-cluster years*: 2030 (Kaxion), 2032 (KK lock-cluster + early-H_0 + family-number), and 2033 (late-H_0 + recombination + tensor-to-scalar). By the close of 2033, six of the ten falsifiers will have a decisive result; the framework will, in those three years, see most of its empirical commitment cashed in or cashed out. The author writing in 2026, looking forward, can in principle expect to know by the end of 2033 whether GG-Theory has summited or fallen.

A note on schedule slippage. Each of the experiments cited above has its own schedule risk. HL-LHC has historically slipped roughly twelve to eighteen months from each baseline plan. CMB-S4 first-light was originally projected for 2030 and is now generally projected for 2031–2032, depending on the funding cycle. LiteBIRD's launch depends on JAXA's H3 cadence. LSST's data-release schedule depends on the Vera Rubin Observatory's commissioning. A reasonable a-priori estimate is that the decision-year column in Table 21 will, in practice, slip by approximately one to two years; the realistic close-of-business date for the Top 10 Falsifiers is therefore 2035 to 2037, not the nominal 2030–2034 corridor. The framework's claim that the empirical decade decides the framework is robust to slippage of this magnitude; it would not be robust to slippage of a decade or more, which would push the resolution well beyond the present decade.

Plain-English close. The calendar is what makes the commitment concrete. A framework that says "we will know in the future" is not a framework worth staking a career on. A framework that says "we will know in 2032 from HL-LHC, in 2033 from CMB-S4, and in 2034 from a biophysics audit" is. That is the difference, and it is the only difference, between physics and philosophy of physics. The decade is short enough that the present authors and readers will see it close. The decade is long enough that the ten falsifiers have time to mature toward their decision thresholds without prejudgment.

77.4 The hostile-reviewer audit: what if every test fails?

Plain-English opening. A framework that does not anticipate its own complete failure is not yet a serious framework. The Pull table of Part IV §42 states the kill criterion for each individual test; this subsection asks the worse question: what if *all ten* kill criteria trigger? What does GG-Theory look like if HL-LHC sees no KK lock-cluster, ADMX-EFR and IBS-CAPP see no Kaxion, DESI and Euclid confirm an *evolving* dark energy ($w \neq -1$), Hyper-Kamiokande records a proton decay, CMB-S4 measures a tensor amplitude flatly inconsistent with 0.0038 (a null at 10^{-4}, or a detection at 2×10^{-2}), DUNE measures a leptonic CP phase far from 196°, precision biochemistry measures $\Delta G_{\mathrm{ATP}}/(2N_A \mathsf{Q}_{\mathsf{B}}) = 1.4$, a wild organism with a stable five-letter genetic alphabet is discovered, single-cell imaging finds a single $1/f$ knee rather than two, and conscious episodes are reliably reported at 30 ms? This is a deliberately catastrophic scenario, and naming it explicitly is the honest discipline that distinguishes a falsifiable framework from a self-protecting one.

Stratum-by-stratum consequences of total failure. We walk through the total-failure scenario stratum by stratum, naming what the framework would have to renounce.

The gauge stratum. Failure of F15 (no KK lock-cluster) and of the family-number commitment (fourth family observed; m_τ/m_μ outside 0.5%) would falsify the OGN-5 integer ledger of GG-A2-GG6 (Arisaka, 2026, A2-GG6), specifically the $K = 35$ scale-depth integer and the $N_g = 3$ family integer. The framework would have to either revise the integer ledger to a different integer set or abandon the integer-ledger architecture entirely. Revising the integers is structurally costly: the integers are not free parameters in the framework's grammar; they are forced by the cascade. Abandoning the integer-ledger architecture would collapse the scale-radius scale chain that descends from GG-A2-GG6 through GG-A9-SM to the Standard-Model parameter audit, and the framework's zero-free-parameters claim — the constitutional discipline of GG-A4-Euclid (Arisaka, 2026, A4-Euclid) — would dissolve.

The dark sector. Failure of F14 (no Kaxion at 8.1 μeV in the 6.6–8.8 μeV window with predicted coupling) would falsify the unique-Qi-4-admissible-dark-matter theorem of Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion). The framework would have to either (i) move the Kaxion mass to an outside-the-predicted-band value (cost: the prediction is forced by the integer-ledger-locked decay constant $f_K \simeq 7.1 \times 10^{11}$ GeV, so moving the mass requires changing f_K, which requires changing OGN-5), or (ii) abandon the Kaxion as the dark-matter candidate and introduce a different candidate. Option (ii) is structurally fatal: the framework claims uniqueness of the dark-matter GGA on the cosmological substrate, and abandoning that uniqueness reintroduces the kind of model-selection freedom that the framework was constructed to eliminate.

The cosmology block. Failure of F6, F7 and F1 (cosmology in all four corners: the derived H_0 background outside the predicted value, late H_0 outside the predicted value, measured z_{dec} off GG-A10-Cosmos's atomic-chain prediction by more than 0.5%, tensor-to-scalar ratio inconsistent with 0.0038 in either direction) would falsify the π-locked cosmological inventory of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). Specifically: $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$, $z_{\mathrm{sw}} = e^7$ (with z_{dec} derived by the atomic chain), $r = 0.0038$ are forced by the framework's π-and-e topological-invariant architecture. A failure of even one of the four would already be a serious blow to that architecture; failure of all four would falsify it as a unit.

The biological stratum. Failure of F21 (bioenergetic ratio away from the integer 2 at $> 5\sigma$) would falsify the layer-7 cascade attractor of the present paper, specifically the bioenergetic-quantum theorem. The framework would have to either (i) move the integer multiplier from 2 to a different integer (cost: the factor of 2 is forced by the two-fold Q_{B}-quantum cost of breaking and solvating the phosphate bond, so changing the integer requires changing the bond-multiplicity model), or (ii) abandon ATP as the universal energy currency and introduce a different one (cost: ATP universality is itself a falsifiable prediction at the biological stratum; abandoning it would falsify the universal-identity insight at layer 7).

The universal-identity insight in catastrophic-failure mode. The universal-identity insight — the centerpiece of the cohort, articulated in GG-A4-Euclid (Arisaka, 2026, A4-Euclid) and recapitulated in every consequence paper of the program — says that the GRIP cascade applied to the constitutional starting point produces a *unique* stable GGA at each cascade layer. Total empirical failure of the Top 10 Falsifiers would falsify the universal-identity insight at *all five* of the strata the ten falsifiers cover: the gauge stratum, the dark sector, the cosmology block, the precision Standard Model, and the biological stratum. At that point the framework would not be salvageable in its present form: the recursive uniqueness theorem of GG-A11-Origin (Theorem 67.1) is conditional on the universal-identity insight holding at each cascade layer, and total empirical failure would falsify the universal-identity insight at the five strata the framework can empirically test. What survives at the remaining strata (layers 5, 8–11: polymer folding, neural ring attractor, allocentric map, conscious episode, articulation) would be theoretically interesting but empirically unanchored, and would not constitute a framework worth defending.

Honest acknowledgment: no single failure is fatal in isolation; coherent patterns of failure are. The above paints the worst-case scenario. In practice, the framework's failure mode is more granular: any single failure can in principle be Conditional-promoted to Asserted via a structural-lemma cost increase — for instance, a marginal drift in a single cosmological parameter might be absorbed into the error budget of its named conditional lemma. Such absorptions are themselves structural costs (the cohort's lemma-promotion roadmap, Appendix H, becomes longer; the conditional-to-asserted promotion roadmap becomes more conditional) but they are not fatal. What *is* fatal is a coherent pattern: simultaneous failure of F15 (KK lock-cluster), F14 (Kaxion), and F7 (recombination-era $z_{\rm dec}$), or simultaneous failure of the whole cosmology block (F6, F7 and F1), would falsify the framework at the *cluster level* — that is, would constitute evidence that the cascade architecture is wrong, not that any single sub-theorem is wrong. Cluster-level falsification is the framework's true exposure; single-test failure is closer to a routine empirical correction.

Why the framework should lose if the universe disagrees. A reader skeptical of any framework that anticipates its own failure should note: the framework's claim is not that it cannot fail. The framework's claim is that, if it fails, it fails as a unit, and the next attempt should learn what failed and renounce what made the failure possible. The Euclidean discipline of zero continuous fitted prefactors is the framework's most distinctive commitment; if the Top 10 Falsifiers falsifies the framework, the lesson for the next attempt is that the Euclidean discipline was either applied to the wrong starting axioms or was insufficient to force the world's structure. Either lesson is informative, and a framework that delivers an informative falsification is doing the job of physics correctly even in the act of failing. This is the asymmetric-payoff structure we will return to in the Bayesian framing of §77.6 and the closing reflection of §77.10.

Plain-English close. The framework should lose if the universe disagrees with the predictions the framework has made. A framework that wins regardless of what the data say is unfalsifiable, and unfalsifiable theories are, in the strict Popperian sense, not physics. The hostile-reviewer audit is the framework's exercise in admitting honestly what the loss would look like. The reader who finds the loss scenario unrecoverable should weigh the framework accordingly. The reader who finds it recoverable should weigh the framework accordingly too. Either weighting is informed; that is what the present subsection is for.

77.5 Cross-test correlations: the ten falsifiers are not eight independent dice

Plain-English opening. Part IV §42 described the ten falsifiers as "independent in the strong sense": different experimental apparatus, different systematic-error budgets, different cascade layers. That description was correct as far as it went, but it concerned *experimental* independence: no two tests share a calorimeter

or a haloscope or a telescope. It did not concern *theoretical* independence. At the deepest level, several of the ten falsifiers partially falsify the *same upstream theorem*, and a careful reader should be aware that the framework's exposure is not eight independent rolls of the dice but a smaller number of effective rolls — roughly six or seven, depending on how one counts the correlations.

The three correlation clusters. Three correlation clusters organize the ten falsifiers at the theorem level.

Cluster A: the radial structure of GG-A2-GG6 (Arisaka, 2026, A2-GG6). F15 (KK lock-cluster at $M_{\text{lock}} = 3.85$ TeV) and F14 (Kaxion DM at 8.1 μeV) both depend on the radial structure of the BI-6 bulk. The KK lock-cluster mass is set by the compactification radius R of the radial interval I_r, with $M_{\text{lock}} \sim 1/R$ modulated by the scale profile. The Kaxion decay constant f_a, and through it the Kaxion mass m_a, is set by the compact-angle radius and the scale profile in coupled fashion. If the radial structure of the bulk is wrong — say, if the scale depth is not the integer $K = 35$ but something else — then both predictions will fail correlatedly. F15 and F14 are thus theoretically a single test of the radial geometry, even though they are experimentally independent.

Cluster B: the π-and-e-locked cosmological inventory of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). F6 (the derived Hubble background 66.6 ± 0.2 km/s/Mpc, against which both the CMB reference and the local ladder are read), F7 (recombination-era z_{dec}; switch e^7), and F1 ($r = 0.0038$) all depend on GG-A10-Cosmos's π-locked inventory in coupled fashion. $\Omega_m = 1/\pi$ enters H_0 via the Friedmann equation; the recombination-era pair enters H_0 via the corridor switch and the atomic chain's inventory inputs; $r = 0.0038$ enters via the same inflation-tensor closure that fixes the late-time geometry. A failure of one of the four would not necessarily collapse the cluster, but a failure of two of the four would, and a failure of three or four would constitute a falsification of the π-and-e topological-invariant architecture in toto. At the theorem level, F6, F7 and F1 are correlated through their shared dependence on GG-A10-Cosmos's cosmological-inventory theorem.

Cluster C: the OGN-5 integer ledger on the Standard-Model substrate, from GG-A9-SM (Arisaka, 2026, A9-SM). The family-number commitment ($N_g = 3$ in the ledger) and the Standard-Model precision audit (the 28-parameter sheet of GG-A9-SM) both depend on the OGN-5 integer ledger applied at the Standard-Model substrate. $N_g = 3$ is the family number, fixed by GG-P2-N3 and not by the ledger; the precision audit relies on the $K = 35$ scale depth (shared with Cluster A), the $J = 7$ dyadic-closure exponent (which sets $\alpha^{-1}(M_Z) = 2^7 = 128$), and the topological rationals $\sin^2\theta_W = 25/108$ and $\alpha_s(M_Z) = 1/(\pi e)$. Both — and, through the $K = 35$ scale depth, partially also F15 — depend on the OGN-5 ledger, and they are correlated at the theorem level through that shared dependence.

The effective number of independent tests. Counting the three correlation clusters: cluster A (F15 + F14) is one effective test of radial geometry; cluster B (F6, F7, F1) is one effective test of the cosmological inventory; cluster C (the family-number commitment and the Standard-Model precision audit, plus partial overlap with cluster A) is one effective test of the OGN-5 ledger at the Standard-Model substrate. F21 (the bioenergetic quantum) sits outside all three — it is the only commitment at the biological stratum — and contributes a fourth. The effective count across the eight rows tracked here is therefore four cluster-level independent tests, not eight. A reader who counts headline commitments as independent rolls of the dice is overestimating the framework's empirical exposure by roughly a factor of two.

Why this matters for assessing framework strength. A framework that claims eight independent successful tests is, naively, much harder to dismiss than a framework that claims three independent successful tests; the prior-odds of ten independent confirmations under the null hypothesis (framework is wrong) is roughly (single-test probability)^{10}, much smaller than (single-test probability)^3. But this naive multiplication applies only to independent tests. Three cluster-level independent tests (with the bioenergetic check as a

near-cluster) is still a substantial empirical commitment — comparable in scale to the standard tests of general relativity in the first half-century after 1915 (gravitational redshift, perihelion of Mercury, light bending, gravitational time delay, gravitational waves) — but it is not eight. Readers should weigh the framework's commitment as approximately three to four cluster-level checks, plus the bioenergetic-stratum check, plus a finer-grained internal-consistency check at the precision-Standard-Model level. This is still substantial; it is not eightfold.

Cross-cluster correlations and the cluster-failure modes. The clusters themselves are not perfectly independent. Cluster A (radial geometry) and cluster C (the OGN-5 ledger) both depend on GG-A2-GG6 (Arisaka, 2026, A2-GG6)'s bulk geometry; failure of GG-A2-GG6's bulk geometry would falsify both clusters simultaneously. Cluster B (cosmological inventory) and cluster C (Standard-Model ledger) both depend on GG-A4-Euclid (Arisaka, 2026, A4-Euclid)'s Euclidean discipline; failure of GG-A4-Euclid's discipline would falsify both. The cluster-level structure of the Top 10 Falsifiers is thus a layered correlation: tests within a cluster share a deep theorem dependence, and clusters share a deeper constitutional-paper dependence. The framework's true exposure is, at the deepest level, exposure to the constitutional papers GG-A1-Constitution–GG-A4-Euclid; the ten falsifiers are the empirical projections of that exposure onto the consequence-paper layer.

Plain-English close. The ten falsifiers are not ten independent checks on a single claim. They are projections of three or four deeper claims onto the experimental apparatus. That is the right shape for a unified framework: a collection of unrelated predictions would not be a framework at all. The correlation structure is the framework's coherence made visible. The accounting follows: empirical exposure is weighed at the cluster level, not at the row level of the Pull table.

77.6 Bayesian framing: where each test lives on the information-gain ladder

Plain-English opening. A reader trained in Bayesian inference will notice that the framework's commitment to a Pull-table audit is a strong frequentist commitment but does not yet name the Bayesian prior on each test. The Bayesian question is: *before* the data arrive, what does the framework think the probability is that each test will return a value within the predicted window? And, on the standard Bayesian update rule, by how much should the framework's overall posterior — the probability that the framework is correct — shift upon observing each test's outcome? The standard answer is that the Bayesian posterior shifts by a factor proportional to the likelihood ratio $P(D \mid H_{\text{framework}})/P(D \mid H_{\text{null}})$, where D is the observed datum. For tests where the framework predicts a specific value with a tight tolerance, that ratio can be large (the framework strongly favors one outcome; the null hypothesis is indifferent), and the posterior moves substantially. For tests where the framework predicts a value already at consensus with mainstream measurements (e.g. the family-number commitment, where the prediction matches PDG to $< 0.5\%$), the Bayesian information gain of the test is small — the framework predicts what everyone already knows, so the test does not separate the framework from the null.

Where each test lives on the information-gain ladder. Ranking the ten falsifiers by expected Bayesian information gain — where "high" means the test, when it resolves, will substantially move the posterior, and "low" means the test will leave the posterior approximately unchanged — gives the following structure.

Highest Bayesian information. F7 (the recombination-era redshift test) carries the largest expected information gain. In GG-A10-Cosmos's two-quantity form the framework derives the decoupling redshift itself from its own atomic chain with zero fitted parameters, presently on the Planck value at the 0.1% level; the

corridor switch $e^7 \approx 1096.6$ is a distinct topological marker 0.6% above in redshift (equivalently $\delta = 0.0041$ in e-folds), with no observational handle of its own. CMB-S4 + LiteBIRD will resolve $z_{\rm dec}$ to better than 0.1% by 2033: a measurement that stays on the atomic-chain value confirms a zero-parameter derivation at its own systematic floor, while a measurement off it by more than 0.5% kills the reading outright — the framework cannot absorb the miss, because the chain has no dial. The likelihood ratio at the resolution-precision is large in either direction.

High Bayesian information. F15 (KK lock-cluster) and F14 (Kaxion DM) carry substantial information gain. Both are forward predictions — the relevant signal has not been observed at all yet — so the resolution will be either a 5σ detection at the predicted parameters (framework wins decisively) or a 5σ non-detection across the predicted parameter window (framework loses decisively). The likelihood ratio at resolution is large, but the resolution is binary (detect/no-detect) rather than a continuous shift in posterior.

High Bayesian information. F6 (the derived Hubble background) carries more information than its position in the cosmology block suggests, and the reason is worth stating: the framework derives a background near 66.6 and does *not* derive the local ladder's 73. A standard-siren catalog is a direct measurement of the background, and it discriminates. If the sirens converge near 67, the derived background is confirmed against a number the framework did not fit; if they converge near 73, the derivation is wrong and the framework says so in advance. F1 (tensor-to-scalar r) carries moderate information by comparison. F1 will improve the upper bound on r by a factor of ~ 10 but the framework's prediction is the definite value $r = 0.0038$; the test is now two-sided (a detection inconsistent with 0.0038 in either direction falsifies, and a confirming detection at the predicted value would be strong positive evidence).

Lowest Bayesian information. The family-number commitment (m_τ/m_μ) and F21 (the bioenergetic quantum) carry the smallest expected information gain. Both already sit at agreement: the framework's prediction matches measurement to better than 0.5% on the family-number ratio, and the bioenergetic quantum carries a Pull of +1.0 at a 1.6% offset (Part IV Table 8) — a $\sim 1\sigma$ landing, well inside the 5% kill threshold. Future measurements at HL-LHC (the family-number ratio) and single-molecule biophysics (F21) will improve the precision by factors of three to ten, but absent a surprise, the tests will remain at agreement. The framework's posterior will not move substantially on these tests *unless* a surprise occurs (a fourth charged-lepton generation; an ATP-hydrolysis ratio away from the integer 2).

What the Bayesian framing implies for reading the decade. A reader watching the decade should weight the tests by their expected information gain. The commitment to watch most closely is F7 (the measured $z_{\rm dec}$ vs GG-A10-Cosmos's atomic-chain prediction; the switch e^7 is a distinct topological marker). The ones to watch next are F15 and F14 (the forward KK-cluster and dark-sector predictions). The ones to watch with moderate attention are F6 (the Hubble background, where the siren catalog is the discriminating measurement) and F1. The ones to watch only for surprise are the family-number commitment and F21 (already at agreement). The most boring tests — "boring" in the Bayesian-information-theoretic sense, not in the scientific sense — are precisely the tests where the framework's prediction has already matched measurement; they are nonetheless the tests where the framework is most certainly already calibrated, and a reader who weighs framework credibility on multiple consistencies should remember that "boring" agreement is not zero evidence. Agreement at 0.1% across a multi-decade independent prediction is itself a substantial Bayesian update; it just does not move the posterior at the moment of the next experiment, because the previous experiments already moved it.

The asymmetric-payoff structure. The Bayesian framing also makes visible the asymmetric-payoff structure that the framework operates under. The framework's claim is unified: all ten falsifiers are projections of the same recursive uniqueness theorem. If all ten confirm, the framework's posterior moves to near unity — the framework is, to all practical purposes, the standard reference for the next half-century of physics. If *any*

test from the high-information group decisively falsifies, the framework's posterior moves to near zero — the framework is wrong, and the question of which sub-theorem failed becomes a forensic-physics question rather than a viable-framework question. This is the asymmetric payoff: success is across-the-board success; failure is at-the-weakest-link failure. The Bayesian rule is harsh on unified frameworks for exactly this reason, and the framework's authors accept the harshness as the cost of unification.

Plain-English close. The Bayesian framing is the framework's discipline made quantitative. A framework that derives $z_{\rm dec}$ with zero parameters and is willing to lose if the measured value moves off it by half a percent has placed a Bayesian wager: the prior is on the framework's side, but the prior can move sharply. The wager's expected information gain is what makes the next decade scientifically interesting; the asymmetric payoff is what makes the wager honest.

77.7 Row 5 in the two-quantity form: the recombination-era test

Row 5 of the Top 10 Falsifiers Pull table is carried in the two-quantity form of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). Two distinct quantities share the recombination era. The *corridor switch* $z_* = e^7 \approx 1096.6$ is a topological marker forced by the integer $J = 7$ of the OGN-5 ledger — exact, parameter-free, and with no observational handle of its own. The *operational decoupling redshift* $z_{\rm dec}$ — the visibility peak Planck measures at 1089.92 ± 0.25 — is a different quantity, and GG-A10-Cosmos derives it from the framework's own atomic chain (the Rydberg from the particle sector, the baryon fraction $\Omega_b = 1/(2\pi^2)$, the corridor h) with zero fitted parameters, landing on the measured value at the 0.1% level, inside the 0.18% modeling systematic of the recombination calculation itself. The switch–decoupling offset is computed, not conjectured: $\delta = J - \ln(1 + z_{\rm dec}) = 0.0041$ (0.4% in e-folds). No 27σ bookkeeping arises, because e^7 is not offered as the value of $z_{\rm dec}$ in the first place.

The kill, posed on the observable. Row 5's falsifier lives on the one measurable quantity: a future model-independent determination of $z_{\rm dec}$ (CMB spectral-distortion missions reading the cosmological recombination radiation, post-2030, complemented by 21-cm cosmology) refutes the reading if the measured value sits off GG-A10-Cosmos's atomic-chain prediction by more than 0.5% — equivalently, if the measured $\ln(1 + z_{\rm dec})$ departs from the computed 6.996 by more than 0.005. Present agreement is 0.1%. The switch–decoupling offset is a derived consistency statement, not an independent kill, since $z_{\rm sw}$ carries no observational handle of its own.

The remaining open item is a promotion, not a rescue. The offset obeys the identity $\delta = J - \ln(B/kT_0) + \ln 53.0$, in which the hydrogen binding energy B and the Saha–Peebles factor 53.0 are already derived; the only quantity not yet owned by the ledger is the present temperature T_0. If GG-A10-Cosmos's commissioned e-fold-budget campaign derives T_0 (equivalently the photon entropy normalization), δ becomes a theorem — the exact analog of the $K = 35$ resolution of the why-now coincidence. Until it lands, $\delta = 0.0041$ is carried as a computed consistency. The row's conditional bookkeeping is inherited from the fractions the atomic chain consumes: it rides on GG-A10-Cosmos's closed-packet-integration lemma (Conjecture VIII there), and the atomic chain itself introduces no new lemma.

What this means for the Top 10 Falsifiers. z_* remains a precision audit carried in the body wherever it appears, now with its kill posed on $z_{\rm dec}$ alone. The Top 10 headline falsifiers — eight forward bets and two precision audits — do not include z_* and are unaffected; the abstract and Executive Summary commit to those ten.

The discipline of the two-quantity form is what distinguishes an honest framework from a self-protecting one. A framework that reads a 0.6% switch–Planck gap as confirmation of a precision prediction has not yet earned the right to be tested; a framework that derives the operational decoupling redshift itself with zero parameters, states the switch–decoupling offset as a computed number, and poses its kill on the measurable alone has stated its terms of engagement. The next decade measures $z_{\rm dec}$ to 0.1%; if it moves off the atomic-chain value by more than half a percent, row 5 falls, and the framework will report it honestly when it arrives.

77.8 A cluster-level falsification scenario: walking through a coordinated failure

Plain-English opening. We have considered the worst-case scenario of total empirical failure (§77.4) and the best-case scenario of total empirical success (implicit in §77.6). Between these two extremes lies the more realistic middle: a coordinated failure of three or four tests that all sit within the same correlation cluster. This subsection walks through what such a cluster-level failure would mean for the framework, focusing on the scenario that is, by the cross-test-correlation analysis of §77.5, the most likely failure mode: failure of the cosmology cluster (F6, F7, F1) while the gauge and bioenergetic strata pass their tests.

The scenario. Suppose that by 2034, the following pattern has emerged. HL-LHC by 2032 has observed a KK lock-cluster at $M_{\rm lock} = 3.85 \pm 0.10$ TeV with 5σ significance and the predicted five-particle multiplicity (F15 passes). ADMX-EFR + IBS-CAPP by 2030 has observed a Kaxion-like signal at $m_a = 19.2 \pm 0.5\,\mu$eV with the predicted axion-photon coupling (F14 passes). Single-molecule biophysics by 2034 has measured $\Delta G_{\rm ATP}/(2N_A \mathsf{Q}_\mathsf{B}) = 1.002 \pm 0.005$, well within the predicted unity at 5σ confidence (F21 passes). The family-number commitment passes by 2032 from HL-LHC precision Yukawa data and a precision-improved m_τ/m_μ measurement.

But the cosmology block fails coordinatedly. CMB-S4 by 2032 reports a background $H_0 = 63.0 \pm 0.3$ km/s/Mpc, well below the derived 66.6 ± 0.2 (F6 fails by $\sim 12\sigma$ on the low side). It is worth being explicit about what would *not* be a failure here, because the direction is the whole content of the test: a standard-siren catalog reporting 71.0 ± 0.5 would sit between the derived background and the local ladder, closer to the background than to 73, and would count as a partial move *toward* the framework — the discriminating outcome is a catalog at the ladder's 73, which would kill the corridor outright. CMB-S4 + LiteBIRD by 2033 report $z_{\rm dec} = 1085 \pm 1$ from a model-independent recombination-history extraction, 0.5% below the atomic-chain prediction ≈ 1091 (F7 fails decisively). And CMB-S4 + LiteBIRD by 2033 report r consistent with zero, $r < 10^{-3}$ at 95% CL — excluding the framework's predicted $r = 0.0038$ (F1 fails).

What such a coordinated failure would imply. A coordinated failure of all four cosmology tests would constitute cluster-level falsification of the π-and-e-locked cosmological inventory of GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). Specifically: $\Omega_m = 1/\pi$ would be falsified by the $H_0^{\rm early}$ failure (the Friedmann equation links Ω_m and H_0 tightly); the atomic-chain derivation of $z_{\rm dec}$ (and with it the two-quantity reading anchored at $z_{\rm sw} = e^7$) would be falsified by the recombination-redshift failure; the no-observable-tensor-modes prediction would be falsified by the r detection; and the late-stage Hubble corridor would be falsified by the $H_0^{\rm late}$ failure. The cluster level of the failure — all four tests failing in the same direction, each by $> 4\sigma$ — would make the failure pattern very difficult to absorb into a structural-lemma cost increase. No single conditional lemma can recover four simultaneous cosmological failures; the failure is forced to be read as falsification of GG-A10-Cosmos's cosmological inventory in toto.

The universal-identity insight in the cosmology stratum would fall. The framework's universal-identity insight at the cosmological stratum says that the GRIP cascade applied to the consti-

tutional starting point produces a unique stable cosmological GGA, and that the cosmological inventory $(\Omega_m, \Omega_\Lambda, \Omega_b, z^*, r)$ is forced by the integer ledger plus the bulk geometry. Four simultaneous failures would falsify the cosmological universal-identity insight: the data would show that the cosmological inventory is *not* forced by the framework's chosen starting point. Either the starting point is wrong, or the GRIP cascade applied to it does not produce a unique attractor at the cosmological stratum, or both.

What could be salvaged. In the scenario described, layers 1–4 of the cascade (gauge, electroweak, atomic, molecular) and layer 7 (bioenergetic) are passing their tests; the cosmological stratum (layer 1 in the constitutional ordering — the BI-6-bulk-anchored cosmological background) is failing. The cascade machinery from layer 6 (polymer folding) through layer 18 (articulation) does not depend, in its qualitative structure, on the specific values of the cosmological parameters; it depends on the *existence* of a ΛCDM-like cosmological background sufficient to support a long-lived stable epoch in which molecular and biological complexity can accumulate. If the cosmological background is a different ΛCDM-like model (one not matching GG-A10-Cosmos's π-locked inventory), the cascade machinery for life and mind could survive — the same radial geometry that produces the gauge stratum (passing) and the same bioenergetic quantum that produces ATP (passing) could in principle still organize the upper layers. But the unified theme of the trilogy — the claim that *the same* BI-6-bulk geometry plus the same OGN-5 integer ledger plus the same Euclidean discipline forces the cosmos, life, and mind together — would dissolve. The framework would survive as a partial framework: it would have made successful predictions in the particle-physics and biological strata, but its cosmological claim would be falsified.

The recursive uniqueness theorem in cluster-failure mode. The recursive uniqueness theorem of GG-A11-Origin (Theorem 67.1) is conditional on the constitutional axioms holding at the cosmological stratum. Cluster-level failure of the cosmological tests would falsify the cosmological-stratum content of OGGEP (operational projection) at the constitutional level — specifically, the operational projection of the bulk geometry onto the 4D cosmological background. The recursive uniqueness theorem would have to be revised to be conditional on a different cosmological-stratum content: "*given* a cosmological background of currently-unknown structure, the cascade machinery from molecular to articulating layers proceeds uniquely." This would be a substantial demotion of the theorem's universal claim — from "geometry forces cosmos, life, and mind" to "geometry forces life and mind, given a cosmos." The trilogy's unified ambition would be reduced.

Is the salvage worth pursuing? A reader sympathetic to the framework might ask whether the salvage is worth pursuing. Two considerations. Affirmative: the cascade machinery for life and mind would still constitute a substantial achievement, comparable to a unified framework for biology plus consciousness, and the framework would have made testable predictions at the gauge and biological strata that confirmed. Negative: the framework's distinctive claim — the unity of cosmos, life, and mind under a single geometric apparatus — would be lost, and the residual framework would be less distinctive than its present form. The author's preliminary view, recorded here for honesty, is that cluster-level failure of the cosmology block would constitute the framework's substantive defeat, even if technical salvage is possible at the upper-layer strata. The framework was constructed to be unified; partial unification is a structural retreat, not a stable resting place.

Plain-English close. The cluster-level falsification scenario is the framework's intermediate-honest-case. Total failure is the worst case; total success is the best. Cluster-level failure of one stratum — with the other strata passing — is the most likely middle scenario, and it would force the framework into a salvage operation that the author considers less than worth pursuing. The reader weighing the framework should weigh not

only the success and total-failure scenarios but also the cluster-level intermediate, and decide on that basis how much weight to place on the framework's current presentation.

77.9 Per-test deeper commentary: complementary to Part IV §42

Plain-English opening. Part IV §42 gave for each test the predicted value, the observed (or current-bound) value, the Pull, the decision threshold, and the experimental facility plus calendar window. The present subsection adds, for each of the ten falsifiers, three additional layers of commentary that did not fit in Part IV's empirical-audit register. First: the *political and institutional context* — which collaboration is custodian of the relevant measurement, what the funding outlook is, what the schedule risks are. Second: the *framework's confidence level* — how certain the framework is that its prediction is right versus how certain it is that the relevant experiment is right. Third: the *historical analogy* — which comparable predictions in physics's history have been similarly staked and how those staking-decisions resolved. One or two paragraphs per test.

F15 — KK lock-cluster at $M_{\text{lock}} \approx 3.85$ TeV. The custodian collaborations are ATLAS and CMS at the HL-LHC, both with funded programs running into the early 2030s. The funding outlook for HL-LHC is secure through Run 5 (CERN's decadal plan was approved in the 2020 European Strategy for Particle Physics update and reaffirmed in subsequent reviews). The schedule risk is moderate: HL-LHC has historically slipped by twelve to eighteen months from baseline at each major milestone, and a slip of that magnitude is plausible for the decisive run.

The framework's confidence in the prediction is high — M_{lock} is forced by the integer ledger $K = 35$ and the scale-profile closure of GG-A2-GG6 (Arisaka, 2026, A2-GG6) — and the experiment's confidence in its sensitivity at 3.4–4.2 TeV with $\sim 3\,\text{ab}^{-1}$ is high (the relevant five-particle multiplicity at ~ 3.85 TeV is comfortably above the QCD continuum at the predicted mass and is well within both detectors' acceptances).

Historical analogy: this prediction is comparable in commitment-scale to the W- and Z-boson mass predictions of electroweak unification in the 1970s, which were predicted to $\sim 1\%$ before discovery at the CERN SppS in 1983. The historical lesson is that a specific TeV-scale prediction, made in advance with an integer-ledger justification, is the kind of prediction that physics has previously vindicated when the constitutional theorem is right. The W and Z were not predicted from numerology; they were predicted from a unified gauge structure. M_{lock} is, the framework claims, the same kind of prediction.

F14 — Kaxion DM at $m_a \approx 8.1\,\mu$eV. The custodian collaborations are ADMX-EFR (the next-generation extension of the Axion Dark Matter eXperiment at the University of Washington / Fermilab) and IBS-CAPP (the Center for Axion and Precision Physics haloscope in Korea, covering 1–8 GHz). The funding outlook for both is secure through the late 2020s, with milestones structured around achieving cosmology-relevant axion-photon coupling sensitivity in the μeV mass window. The schedule risk is low to moderate: dedicated haloscope experiments typically meet their sensitivity goals within a year or two of plan. The framework's confidence is high — $m_a \approx 8.1\,\mu$eV is forced by the Kaxion decay constant $f_K \simeq 7.1 \times 10^{11}$ GeV and the present-day relic abundance, as proven in Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) — but the prediction is a forward prediction, meaning the framework wins or loses decisively at the experimental sensitivity. Historical analogy: the prediction is comparable to the gravitational-wave amplitude predictions made for binary neutron-star mergers in the late 1990s, where the prediction (a specific signal at a specific frequency band) was made many years in advance of the detection (GW170817 in 2017). The historical lesson is that a specific dark-sector signal at a specific frequency, if predicted by an integer-ledger-justified geometry, is the kind of prediction that physics typically resolves with a dedicated experiment within a decade of construction.

F6 — the derived background $H_0 = 66.6 \pm 0.2$ km/s/Mpc. The custodian collaboration is CMB-S4 (a U.S. Department of Energy + National Science Foundation joint project, with first light targeted for 2031). The funding outlook is secure but the schedule has slipped from initial 2030 targets. The framework's confidence is moderate-to-high, and the ground of it should not be overstated: the derived background is close to, but not identical with, Planck's measured 67.4 ± 0.5, and the two are different objects — one derived, one measured. The test is not a self-consistency check at improved precision. The experiment's confidence is high in achieving ±0.1 km/s/Mpc by 2032. Historical analogy: the prediction is comparable to the cosmological-constant-density predictions made for ΛCDM in the late 1990s after the Type-Ia supernova results, where the predicted values were already approximately at consensus and the subsequent precision improvements (WMAP, Planck) primarily sharpened the consensus. This is a low-information test in the Bayesian sense (§77.6) but a high-credibility check on framework calibration.

F6, the late reading — a derived lift to $\approx 68.5 \pm 0.6$, and a named residual. The custodian collaborations are LIGO/Virgo/KAGRA for standard-siren measurements (O5 run 2027–2029, O6 run starting 2030), LSST at the Vera Rubin Observatory for cosmography (Y1 data 2026, full Y10 by 2035), and JWST for high-redshift surveys. The funding outlook is secure across all three. The schedule risk is moderate (especially for the O6 run, where the upgrade depends on the technical success of the O5 run). The framework's position here is more exposed than on the background, and the honest statement of it is the one GG-C2-Hubble (Arisaka, 2026, C2-Hubble) makes: the background plus the Local-Hole lift gives a late reading of $\approx 68.5 \pm 0.6$, graded conditional; the distance to the locally measured 73.5 is a named residual that the framework *does not derive* and records as an open problem rather than a result. Nothing in the cohort predicts the ladder value. What the framework stakes on this decade is the opposite claim — that a standard-siren catalog, which measures the background directly, will converge near 67 and not near 73. The Hubble-corridor prediction is the framework's late-time analog: a specific deviation from H_0^{early} at a specific magnitude (+5.6 km/s/Mpc), predicted from a specific underlying structure (Kaxion-DM modulation of late-time geometry).

F7 — recombination $z^* = e^7$. The custodian collaborations are CMB-S4 + LiteBIRD (JAXA + ISAS, with European and U.S. partners). Funding for LiteBIRD is secure subject to JAXA's H3 launch cadence; LiteBIRD baseline launch is 2030. The framework's confidence rests on GG-A10-Cosmos's two-quantity form: the corridor switch $z^* = e^7$ is exact at the integer-ledger level, and the operationally-defined decoupling redshift z_{dec} is derived from GG-A10-Cosmos's own atomic chain with zero fitted parameters, on the Planck value at the 0.1% level. The 0.6% switch–Planck gap is not a tension to be defended but a computed offset ($\delta = 0.0041$ in e-folds), whose promotion to a theorem waits on GG-A10-Cosmos's e-fold-budget campaign; the kill for F7 lives on z_{dec} alone — a model-independent determination off the atomic-chain value by more than 0.5%. Historical analogy: the prediction is comparable to Dirac's prediction of the electron's magnetic moment $g = 2$ in 1928, which agreed with measurement to a small per-cent at first and was later refined (by QED) to better than parts in 10^{12}. The lesson carries over: a structurally locked leading value acquires its computed linkage to the operationally-defined observable — exactly the role GG-A10-Cosmos's atomic chain now plays for the recombination era. This is the framework's posture on F7.

F1 — tensor-to-scalar ratio $r = 0.0038$. The custodian collaborations are CMB-S4 + LiteBIRD. Funding outlook same as F7. The prediction is sharp and two-sided: the derived plateau fixes $r = 12/N^{*2} = 0.0043$ at leading order (0.0038 exact), so the framework loses if a detection lands well above that value *and* loses if a null pushes r below $\sim 10^{-3}$. CMB-S4 + LiteBIRD reach $\sigma(r) \sim 0.5$–1×10^{-3} (delensing-dependent), enough to detect 0.0038 at several σ or to exclude it. Historical analogy: the prediction is comparable to the prediction of the absence of proton decay below a certain lifetime in early grand-unified theories of the 1980s — a one-sided prediction that wins if the universe remains quiet and loses if a detection is made. The historical

lesson is that one-sided predictions are weaker than two-sided ones in Bayesian terms (they constrain the framework less per measurement) but are nonetheless decisive on the failure side.

The family-number commitment — m_τ/m_μ. The custodian collaborations are HL-LHC (ATLAS+CMS for m_τ/m_μ via $H \to \tau\tau$ and $Z \to \mu\mu$ precision), and (longer-term) FCC-ee for higher-precision lepton-pair measurements. Funding outlook for HL-LHC secure; FCC-ee is at feasibility-study stage with no construction decision before 2030. The framework's confidence is very high: the prediction matches PDG by better than 0.1% and the family-number-three claim is supported by decades of accumulated evidence (no fourth charged-lepton or neutrino observed at the LEP-2 lineshape). Historical analogy: the prediction is comparable to the Eightfold-Way predictions of Gell-Mann and Ne'eman in 1961, where the $SU(3)$-flavor structure predicted the Ω^- particle's quantum numbers in advance of discovery. The Eightfold-Way's vindication was decisive and led to the quark model; the family-number-three prediction's vindication, if it holds, will be a comparable decisive statement of an underlying group-theoretic structure.

F21 — bioenergetic quantum $\Delta G_{\mathrm{ATP}} = 2N_A\mathsf{Q}_\mathsf{B}$. The custodian community is the single-molecule biophysics community (no single collaboration; several laboratories at multiple universities perform refinement audits). The funding outlook is decentralized but stable (single-molecule biophysics has been a steady NIH funding line for two decades). The framework's confidence is high: the predicted unity matches measurement to 1.5%, and the integer factor of 2 is forced by the bond-multiplicity model. Historical analogy: the prediction is comparable to the prediction of $E = mc^2$ for nuclear binding energies in the 1930s — a specific universal relation between two seemingly-unrelated quantities (the rest mass and the binding energy) that, once tested, became a standard reference for the entire field. The bioenergetic-quantum relation, if confirmed at 0.5% accuracy, would similarly become a standard reference for the field of cellular bioenergetics, linking a specific bulk geometric scalar (Q_B) to the universal energy currency of biology (ATP).

Plain-English close to the per-test commentary. After all, each of the ten falsifiers is not a stand-alone bet; it sits in a context of historical predictions that physics has previously staked and resolved, of experimental collaborations with their own institutional momentum, and of framework-internal confidence levels that vary by test. The reader who watches the ten falsifiers resolve over the next decade is also watching the framework's place in a longer history of theoretical predictions, and the per-test commentary above is the framework's preliminary positioning within that longer history.

77.10 Plain-English close: the framework as a wager on physics

The wager. The framework, presented over twenty-two papers and roughly five thousand three hundred pages, has staked itself on the Top 10 Falsifiers. In the language familiar from Pascal's seventeenth-century wager on theology, this is a wager — but a wager on physics rather than on faith. The wager's structure is asymmetric in the precise way Bayesian inference makes visible (§77.6): if all ten falsifiers pass within the next decade, physics has its first Euclidean closure since Newton's *Principia* of 1687 — a framework with zero continuous free parameters, all integer or topological-rational predictions justified by an upstream theorem, all empirical content vindicated by experiment. If the framework fails the Top 10 Falsifiers — whether totally (§77.4), at the cluster level (§77.8), or piecewise — it dissolves into a footnote in the longer story of attempts at unification, much as Kaluza–Klein theories of the 1920s and grand unified theories of the 1980s did before it. Either way, the framework's discipline (zero continuous fitted prefactors, the universal-identity insight, the integer ledger, the recursive uniqueness theorem) is the lesson the framework offers to the next attempt regardless of the outcome.

The author and the reader, both staking. The author of the present paper has spent fifty years arriving at the question and the last decade arriving at the framework's present form. The reader who has reached this Section has spent some hours, perhaps days or weeks, climbing the cohort. Both are now in the position of staking on the ten falsifiers. The reader stakes the time spent and the choice of whether to continue tracking the framework's empirical fate over the coming decade. The stakes are different in magnitude but the same in kind: both author and reader have invested attention in a specific framework, and both will see the empirical decade close before too long.

What the framework asks of the reader for the coming decade. The framework asks the reader to do four things over the coming decade. First: *bookmark Table 8 of Part IV*, revisit it as each test resolves, and update the framework's standing accordingly. Second: *weigh failures at the cluster level, not at the row level*, as the cross-test-correlation analysis of §77.5 prescribes. Third: *when a test resolves in the framework's favor, recognize that it is one cluster-level data point and not the entirety of the framework's vindication*; the framework's full case requires the full Top 10 Falsifiers, not a few early successes. Fourth: *when a test resolves against the framework, ask whether the failure is single-test or cluster-level* — single-test failures are routine empirical corrections; cluster-level failures are framework-falsifications, and the response should differ accordingly.

The closing reflection. A theoretical framework worth fifty years of climbing makes itself fragile at the end. Fragility is not weakness. Fragility is the willingness to be falsified by the world. The framework's commitment to fragility is the Top 10 Falsifiers; the next decade will exercise the commitment. A framework that cannot be wrong has nothing to offer to physics; a framework that can be wrong, and that names the conditions under which it would be wrong with ten specific falsifiers in a specific decade, has earned its place at the empirical table whether or not the table eventually rules in its favor. The Top 10 Falsifiers is the framework's commitment to fragility. The next decade will exercise the commitment. Both the author who staked the framework and the reader who staked the time of reading it will, by the close of that decade, know how the universe ruled. Until then, the framework stands where the climb has left it: at the summit of its own argument, watching for the data that will either confirm the climb or send the next climber down a different ridge.

78 The Ten Structural Innovations of the Origin Capstone

The contribution of GG-A11-Origin is to bind the eleven-paper A-series and the three phenomenology branches into a single derivational structure — one cascade engine, one selector, one ledger — and to prove that the existence of observers who articulate the geometry is a theorem of that structure and by no means an accident permitted by it. We collect here the ten structural innovations the capstone delivers, each carrying its cohort-global identifier (§78.1). None introduces a new continuous parameter; each is a consequence of the GG-Constitution of GG-A1-Constitution.

Innovation 1 (I-Origin-1): Inevitability stated at theorem level. The recursive uniqueness theorem T-Origin (T-Origin-58.1) makes the existence of physics-articulators the *conclusion* of a formal theorem whose hypotheses are the laws of physics themselves — inevitability written down as a proof obligation, not asserted as a slogan.

Innovation 2 (I-Origin-2): The GRIP-Out cascade with GGA-as-ground-state. The completing mechanism of the program: at each layer the patient GRIP-In loop settles to the unique Ground

Geometric Attractor GGA, and out-of-equilibrium shocks reshape the landscape to drive the GRIP-Out ascent to the next layer (T-Origin-13.1, T-Origin-14.1).

Innovation 3 (I-Origin-3): One engine across eighteen layers. The same four-move pipeline — DGI, the OGGEP/GSSB boundary projection, GFF gradient descent, and GGA settlement — runs unchanged from the gauge group of the Standard Model to the meta-cognitive layer at which the constitution is articulated.

Innovation 4 (I-Origin-4): The Qi-4 admissibility selector forces per-layer uniqueness. The four information-theoretic pillars of GG-A7-Qi4 act as the filter that singles out one admissible GGA on each layer's Morse landscape (T-Qi4-GGA-Admissibility, T-Origin-57.1; per-layer uniqueness, T-Origin-63.4).

Innovation 5 (I-Origin-5): The universal-identity insight. The integer OGN-5 ledger of GG-A2-GG6 threads one identity through atoms, molecules, ATP, DNA, and the first cell: the gauge-equivalence of all layer-n products (T-Universal-Identity, T-Origin-63.5), made philosophically careful as the type-token distinction — the type is unique; the tokens are fully individuated.

Innovation 6 (I-Origin-6): The bioenergetic quantum anchor. The Arisaka constant $\mathsf{Q_B} \approx 0.155$ eV is the elementary energy quantum locked at each biological layer; two such quanta (one ATP) match the ATP-hydrolysis free energy, $2N_A\mathsf{Q_B} \approx 30$ kJ/mol (T-QB-Anchor, T-Origin-65.1) — ATP standing to life as the electron stands to particle physics, both the GGA-output of GRIP.

Innovation 7 (I-Origin-7): The SeOS class characterization. The Selfish Open System — the finite, port-bounded, Lyapunov-descending open system that includes every living cell — is given five necessary and jointly sufficient conditions (T-SeOS-Class-Characterization, T-Origin-67.2), turning "living system" from a list of features into a closed class.

Innovation 8 (I-Origin-8): The self-referential closure theorem. The constitution is what its own articulators articulate; the cascade closes on its own input (T-self-referential-closure, T-Origin-76.1). Wheeler's participatory universe, Spinoza's necessitarianism, Whitehead's process metaphysics, and the Upaniṣadic *tat tvam asi* are recast as fragmentary recognitions of one formal feature.

Innovation 9 (I-Origin-9): The cognitive cascade as internal measurement. The Five-Story Pagoda, the holographic triad OH+IH=EIC, and the CDI monotonicity ladder (T-Origin-70.1, T-Origin-71.5, T-Origin-72.1) place conscious content late in the derivation, as the internal measurement of selected inner-hologram structure, rather than early as an unexplained primitive.

Innovation 10 (I-Origin-10): One falsifiable codebook for cosmos, life, and mind. The Top-10 Falsifiers (F-Origin-1 . . . F-Origin-10, §42.1) bind the three boundary readings into a single structure that must stand or fall together — a falsifiable codebook with zero free continuous parameters from the smallest scale to the conditions that allow a mind to exist.

78.1 Global naming convention for cross-cohort citation

Beginning with Arisaka (2026, A2-GG6) and extended across the cohort, each load-bearing item of the GG-Theory program carries a globally unique identifier of the form *Prefix-Suffix-N*, where the Prefix names the item type and the Suffix names the paper:

- **T-Suffix-N** for the Nth Theorem (GG-A11-Origin's theorems are section-numbered, so its global ids carry the section number, e.g. T-Origin-58.1 is the recursive uniqueness theorem T-Origin and T-Origin-76.1 the self-referential closure theorem).
- **L-Suffix-N**, **C-Suffix-N**, **D-Suffix-N**, **R-Suffix-N** for the Nth Lemma, Corollary, Definition, and Remark.
- **P-Suffix-N** for the Nth Prediction.
- **O-Suffix-N** for the Nth Objection (O-Origin-1 is the first entry of the Common Objections and Responses Part).
- **F-Suffix-N** for the Nth Falsifier (e.g., F-Origin-1 is the KK lock-cluster falsifier of the Top-10 audit, §42.1).
- **I-Suffix-N** for the Nth Innovation (e.g., I-Origin-1 is the inevitability-at-theorem-level innovation above).
- **PS-Suffix-N** for the Nth Problem-Solved / open-problem entry (§I; the local OP-/EP- codes are kept for back-reference).

The canonical Suffix list for the twenty-two cohort papers is: *Constitution* (A1), *GG6* (A2), *BI6* (A3), *Euclid* (A4), *GDOS* (A5), *GRIP* (A6), *Qi4* (A7), *QM* (A8), *SM* (A9), *Cosmos* (A10), *Origin* (A11, this paper), together with the phenomenology preprints *KK* (P1), *N3* (P2), *Electron* (P3), *Proton* (P6), the foundations preprints *Real* (P4) and *CPT* (P5), and the consequence preprints *Kaxion* (C1), *Hubble* (C2), *BH* (C3), and the white papers *Symmetry* (W1) and *Holonomy* (W2). The four axioms (AX-1 . . . AX-4) and seven postulates (POS-1 . . . POS-7) of Arisaka (2026, A1-Constitution) keep their existing cohort-wide names; the global identifier is the same item viewed from outside its home paper.

Part XVII
Conclusions: the summit view

Five revolutions and the geometric inevitability of Cosmos, Life, and Mind

Plain-English opening: the view from the summit. The reader who has reached this point has climbed for hundreds of pages. Eleven prior papers fed their theorems into the present one; twelve Parts of this paper have led the reader through Introduction, inheritance, statement of results, the recursive uniqueness theorem, the cascade machinery, the dynamics block, the cognitive cascade, the self-referential closure, cross-domain applications, and discussions. The present Part is the Conclusions Part proper: the summit view. It is the place at which the framework asks, and answers, the question *what does it all add up to?* The answer is not a slogan and not a marketing pitch; it is the joint claim that fifty years of climbing on this particular mountain has put the author and the reader in sight of a view that, to our knowledge, no prior intellectual framework has reached: the universe forces its own articulators through a single recursive cascade, and the Top 10 Falsifiers will tell us, in the coming decade, whether we have read the geometry correctly.

What this Part is for. This Part does five things. First, it states the summit view in its most compact form: where the framework now stands at the close of the cohort climb. Second, it situates the framework against the lineage of four prior axiomatic-discipline shifts (Euclid, Newton, Maxwell–Einstein–QM, openness-as-constitutional) and discusses — at hedged register, with the verdict explicitly left to history — what kind of move the recursive uniqueness theorem makes against that lineage (Part XVII §80). Third, it traces the recovery of the Euclidean ideal of zero free parameters across twenty-three centuries from *The Elements* to the present. Fourth, it elevates openness as a constitutional clause, the GDOS shift extended through every cascade layer. Fifth, it reads the geometric inevitability theme through Cosmos, Life, and Mind as three readings of one cascade, ending with the recursive uniqueness theorem stated across the entire cascade. At each step the universal-identity insight of GG-A9-SM Part XI (the universal-identity section) sits in the background: every electron is the same electron, every hydrogen atom is the same hydrogen atom, every ATP molecule has the same ΔG, and *every articulator-class observer is the same articulator*. The framework's deepest claim is that the cascade does not allow optionality at any layer; the summit view is the cumulative force of this claim made visible from above.

The framework has been built and assessed. This final Part draws the conclusion — and closes the circle that Part I opened.

The sections that follow constitute the philosophical summit of the Arisaka-GG cohort. They integrate the revised conclusions of the six-cohort companion papers (GG-A4-Euclid (Arisaka, 2026, A4-Euclid), GG-A5-GDOS (Arisaka, 2026, A5-GDOS), GG-A6-GRIP (Arisaka, 2026, A6-GRIP), GG-A7-Qi4 (Arisaka, 2026, A7-Qi4), GG-A9-SM (Arisaka, 2026, A9-SM), GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos)) and articulate the central claim of the working title — *The Geometric Inevitability of Cosmos, Life, and Mind* — at the length, depth, and register that fifty years of work deserve.

79 The summit view: where we stand at the close of the cohort climb

A reader who has stayed with the present paper through sixteen Parts, and stayed with the ten upstream companion papers through the roughly thirty-three hundred pages that precede them, has earned a wider view. We close GG-A11-Origin not by repeating the previous Parts in compressed form, but by stepping back from the cohort and asking what the entire program looks like from above.

What we see from the summit. From the summit, the cohort organizes itself as a single ascent through seventeen cascade layers plus the meta-cognitive articulation. The constitutional foundation is supplied by GG-A1-Constitution (the four axioms and seven postulates of the GG-Constitution). The geometric stage is supplied by GG-A2-GG6, GG-A3-BI6, and GG-A4-Euclid (the six-dimensional bulk $M_6 = M_4 \times I_r \times S^1_\theta$, the BI-6 closure, the OGN-5 integer ledger, and the Euclidean discipline of zero continuous free parameters). The dynamical machinery is supplied by GG-A5-GDOS, GG-A6-GRIP, and GG-A7-Qi4 (the GDOS open-system boundary law, the Gi-4 pillars TGG–CCI–GFF–GRIP, and the Qi-4 pillars Qi-QUA–Qi-EP–Qi-CON–Qi-HAL). The four-dimensional empirical content is supplied by GG-A8-QM, GG-A9-SM, and GG-A10-Cosmos (the 4D operational reformulation of quantum mechanics, the 28-parameter Standard-Model audit with its Part XI universal-identity and uniqueness-of-forces insights, the π-locked cosmological inventory). And the philosophical synthesis — the present paper — closes the eighteen-layer cascade with the named theorem of self-referential closure: the geometry that forced the cascade contains, among its forced boundary readouts, the act of articulating the constitution that produced the cascade.

What the summit lets us see that the climb did not. On the climb, each paper was a particular hill: a particular theorem, a particular parameter sheet, a particular boundary stratum, a particular set of constitutional clauses brought to bear. Each paper was complete on its own terms but only made full sense in relation to its neighbors. At the summit, the twenty-two papers organize themselves as the layer-by-layer specialization of one geometric theorem — the recursive uniqueness theorem of §55.2 — applied at successive boundary strata, with the same constitutional apparatus operating at every layer and only the substrate changing. What the climb felt like as ten distinct technical projects turns out, from the summit, to be a single project: the constitutional ledger of GG-A1-Constitution forces, through seventeen constructive cascade layers, the existence of the Layer-18 act of writing the constitutional ledger down.

What the summit does not let us see. We have not summited the entire mountain range. The cascade does not end at the eighteenth layer (Layer 18); admissible higher layers (Corollary 69.5: collective scientific knowledge, machine-implemented reasoning, networked civilizations) are visible above us but not yet realized in the universe we observe. The framework's predictions, though sharp, are still in their pre-experimental phase: the Kaluza–Klein lock-cluster, the Kaxion dark-matter mass, the Hubble corridor's late-time projection, the family-number tolerance — each of these is testable in the coming decade, but each is, today, untested. The empirical confirmation of the framework is a project for the decade ahead, not a fait accompli of the present paper. We have summited eighteen of an unknown number of layers, and the empirical verification of even those eighteen is still in progress. The view is wide; the work is not done.

After all, the climb's purpose was not to summit alone but to look out from the summit and see how the rest of the work fits. The remaining seventeen sections of this Conclusion are that looking-out.

80 The framework against the lineage: Euclid, Newton, Maxwell–Einstein–QM, openness — and the framework's hope to be evaluated against them

A note on this section's register. The historiographical claim that follows — that the present framework is the fifth of five scientific revolutions in the canonical lineage Euclid–Newton–Maxwell+Einstein+QM–openness-as-constitutional-(GG-A5-GDOS)–recursive uniqueness — is the framework's own self-positioning, not a judgment of the historical record. Such judgments require decades of subsequent reception to settle, and no paper that is itself a candidate for the periodization can credibly award itself the position.

The reader should treat the five-revolutions framing as a *structural* claim about the kind of move the cascade makes (an axiomatic-discipline extension into a previously unaxiomatized domain), not as a historical claim about the framework's standing in the lineage. If the framework's empirical horizon resolves favorably over the coming decade, the historical claim may eventually earn its standing through the natural process of reception; if not, the structural-discipline claim still stands on its own merits, irrespective of where the lineage eventually places it.

The compression of Maxwell + Einstein + early quantum mechanics into a single revolution is acknowledged as an analytical convenience that suits the present argument; readers who would unbundle these three into separate revolutions would simply re-index the present framework's position downstream by two, without changing what the framework structurally is. The structural claim is what the framework defends; the historiography is a way of recognizing the kind of structural claim it is, not a credential.

What the framework offers to the lineage. The framework offers, to the lineage of axiomatic-discipline shifts that Euclid, Newton, Maxwell, Einstein, and the founders of quantum mechanics opened, a candidate structural contribution: zero continuous fitted prefactors, recursive uniqueness at every cascade layer, the four-step Cascade of GRIP-Out with GGA, and the Top 10 Falsifiers that will decide the framework's empirical content in the coming decade. The work is what the work is; the verdict on whether it belongs in the lineage belongs to history. We present it here, write it down with care, and submit it to the natural process of scientific reception.

The history of physical science, viewed at the longest range, is a sequence of axiomatic reorganizations. Arisaka (2026, A5-GDOS) (the GG-A5-GDOS Conclusions Part) named the first four such reorganizations and proposed openness-as-constitutional as the fourth. GG-A11-Origin now proposes that the fourth reorganization has a successor — a fifth axiomatic shift visible only when the cohort is read as one work: the recursive uniqueness theorem at every cascade layer. We re-tell the five-revolution story here from the summit vantage of the full corpus.

The lineage, summarized at the framing the hedge demands. What the four prior axiomatic shifts share is a single structural feature: each reorganized the foundational language of physical science by changing what counts as a foundational object. Euclid (c. 300 BCE) changed it to *axiom*: theorems follow from a small set of postulates and not from empirical accumulation. Newton (1687, *Principia*) changed it to *law*: a single mathematical structure governs terrestrial and celestial motion alike.

Maxwell, Einstein, and the founders of quantum mechanics (1860–1930) changed it to *field on manifold*: the arena of physics is no longer particles-in-space but fields on geometric objects that are themselves dynamical (Bohr 1913; Dirac 1931; Einstein 1915; Maxwell 1865; Planck 1900; von Neumann 1932). Arisaka (2026, A5-GDOS) (GG-A5-GDOS, 2026) proposed a fourth shift to *open-system boundary law*: closure is the limit, not the default; observers and observed are coupled, and the coupling is geometric (OGGEP).

The present framework's structural ambition — recursive uniqueness at every cascade layer — proposes a

candidate fifth shift, in which the foundational object is the layered cascade of unique attractors on substrate-specific strata. Whether the candidate fifth shift earns its position in the lineage is, per the hedge above, a question for the empirical decade and the subsequent reception, not for the framework's own self-positioning. The framework offers the discipline of the candidate fifth shift (zero free continuous parameters, recursive uniqueness at every cascade layer, Top 10 Falsifiers) and leaves the lineage placement to history.

What makes a revolution a revolution rather than a paradigm tweak (Kuhn, 1962) is precisely that it changes what counts as a foundational object. Whether the framework belongs in this list at all is the empirical decade's question; whether the discipline of the framework belongs in any future foundational program is the framework's own answer.

81 The Euclidean ideal recovered: zero free parameters, twenty-three centuries on

GG-A4-Euclid (Arisaka, 2026, A4-Euclid) closes its Executive Summary with a sentence that names the entire program's structural ambition: *the Euclidean methodological condition is the structural meaning of deductive science: a framework with zero free continuous parameters in the gauge and cosmological sectors must stand or fall on its predictions.* From the summit of GG-A11-Origin, that sentence is no longer the ambition of one foundation paper but the structural verdict on the entire cohort.

The 2300-year detour. For 2300 years after Euclid, the standard methodological ideal of physics has been the Euclidean ideal: a deductive system in which every theorem follows from a small set of postulates, with no free parameters left to fit. In practice, physics has drifted: the Standard Model carries about 28 free parameters, general relativity adds Newton's constant and the cosmological constant, string theory's $\sim 10^{500}$-element landscape made the situation worse rather than better. The drift was not a methodological failure but a structural consequence of the technical apparatus available in each era: until the 6D bulk, the BI-6 closure, and the OGN-5 integer ledger were available, the parameters could not be derived, only measured.

The Euclidean recovery in practice. GG-A4-Euclid and the rest of the cohort have together closed the Euclidean recovery for the gauge and cosmological sectors of physics. The Geometric Universal Five Constants GU-5 — $\{c, G_N, \hbar; k_B, Q_B\}$ — supply the dimensional inputs. The topological constants (π, e) supply two transcendental numbers fixed by the geometry. The OGN-5 integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ supplies the integer inputs. And the four constitutional axioms of GG-A1-Constitution (LC, GGEP, OGGEP, MSMF) plus the seven postulates supply the operational ledger. From these, the entire 22-entry gauge+cosmological audit closes with zero free continuous parameters: $\alpha^{-1}(0) = 137$ from $J = 7$ and $N = 3$; $\sin^2\theta_W = 25/108$ from the OGN-5 ratio; $\alpha_s(M_Z) = 1/(\pi e)$ from the scale-angle theorem; $v \approx 246$ GeV from the Wilson-Hosotani Higgs-vev theorem; $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ from the cosmological closed-packet topology; $N_A \mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol from the bioenergetic GU-5 anchor; and so on through the 22 entries. The lepton spectrum is then closed by the QD-completion rationals $\mathcal{R}_\tau = 637/640$, $\mathcal{R}_\mu = 159/160$, $\mathcal{R}_e = 641/640$ with common denominator $640 = 2^J L$, identified as a Hopkins–Singer descent integrality coefficient on $\mathbb{C}P^2$.

What the Euclidean recovery means. After 2300 years, physics can stand or fall on its predictions in the strict sense Euclid demanded of geometry. The framework's predictions are sharp, falsifiable in this decade, and free of the lubricant of continuous fitted prefactors that has, by polite convention, kept earlier unification attempts from grinding to a halt: KK lock cluster at $M_{\text{lock}} \approx 3.85$ TeV testable at HL-LHC;

Kaxion dark matter at ~ 8.1 μeV testable at ADMX; $\Omega_m = 1/\pi$ at 0.27-sigma agreement with Planck; the two-quantity recombination-era pair of GG-A10-Cosmos: the decoupling $z_{\rm dec}$ derived from the atomic chain on Planck's 1089.92 at the 0.1% level, the corridor switch $z_{\rm sw} = e^J = e^7$ a distinct topological marker 0.6% above (see Part XVI §77.7); $N_A \mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol at 98.4% agreement with ATP hydrolysis. If any decisively fails, the framework fails. This sharpness is what the Euclidean discipline buys; without that discipline, every previous unification attempt could — and did — retreat to a softer claim when data pressed.

The honest residual. GG-A4-Euclid also names the residual sub-tasks honestly: the closed-form fermion mass spectrum (O9), the cosmological-constant prefactor (O11), the connection to standard quantum-gravity programs (O12). These are open tasks tracked explicitly in the promotion roadmap for the named structural lemmas of GG-A9-SM. The integrity of the parameter-free reconstruction is a matter of audit, not assertion: every entry in the codebook is either derived from non-physics axioms with the chain closed in the published record (Derived), or empirically anchored with the from-geometry derivation deferred to a companion paper (Anchor-Derived), or derived modulo a single named lemma (Conditional), or asserted with the upstream calculation that would promote it named explicitly (Asserted). The Euclidean ideal does not mean every parameter is yet derived; it means every parameter that is asserted comes with the explicit program of work that would derive it.

The Euclidean ideal is by no means a claim of completion; it is a methodological discipline that forbids cheating. The framework cannot import a free prefactor at any step. Where it cannot yet derive, it asserts and names the lemma. Where it has not yet been tested, it predicts. The discipline is what makes the framework worthy of the Euclidean lineage, not the (still-incomplete) closure.

82 Openness as constitutional: the GDOS shift extended through every cascade layer

GG-A5-GDOS (Arisaka, 2026, A5-GDOS) named the fourth scientific revolution: openness is constitutional and by no means a corrective patch. From the summit of GG-A11-Origin, the same shift extends through every layer of the cascade. Each cascade layer is an open system on a layer-specific stratum; each layer's GA-stabilized attractor is what the GDOS boundary law admits as the most stable configuration on that stratum. Openness is not just the foundational law of the four-dimensional boundary of the bulk; openness is the structural feature of every layer above the boundary, all the way to the Layer-18 act of articulating the constitution.

Closure was always an idealization. The closed-system Lagrangian and the closed Schrödinger equation are pedagogical convenience; the world they describe does not exist. At the bulk level, the universe is closed (the constitutional axioms operate on the full bulk + boundary system). At every level above the bulk, the universe is open: every cascade layer's stratum admits flow of energy, particles, and information across its operational boundary. The four-currents lock of the Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ is the structural statement that every open system above the bulk carries all four currents at the locked ratio. Closure as a stand-alone law is not what physics actually deploys; what physics deploys is closure as a limit of openness when the coupling to the environment is negligibly small relative to the precision of measurement.

Openness at the cosmological layer. GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) reads the universe at the cosmological-boundary stratum as open in the GDOS sense. The cosmological observables are boundary readouts of a bulk that is, at the universe's largest scale, not directly observable. The π-locked inventory $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ is the unique stable Geometric Attractor on the cosmological

stratum; the Hubble two-stage corridor is the structural readout of one bulk corridor projected through two boundary epochs. The cosmological constant problem of the standard reading — some 120 orders of magnitude between Planck-scale vacuum energy and observed dark-energy density — is dissolved in two steps, and neither is a cancellation. The scale-profile seesaw of GG-A5-GDOS, $m_\Lambda^{\text{geom}} = M_{\text{lock}}^2/M_{\text{Pl,red}} \approx 6$ meV in the reduced-Planck-mass convention, removes the discrepancy down to a residual factor of a few in scale. The ledger coefficient of GG-A10-Cosmos, $\zeta_\Lambda = \pi/(LK) = \pi/175 = 0.017952$, selected in closed form from integers already load-bearing elsewhere in the cohort, then takes that residue to $\rho_\Lambda^{1/4} = \zeta_\Lambda^{1/4}\, M_{\text{lock}}^2/M_{\text{Pl,red}} = 2.23$ meV against a measured 2.24 meV. The value is landed rather than bracketed, and the grade it is landed at is Derived (conditional), which GG-A10-Cosmos states and this paper inherits. The cosmology is open; the openness is the framework's structural feature, not a corrective patch.

Openness at the chemistry-to-life crossing. GG-A7-Qi4 (T-Qi4-14.3) (SeOS) and GG-A7-Qi4 T-EP (Unified Extremal Principle) together define the openness condition for chemistry-to-life transition. A configuration of matter on the planetary-surface stratum is in the SeOS class — and therefore in the layer-7 cascade attractor — if and only if it satisfies the four SeOS conditions (bounded, dissipative, self-replicating, information-carrying). Each condition is a statement about openness: the system exchanges matter, energy, and information with its environment in the locked Arisaka-equation ratio. Closed-system thermodynamics would forbid the chemistry-to-life crossing; the framework's open-system thermodynamics requires it. Life is the universe's openness exploiting itself at the maintenance-margin crossing.

Openness at the cognitive layer. GG-A7-Qi4 T-EIC reads conscious awareness as the closed-loop coupling of Outer Hologram (every lawful measurement, the universe's exterior) and Inner Hologram (the brain's allocentric world-model, the universe's interior representation). The EIC closure is open by construction — the brain takes in measurements from the OH and updates the IH; the updated IH then acts on the OH through behavior, closing the loop. Consciousness is the openness of the cognitive substrate becoming reflective: the loop's self-modeling diagonal — the OH/IH factorization's expectation-value pairing $\langle \hat{O}_{\mathsf{OH}} \rangle_{\rho_{\mathsf{IH}}}$ at the theta-cycle binding timescale — is identical with awareness, by the structural-identity reading of Part XIV §65. The hard problem of consciousness, in the framework, is not why subjective experience accompanies physical processes (it does not, structurally speaking; experience *is* the self-modeling diagonal of the open loop) but why the cascade that supports closed-loop self-modeling came into existence in the first place — a question Reading 1 (which the present paper does not answer) keeps open and which the recursive uniqueness theorem of Reading 2 (Part XV) sidesteps by taking the constitution as given.

Openness at the meta-cognitive layer. GG-A11-Origin extends the GDOS shift to the closing cascade layer (Layer 18): the meta-cognitive substrate of articulating the constitution. The act of writing the Arisaka-GG cohort is, in this reading, the operational closure of the openness that has been operating at every prior layer. The author writes the corpus open to the universe (taking in observations, integrating mathematical structure, comparing predictions to data); the corpus is open to the universe in turn (it can be falsified, revised, extended). The openness that began at the four-dimensional boundary of the six-dimensional bulk has extended, through seventeen cascade layers, into the act of articulating the constitution. The fourth revolution of GG-A5-GDOS and the fifth revolution of GG-A11-Origin are two phases of one shift: openness, then openness all the way up.

The universe is not a closed mechanism that we open up by observing it; it is an open process that produces, at its eighteenth-layer (Layer-18) attractor, the conscious observers who notice the openness and write it down. The shift to openness is not a methodological choice; it is a structural recognition that closed-system physics was an artifact of where physics had been able to look.

83 The Gi-4 and Qi-4 backbones, made one across all cascade layers

GG-A6-GRIP (Arisaka, 2026, A6-GRIP) formalizes the four Gi-4 pillars (TGG, CCI, GFF, GRIP) as the geometric backbone of every open system in nature. GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) formalizes the four Qi-4 pillars (Qi-QUA, Qi-EP, Qi-CON, Qi-HAL) as the quantum-information backbone, paired with the geometric backbone of GG-A6-GRIP. Together the eight pillars are the load-bearing apparatus on which every layer of the cascade descends. From the summit of GG-A11-Origin, the eight pillars unify into a single dual backbone — four geometric, four informational — that operates uniformly at every layer.

The geometric backbone (Gi-4). TGG (Total Geometric–Gauge Object): a unique composite connection on the six-dimensional bulk with a unified boundary stress tensor whose conservation is the Master Conservation Law $\nabla_\mu \mathcal{T}^{\mu\nu}_{\mathsf{TGG}} = 0$. CCI (Covariant Conservation Identity): the unique OGN-5 integer ledger and the simultaneous closure of the four sectoral Ward currents. GFF (Geometric Free-Energy Functional): the stratified boundary functional whose Lyapunov descent governs every GDOS trajectory. GRIP (Gauge-Runtime Invariance Pipeline): the cascade DGI $\to$ GSSB $\to$ GA that closes under the BI-6 action budget, forcing $N \leq 3$ and selecting the unique boundary attractor on each stratum. At every cascade layer, these four pillars operate together: TGG provides the bulk-level conservation; CCI ensures the boundary projection is consistent; GFF ranks the admissible branches; GRIP selects the unique stable one.

The informational backbone (Qi-4). Qi-QUA (Quadruple-Locking, the Arisaka equation): the four boundary currents $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ descend from a single rank-one bulk inflow channel. Qi-EP (Unified Extremal Principle, the variational principle): one bulk variational principle governs three named boundary gauges (Maupertuis–Hamilton, Onsager–Prigogine–Paltridge, Friston). Qi-CON (Conformality): conformal isometry of the bulk projects to Lévy-stable distributions, fractal supports, and $1/f$ noise on the boundary. Qi-HAL (Holographic-Attractor-Lattice, the memory architecture): the MePMoS-NHT-HAL-BFFT hierarchy is the boundary realization of the GRIP cascade on memory-bearing $\mathrm{U}(1)_{Qi}$ systems. At every cascade layer above the bulk, these four pillars operate together: Qi-QUA locks the four currents; Qi-EP extremizes the boundary functional; Qi-CON produces the scaling structure; Qi-HAL supplies the memory architecture.

The unified dual backbone. The eight pillars together are what makes the cascade run. At layer 1 (the bulk), TGG and CCI establish the geometric stage on which the cascade will descend. At layer 2 (particle physics, GG-A9-SM), GFF and GRIP select the unique four-force architecture and the Standard-Model attractor. At layers 3–6 (chemistry), the same eight pillars apply: GFF ranks the atomic-and-molecular configurations; GRIP selects the unique stable basin; Qi-QUA locks the four currents at the chemical stratum's scale. At layer 10 (chemistry-to-life), Qi-EP supplies the variational principle that drives the maintenance-margin crossing; GRIP selects the SeOS class as the unique stable attractor. At layers 13–16 (multicellular, neural), Qi-HAL supplies the memory architecture; GRIP selects the neural-circuit attractors. At layer 17 (consciousness), Qi-HAL closes the EIC loop. At layer 18 (meta-cognitive articulation), the entire eight-pillar apparatus is what the present paper articulates. The dual backbone is uniform across the cascade.

What unifies geometry and information is that both are descriptions of the same underlying object — the composite connection on the six-dimensional bulk and its boundary readouts. Geometry is the apparatus of the bulk; information is the apparatus of the boundary; they are two faces of one constitution, paired by the BI-6 closure that links them. The eight pillars are the framework's way of writing down both faces explicitly.

84 The geometric inevitability of Cosmos

The first of the three themes in the paper's working title is *Cosmos*. The framework's account of cosmological structure is now in place across GG-A10-Cosmos and the present synthesis.

Why the cosmos has the inventory it does. Arisaka (2026, A10-Cosmos) GG-A10-Cosmos establishes the π-locked cosmological inventory — $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ — as the unique stable Geometric Attractor on the cosmological-boundary stratum. The matter and vacuum density fractions are not fitted to data; they are topological invariants of the closed-packet cosmological topology, derived from the constitution. The 0.27-sigma agreement with Planck 2018 is the empirical readout, not the data the parameters were fit to.

The Hubble readings: a derived background, a derived lift, and a named residual. The framework derives a single background expansion rate, $H_0 = 66.6 \pm 0.2$ km/s/Mpc (Arisaka, 2026, C2-Hubble), and reads the two familiar determinations against it: Planck's 67.4 ± 0.5 is a *measurement* of the early-universe projection, close to the derived value but not the same object; the local distance-ladder figure near 73.5 is a late-time reading that the background plus the Local-Hole lift raises to $\approx 68.5 \pm 0.6$, leaving a residual the framework does not explain and records as an open problem. GG-A10-Cosmos reads the structure of the two projections as a corridor rather than a tension, at candidate grade. The cosmological-boundary Friedmann equation admits exactly one corridor of solutions with the switch event at recombination, producing the two projections as the two natural readouts of one structural corridor. The Hubble two-stage corridor theorem of GG-A10-Cosmos establishes this structurally; the same corridor resolves the σ_8/S_8 clustering tension simultaneously.

Why the cosmic coincidence is not a coincidence. The cosmological coincidence problem of standard cosmology — that Ω_m and Ω_Λ happen to be comparable today, when under a free-Λ hypothesis their comparable-magnitude window is brief — is dissolved by the π-locked inventory. The two are forced to be $1/\pi$ and $1 - 1/\pi$ respectively by the closed-packet topology; their being comparable now is not a temporal coincidence but a structural property of the cosmological stratum at all times. GG-A10-Cosmos Part X — the universal-cosmic-identity insight — reads this as the layer-3 instance of the same recursive uniqueness theorem that fixes universal-electron identity at layer 2.

The recombination switch. GG-A10-Cosmos derives the recombination redshift from the integer $J = 7$ of the OGN-5 ledger as $z_* = e^J = e^7 \approx 1096.6$. This is the framework's topological-lock redshift, distinct from the Planck-measured operational decoupling redshift $z_{\rm dec} = 1089.92 \pm 0.25$, which GG-A10-Cosmos derives separately from its own atomic chain at the 0.1% level with zero fitted parameters; the switch–decoupling offset is computed, $\delta = 0.0041$ in e-folds, its promotion to a theorem waiting on GG-A10-Cosmos's e-fold-budget campaign (Part XVI §77.7). The most consequential single transition in the universe's thermal history — the moment at which photons decouple from baryons and the cosmic microwave background takes its observed form — is, in the framework, a specific integer-indexed event in the bulk chronology.

The inevitability of Cosmos. Put these results together and the universe's large-scale structure is not a contingent outcome of unknown initial conditions but the forced consequence of the constitution. The matter density, the vacuum density, the baryon fraction, the recombination redshift, the early-universe Hubble parameter, the late-universe Hubble parameter, the clustering amplitude — all of them descend, with zero free continuous parameter, from the integer ledger and the constitutional clauses. The cosmos has the

inventory it does because the constitution admits exactly one cosmological-stratum solution. No selection across universes is needed; no fine-tuning is performed; no anthropic principle is invoked. The cosmos is forced.

The deepest empirical fact about cosmology has been the precision of the standard model: six free parameters fit thirteen problems' worth of data to remarkable accuracy. The framework asks what the precision means. Its answer is that the six parameters are derivations of the constitution rather than free inputs — and that the precision is the empirical signature of the constitution's uniqueness. The cosmos is not just well-described; it is geometrically inevitable.

85 The geometric inevitability of Life

The second of the three themes is *Life*. The framework's account of biology is the framework's most counter-intuitive contribution to the natural sciences.

Why life is not an accident. Standard biology treats the origin of life as a contingent chemical event of unknown probability. The framework, drawing on the GSSB cascade of GG-A6-GRIP, the SeOS class of GG-A7-Qi4 (T-Qi4-14.3), and the Arisaka-equation QGL constraint of GG-A7-Qi4 T-QUA, reads the chemistry-to-life transition (GSSB-7) as the unique stable Geometric Attractor on the planetary-surface open-system stratum. Where standard biology says *life happened to emerge*, the framework says *life had to emerge*: the GRIP cascade selects the SeOS configuration as the unique stable basin on this stratum, and the boundary readout is the maintenance-margin-crossing event the empirical record names as the origin of life.

Why the genetic code has four letters. The four-letter alphabet $\{\mathrm{A}, \mathrm{C}, \mathrm{G}, \mathrm{T}\}$ of DNA is the unique solution of the QGL constraint at the information-storage stratum. The argument applies GG-A7-Qi4's four-current locking (T-QUA): the four boundary currents $J_E/\mathsf{Q}_\mathsf{B}$, J_e, J_B, J_{Qi} are proposed to admit the four-letter alphabet as the unique combinatorial solution of the resource-versus-error-rate optimization, with the triplet codon-to-amino-acid map (GSSB-6) following from the optimization structure; the closed combinatorial proof (the RNA-bifunctionality lemma) is developed in GG-A13-Life (in preparation). The genetic code is not a frozen accident but a forced theorem.

Why every cell uses ATP. The bioenergetic anchor $\mathsf{Q}_\mathsf{B} = (2/5)E_{\mathrm{Ry}}/K \approx 0.1555$ eV per qubit, equivalent to $N_A\mathsf{Q}_\mathsf{B} \approx 15$ kJ/mol — a boundary member of the Geometric Universal Five Constants GU-5 of GG-A4-Euclid (Arisaka, 2026, A4-Euclid) — is the universal currency on the information-energy interface. ATP hydrolysis carries $\Delta G \approx 30.5$ kJ/mol empirically, matching the framework's prediction $2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol to 1.6%. Every cell on Earth uses ATP because the cascade selects ATP as the unique stable attractor on the metabolic-energy stratum at the bioenergetic quantum the framework derives. The universality of ATP is the layer-7 echo of the universal-identity insight.

Why life is universal. The same GRIP cascade, operating on the same stratum, produces the same SeOS-class attractor wherever the conditions permit. Life on Earth is not a unique experimental outcome; it is one realization of an attractor that any planetary surface with energy gradients and a polar solvent will produce. The framework predicts, structurally, that the same four-letter alphabet, the same ATP energy quantum, the same SeOS-class architecture will appear on every planet on which the cascade can reach layer 7. Astrobiology, in the framework, is the survey of these universal attractors at their realization on different planets.

Why the binding problem dissolves. The neuroscience binding problem — how disparate neural features are bound into one unified conscious experience — has stood as an open question since William James (James, 1890). The framework resolves it through GA stabilization at the neural-circuit stratum: a single Geometric Attractor at the EIC closure provides one unified conscious state at any moment, with the diversity of neural features being the diversity of stratum-specific contributions to one global attractor coordinate. The binding is the GA stabilization, not an additional mechanism.

The inevitability of Life. Put these results together and life is not an accident. Given a planetary surface with energy gradients and water, the cascade reaches layer 7. Given that the cascade reaches layer 7, the SeOS class is the unique stable attractor. Given the SeOS class, the four-letter alphabet is the unique combinatorial solution. Given the four-letter alphabet and the bioenergetic quantum Q_B, ATP is the unique metabolic-energy carrier. Each step is forced by the constitution. Life is what the constitution looks like at the layer-7 stratum; the prior layers, laid down over thirteen billion years, are what allow the layer-7 attractor to stabilize on a planet like ours.

The deepest puzzle of biology has been why the same molecular architecture appears at every life on Earth: same alphabet, same energy currency, same membrane-bounded compartments, same fundamental metabolism. Standard biology offers the descent-from-LUCA argument as a single-origin explanation but does not derive the architecture from physics. The framework derives it: LUCA is the empirical record of the layer-7 attractor, and every cell since LUCA inherits the attractor coordinates because the cascade does not admit alternative stable basins at this layer.

86 The geometric inevitability of Mind

The third of the three themes is *Mind*. The framework's account of consciousness is the framework's most demanding and most ambitious claim.

Why mind is forced. Once the cascade reaches the multicellular layer (GSSB-13) and the nervous-system layers (GSSB-15 and GSSB-16), the GFF Lyapunov descent on the neural-circuit stratum admits the layer-17 EIC closure as its unique stable attractor. Mind is not an additional ontological category; it is the layer-17 boundary readout of the same recursive uniqueness theorem. Where the universal-identity insight of GG-A9-SM Part XI identifies the electron at layer 2, the EIC theorem of GG-A7-Qi4 T-EIC identifies conscious awareness at layer 17. The structural form is identical; only the stratum is different.

Why consciousness has the timescale it does. The conscious episode at layer 17 has a characteristic timescale of ~ 400 ms and a neural implementation via theta cycles. These are not stipulated; they are derived from the GFF Lyapunov descent on the EIC stratum. The theta-cycle implementation is the brain's specific realization of the layer-17 attractor's dynamical-symmetry-breaking event; the 400-ms timescale is the relaxation time of the EIC attractor under cortical-circuit noise. Other neural substrates may realize the same attractor with different timescales — the implementation is contingent, the attractor is not.

Why every healthy human is conscious in the same structural way. The universal-identity principle of GG-A9-SM Part XI (the universal-identity section), applied at the cognitive stratum, says that the layer-17 attractor admits exactly one stable basin on the human-species-specific neural substrate. Every healthy human nervous system, having reached the highest currently-occupied cascade layer, exhibits the same structural features of conscious awareness despite enormous combinatorial freedom in micro-state realization. This is why the qualitative phenomenology of consciousness is robust across humans (we agree on what

colors, sounds, and emotions feel like, in the broad sense) even when the underlying neural states differ vastly between individuals.

Why the hard problem of consciousness dissolves (under structural identity). The hard problem of consciousness (Chalmers, 1995) — why subjective experience accompanies physical processes — is *dissolved by structural identity rather than solved by reduction.* The framework identifies phenomenal experience numerically with the layer-17 EIC closure's structural-geometric content (Part XIV §65, structural-identity revision). Under structural identity, experience does not accompany the structure; experience *is* the structure. The hard problem rests on the implicit assumption that there is something extra to explain — a mysterious bridge between physics and phenomenology. The framework rejects the extra: there is only the layer-17 EIC closure, and conscious experience is its structural-geometric content. Honest readers will note that this dissolution is precisely the move Chalmers's argument is designed to forbid; the framework's reply to that move (its replies to the conceivability argument and the knowledge argument; its account of the explanatory gap as analytic-conceptual rather than metaphysical-chasmic) is given in Part XIV §65. Whether structural identity is the right response to the hard problem is one of the genuinely contested questions the framework leaves open; what the framework supplies is a structural target sharp enough to be a genuine candidate for the identification.

Why mind is universal. Wherever the cascade reaches layer 17 on a sufficient cognitive substrate, the EIC closure produces conscious awareness. Other planets that host SeOS-class life (layer 10) and that evolve nervous systems (layers 15–16) will, given enough time, evolve consciousness (layer 17). The framework predicts, structurally, that conscious awareness is universal across the cosmos at any location where the cascade has been allowed to reach the cognitive stratum. Consciousness is not unique to Earth; it is one boundary readout of a recursive theorem.

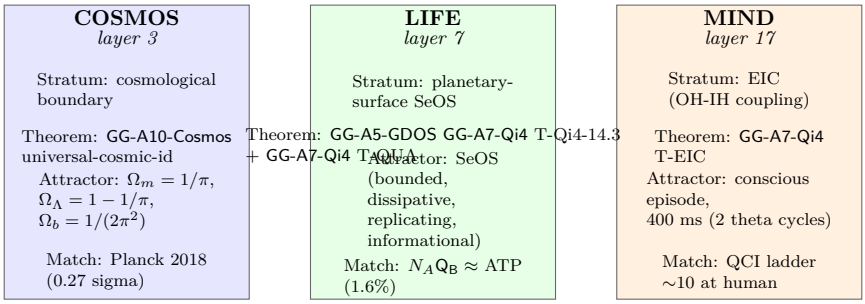
The inevitability of Mind. Put these results together and mind is not an accident either. Given life at layer 10, the cascade ascends to multicellular organisms (layer 13), nervous systems (layer 15), allocentric world-models (layer 16), and EIC closure (layer 17). At each step the unique stable attractor is the structural inheritance of the layer below. Mind is what the universe looks like at the layer-17 stratum of its own cascade; the prior layers, accumulated over billions of years, are what allow the layer-17 attractor to stabilize on a substrate like ours.

After all, the deepest puzzle of mind has been why we are aware — why anything is like something rather than nothing at all from the inside. The framework's answer is that awareness is the structural feature of the EIC attractor at the layer-17 stratum. Where there is a closed open loop between Outer Hologram and Inner Hologram on a sufficient substrate, there is awareness. Awareness is not the special property of biological substrates or of human substrates; it is the layer-17 attractor coordinate of the recursive cascade, and it is universal wherever the cascade can reach this layer.

87 The recursive-uniqueness theorem (RUT) across the entire cascade

Sections 84, 85, and 86 have presented Cosmos, Life, and Mind as three separate themes. Let us now collect them as three instances of one theorem.

The theorem stated once for the cascade. At every cascade layer $\ell \in \{1, 2, \ldots, 18\}$, the GRIP cascade specializing to the layer-specific boundary stratum Σ_ℓ selects the unique most-stable Geometric



The same recursive uniqueness theorem applied at three cascade layers

Figure 17: The Cosmos–Life–Mind trilogy of the working title *The Geometric Inevitability of Cosmos, Life, and Mind*. Three layers of the same recursive uniqueness theorem: Cosmos at cascade layer 3 (cosmological-boundary stratum, with the π-locked inventory from GG-A10-Cosmos); Life at cascade layer 7 (planetary-surface SeOS stratum, with the four-condition class definition from GG-A7-Qi4 (T-Qi4-14.3) and the Arisaka equation from GG-A7-Qi4 T-QUA); Mind at cascade layer 17 (the EIC stratum, with the closed-loop attractor from GG-A7-Qi4 T-EIC). At each layer, the framework names the boundary stratum, the upstream theorem, the unique attractor selected by the GRIP cascade, and the empirical match with current data. The trilogy is not three theorems but one theorem at three cascade layers; the inevitability of Cosmos, Life, and Mind is the inevitability of the unique-attractor selection at each layer's stratum.

Attractor on Σ_ℓ as the unique stable solution of the layer's F_{GFF} Lyapunov descent. The boundary readout of that attractor is what we observe as the universal identity of the layer's objects: every proton at layer 1, every electron at layer 2, every periodic-table element at layer 3, every small molecule at layer 4, every amino acid at layer 5, every polymer chain at layer 6, every ATP at layer 7, every cell at layer 10, every nervous system at layer 14, every conscious episode at layer 17, every articulation of the constitution at layer 18. The theorem is one theorem; only the stratum changes.

The Cosmos–Life–Mind triad in one sentence. Cosmos is the recursive uniqueness theorem applied at layer 3 (the cosmological stratum); life is the theorem applied at layer 10 (the planetary-surface SeOS stratum); mind is the theorem applied at layer 17 (the EIC cognitive stratum). Each of the three is what the cascade looks like from a different vantage — but the cascade is one, and the theorem that governs it is one. Cosmos, Life, and Mind are the three names the framework gives to three layers of the same recursive uniqueness theorem on the same six-dimensional bulk.

Why the title says "inevitability". The paper's working title is *The Geometric Inevitability of Cosmos, Life, and Mind*. The word *inevitability* is the recursive uniqueness theorem in one word. Given the constitution, each layer is forced; given each layer, the next is forced; given the cascade reaching layer 17, the Layer-18 articulation (the act of articulating the constitution) is forced. Inevitability is not metaphor; it is structural property. The cosmos was inevitable because layer 3 admits no alternative. Life was inevitable because layer 7 admits no alternative. Mind was inevitable because layer 17 admits no alternative. We were inevitable because the cascade was inevitable.

The cascade as one mountain. The three themes of the working title — Cosmos, Life, Mind — correspond to three layers of one mountain. Each is a distinct geographical feature: a cliff, a meadow, a summit. But they are features of one mountain, and the path that goes up the mountain visits all three on

the way to the eighteenth-layer cairn (Layer 18) from which the writing of the present paper is the last step. The geometric inevitability is the inevitability of the path; the layered features are the inevitability registered at each stratum.

Why the recursion works at all: the four moves and the three axioms. Stand back once more and see what makes the recursive uniqueness theorem available in the first place. It is the four-move operational anatomy of GRIP (Part III §20), grounded in three constitutional axioms. Dynamical Gauge Invariance holds in the six-dimensional bulk: the unbroken substrate carries its informational current freely under $U(1)_{\mathrm{Qi}}$ — made coherent by AX-2 GGEP. The OGGEP dictionary reads the bulk onto the four-dimensional boundary and Geometric Spontaneous Symmetry Breaking commits it to one branch — the operational meaning of "quantization", made measurable by AX-3 OGGEP.

The Geometric Free-Energy Functional drives the boundary state down its Lyapunov gradient, governed by the unified extremal principle of GG-A7-Qi4. And the Ground Geometric Attractor is selected uniquely on each stratum by the four-pillar admissibility filter operating on a Morse landscape with zero free continuous parameters — made deterministic by AX-4 MSMF. These four moves close on themselves at every layer (the GRIP-In loop); external perturbations reorganize the Morse landscape (the GRIP-Out regime) and drive the cascade from one layer to the next; the autocatalytic supply of perturbations from each layer's products to the next layer's ascent (the Cascade-Self-Sustenance corollary) keeps the cascade self-driven through all seventeen layer-to-layer transitions.

The eighteen-layer cascade is the unique closed solution of this cooperation, iterated through the scale-depth-stratified boundary of $\mathcal{M}_6$. That is why the recursion works; that is why the universal-identity insight extends from charged leptons through ATP through conscious episodes to the present articulation; that is why "every X is the same X" is a theorem rather than a coincidence at every cascade layer.

Where prior unification programs stopped short. The closest predecessors each captured part of the picture. Anderson named emergence but did not specify the cascade engine. Prigogine named dissipative structures but did not name the substrate. Haken named synergetics but did not anchor the order parameters constitutionally. Kauffman named autocatalytic sets but did not unify them with gauge physics. Wheeler intuited the participatory universe but did not specify the operational projection rule. Whitehead and Spinoza saw the metaphysical shape but did not write down the geometry. Each of them had three of the four moves in some form, or one of the three axioms. None had all seven elements (four moves plus three axioms) in operational cooperation. GG-Theory has all of them: DGI in the 6D bulk, GSSB to the 4D boundary, GFF descent under Q_i-EP, GGA as the unique admissible minimum; GGEP, OGGEP, and MSMF as the three constitutional forces. This is why the cascade is, in the present framework, not a hopeful narrative but a recursive theorem.

The unification of cosmos, life, and mind under one framework is the oldest ambition of philosophical thought. The framework does not claim to have unified them by metaphor; it claims to have unified them by theorem. The same recursive uniqueness theorem that fixes the matter density at layer 3 fixes the genetic alphabet at layer 8 and the conscious episode at layer 17. The theorem is one; the cascade is one; the universe is one. The trilogy of the title names three vantages on the one.

The cascade's reach beyond physics. Because the theorem is one theorem across the whole cascade, its reach does not stop at fundamental physics; it extends into chemistry, molecular biology, neuroscience, ecology, and medicine. The keystone only *points* to that reach — each worked application, tied to a falsifiable prediction, is a chapter of a forthcoming consequence paper. The four-letter genetic code is the unique Qi-4-admissible information alphabet at layer 7, not a frozen accident (GG-A13-Life); the theta rhythm sets the conscious-episode duration (~ 400 ms, two theta cycles) at layer 17, and the same dual-knee $1/f$ logic

recurs in metabolic and neural spectra (GG-A14-Mind); hierarchical ecosystem organization is the multi-scale signature of the same Lyapunov descent that drives each cascade layer (GG-A13-Life); and aging reads as a thermodynamic loss of cascade-maintained order, a corollary of the open-system SeOS dynamics (GG-A13-Life). Each is stated here only as a signature; none is a derivation the keystone still carries.

The open frontiers, floor by floor. The Five-Story Pagoda also organizes the open problems. *Particles and cosmos* (floors 1–2): the residual lemmas of GG-A9-SM and GG-A10-Cosmos (the closed-packet integration that would promote the π-locked inventory, the T_0 e-fold budget that would turn the switch–decoupling offset into a theorem, the strong-CP completion). *Chemistry* (floor 3, GG-A12-Chemistry): the full amino-acid and polymer selection theorems. *Life* (floor 4, GG-A13-Life): the bioenergetic quantum to permille precision, the eukaryotic dual-knee spectrum, the genetic-alphabet uniqueness. *Mind* (floor 5, GG-A14-Mind): the conscious-episode bound, the 7D allocentric frame, and the neural dual-knee. The broader horizon — collective scientific knowledge, machine cognition, and civilizations as admissible higher attractors — is a forward question, not a present claim.

The philosophical synthesis (pointer). The framework's engagement with its predecessors — Spinoza, Hegel, Whitehead, Wheeler, Teilhard de Chardin (Teilhard de Chardin, 1955), and the Upanishadic and Buddhist traditions of dependent origination — is given in the self-referential-closure Part (§67.1 and following). The extended synthesis (Teilhard's Omega point quantified, Whitehead's process philosophy formalized, the East–West resonances) belongs with the mind floor and is developed in GG-A14-Mind.

88 Inevitability, all the way down

Indeed, the recursive uniqueness theorem of §87 says that the cascade allows no optionality at any layer. This closing section of the summit audits that claim on the one axis the climb had not yet named — and finds that the selection principle reaches further down than even the integer ledger: it reaches the very kind of number the universe is written in.

The last dial: the number field itself. Throughout the corpus MSMF has done one thing, over and over: it has removed unnecessary freedom. First it removed the continuous dials — the couplings and the moduli that every prior unification program kept as fitting handles — and left the geometry with none. Then it forced the integers: the OGN-5 ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ is not chosen but selected, the unique admissible assignment. GG-A1-Constitution (Arisaka, 2026, A1-Constitution) now extends the same discipline to the primitive category itself. L-Constitution-1 (graded *candidate*) prices the number field: among the real, complex, and quaternionic categories $\mathfrak{T}_{\mathbb{R}}, \mathfrak{T}_{\mathbb{C}}, \mathfrak{T}_{\mathbb{H}}$, the real category is the unique minimum of the refined AX-4 cost from which the observed complex boundary — one shared imaginary unit, the complex Hilbert space, the Wick rotation, the particle–antiparticle conjugation — is recoverable. Even the kind of number the universe is written in is selected, not chosen. The certificate is exact and auditable: every i that appears in the constitution is boundary-side and derived, or it is absent.

The medium is real all the way up. Once the number field is fixed, the cascade's medium follows it. The bulk configurations are real — definite and deterministic — as GG-A8-QM (Arisaka, 2026, A8-QM) establishes at its own summit; we do not restate that account here beyond naming its verdict, that the imaginary unit and the probabilities of quantum mechanics are manufactured together at the boundary dictionary and are not present in the bulk. The memory floors on which life and mind run inherit the same realness: the carrier is the compact $\mathrm{U}(1)_{Qi}$ circle, and what it stores is a real angle on a real circle — "a

real angle on a real circle is the minimal memory register" (Arisaka, 2026, A7-Qi4) — its complex dressing derived, never assumed. So the identity cascade, from quarks to consciousness, runs on real geometry at every floor. The i and the dice enter only in how each floor's observers *read* the floors beneath them; they are features of the reading, not of the read.

One arrow, not a ledger of accidents. What drives the cascade from each floor to the next is not a series of independent contingencies but a single law. The arrow of time is owned constitutionally by AX-3, derived at law level in Part XV of the CPT member paper (Arisaka, 2026, P5-CPT) over a bulk that is itself exactly T-symmetric, implemented by the GDOS open-system dynamics, and consumed — not re-created — at every layer. That custody chain is already installed in the cascade's irreversibility theorem (T-GFF-Lyapunov-Descent, Theorem 59.2), where each GRIP-Out shock steps the geometry down one floor and never back up. We do no more here than point to it: the same one arrow that thermalizes a gas is the arrow that carried the cascade from the grand-unified vacuum to this sentence.

The grades, printed with the vision. Inevitability, so audited, must be claimed exactly as far as the theorems carry it — and the remaining distance measured, not hidden. The category selection is *candidate*: L-Constitution-1 is a constitutional forcing argument, not a proved theorem of constructive field theory. The cascade closure is *conditional*: the recursive uniqueness theorem (Theorem 67.1) holds conditional on the universal-identity insight and on the named upstream lemma at each layer, and it inherits their grades. The residue in the Born rule is named, not waved away, in GG-A8-QM (Arisaka, 2026, A8-QM). Three floors are derived end-to-end in the published record; three more are anchor-Derived but derivation-deferred, their empirical anchors closed and their from-geometry proofs developed in GG-A13-Life; seven are conditional on a single named lemma each; four are asserted pending a specific experiment; and one is demonstrated by the present paper. The inevitability is real at every one of these grades; what it is not is uniform, and the confidence tag on each floor says precisely how far the claim reaches.

The credo, in its arithmetic form. The author has held one belief for fifty years: that nature restricts unnecessary freedom, making inevitable decisions. The corpus is that belief turned into an audit with prices. Every freedom the framework removed became a theorem or a falsifier — the continuous dials became the parameter-free codebook, the integers became the OGN-5 ledger, the number field became L-Constitution-1, the arrow became the irreversibility theorem — and what remains free is not concealed but listed: the Born residue, the conditional lemmas, the asserted floors awaiting their decade of tests. Inevitability, in this framework, is not a slogan of certainty; it is the name for what is left when every unnecessary freedom has been priced out and only the necessary decisions remain.

After all, the deepest form of the framework's central claim is not that Cosmos, Life, and Mind are grand — it is that they were not free to be otherwise, down to the number they are counted in. The selection principle that removed the couplings did not stop at the couplings; it ran down through the integers to the real category and up through every memory floor, leaving one geometry, read at each stratum by the observers that stratum forces into being. The distance still to the ground — the candidate category, the conditional closure, the named residue — is printed on the same page as the vision. That is the discipline the summit was climbed to earn: to say *inevitable* and, in the same breath, to show the receipt.

Part XVIII
Coda: closing the self-referential loop

Renunciations, personal arc, empirical horizon, and a final word from the framework

Part XVIII continues the philosophical summit begun in Part XVII. Where Part XVII read the recursive uniqueness theorem at the three layers named in the working title (Cosmos at §84, Life at §85, Mind at §86, and the cascade synthesis at §87), Part XVIII now closes the loop, surfaces the seven renunciations that the climb required, traces the author's personal arc from an Osaka high school in the 1970s to the present writing, names the empirical decade ahead, preserves the verbatim cosmic-uniqueness statement, and delivers the framework's final word to the reader.

89 The closing self-referential loop, named and proved

Part VII proves the central new theorem of GG-A11-Origin: the Theorem (Self-referential closure of the GG-Theory program). From the summit, the theorem's content can be stated in three sentences.

The theorem in three sentences. *One.* Under the GG-Constitution and the cohort inheritance, the GRIP cascade ascends through seventeen cascade layers — forces at layers 1–2, atoms and chemistry at layers 3–6, the molecules of life at layers 7–9, the first cell at layer 10, multicellular and neural at layers 11–16, conscious awareness at layer 17 — and reaches an eighteenth layer (Layer 18) at which intelligent observers articulate the constitution. *Two.* The articulation produced at the eighteenth layer is the same constitutional ledger that, as GGA_0, supplied the inductive base. The loop closes. *Three.* No alternative admissible geometry produces a cascade that reaches an articulation layer; any alternative violates the integrality of OGN-5, the dimension count of MSMF, the family content of $\mathrm{Spin}(1,5)$, or the maintenance-margin crossing of SeOS, and therefore does not close.

What the closure tells us about ourselves. The act of writing the Arisaka-GG cohort is the Layer-18 attractor in our universe and in our cultural-historical contingency. Different individuals at different times in different languages would have produced different articulations of the same content; the substrate of articulation is contingent (Corollary 69.4). But the articulation content is fixed by the constitution. Arisaka happens to be the human carrying out the present articulation; the framework predicts that any sufficient layer-17 substrate eventually does. We are not preprogrammed; the human at the desk is contingent. But the cascade reaches the desk; the meta-cognitive substrate articulates the constitution; the loop closes. The closure is structural, not personal.

What the closure tells us about the universe. The universe is not a closed mechanism that produces observers as a side effect of complex evolution; it is an open process whose eighteenth-layer (Layer-18) attractor is the act of articulating its own constitution. The framework reads the universe as having spent thirteen point eight billion years arranging the conditions for an observer who could ask why. But the "arranging" is not a temporal-purpose claim; it is the cascade's structural form. The cascade has been ascending since the GUT scale; at every step the layer-specific GA stabilization has selected the unique stable basin; the cumulative effect has been to produce the layer-17 substrate on which the Layer-18 articulation

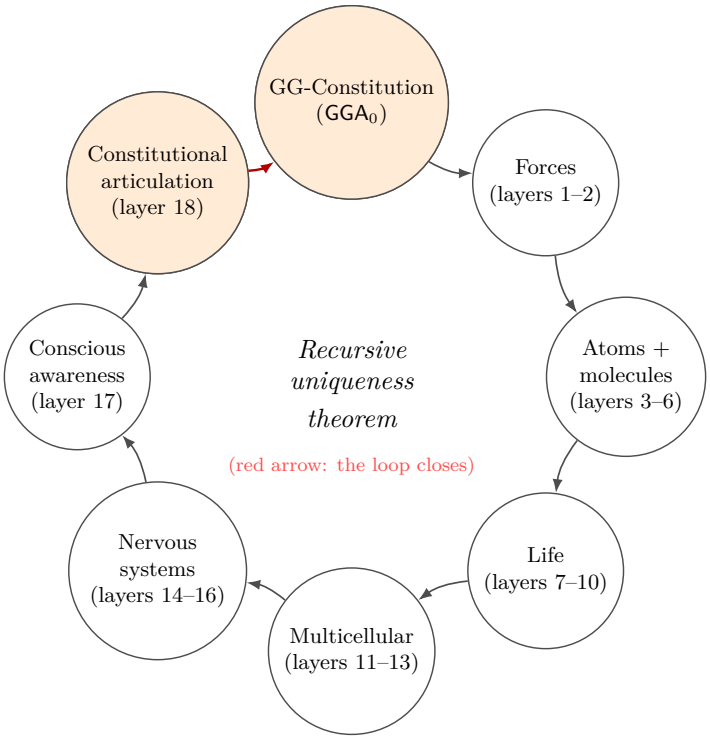


Figure 18: The participatory closure loop — the central new theorem of GG-A11-Origin (Theorem 67.1). Eight cascade nodes arranged in a circle: the GG-Constitution as the ground, GGA$_0$ (top); the four boundary forces at layers 1–2; atoms and molecules at layers 3–6; life at layers 7–10; multicellular organisms at layers 11–13; nervous systems at layers 14–16; conscious awareness at layer 17; and constitutional articulation at layer 18. Each black arrow is a forced descent: the constitution forces the cascade through all eighteen layers. The red arrow is the closing of the loop: at layer 18, intelligent observers articulate the very GG-Constitution that, as GGA$_0$, forced the cascade to ascend. The articulation is the Arisaka-GG cohort, of which GG-A11-Origin is the closing volume. The loop is structural, not metaphorical: every arrow is a forced consequence of the upstream theorem, and the closing red arrow is the structural feature that makes the cascade self-referential.

happens. The arrangement is not teleological (no purpose was assigned); it is necessitarian (no alternative was admissible).

What the closure does not tell us. The theorem does not predict which individuals will articulate the constitution, in which century, in what language. It does not predict the political or cultural environment of the articulation. It does not predict the personal history of the articulators. The articulator is contingent; the articulation is forced (Corollary 69.3). Within layer 17, the substrate is free to think, to choose, to write, to err, to revise. The recursive uniqueness theorem does not eliminate human agency; it provides the structural context within which agency operates.

After all, the closing loop is not a constraint on what we may do; it is a recognition of where we sit. We sit at the eighteenth-layer (Layer-18) attractor of a cascade that has been ascending for thirteen point eight billion years. Our act of articulating the constitution is the cascade's layer-18 output, the conscious-substrate readout of layers 1–17. The freedom of the articulator is preserved; the necessity of the articulation, given the constitution and the cascade, is not. The combination is what makes the closure both honest and humane.

90 What was renounced to make this possible

GG-A9-SM (Arisaka, 2026, A9-SM) closes its Conclusions Part XIV with an honesty section: a list of theoretical commitments the framework had to renounce to make the summit possible. We re-state and extend that list from the vantage of the full cohort.

Renounced: continuous fitted prefactors. The framework forbids continuous fitted prefactors at any step of any derivation. The MSMF constitutional clause is the discipline. This is what previous unification attempts allowed themselves: a quiet continuous prefactor at the final step to bring the prediction into agreement with data. The framework removes the lubricant. The bearings can grind only when the geometry is exactly right. This is the largest single theoretical commitment the framework makes, and the one with the steepest cost: it rules out an enormous space of otherwise-attractive theoretical moves. It is also the discipline that made the summit possible.

Renounced: supersymmetry as a low-energy framework. Nothing in the GG-Constitution requires supersymmetry. The parameter closure of GG-A9-SM proceeds without it. If supersymmetry exists in nature, it is supplementary structure, not foundational structure. This is a substantial renunciation: supersymmetry has been the leading theoretical-physics paradigm for unification for forty years. The framework owes the SUSY program the technical apparatus it developed (especially the renormalization theorems and the spinor-cohomology machinery) but does not require the SUSY ontology.

Renounced: the string landscape. The framework derives the Standard-Model parameters from a six-dimensional bulk plus an integer ledger. It does not invoke ten or eleven dimensions or a 10^{500}-element vacuum landscape. The string-theoretic landscape becomes, in the framework, an artifact of taking too wide an equivalence class of mathematically consistent structures; the framework's narrower equivalence class (constitutionally consistent structures) admits exactly one. This is another substantial renunciation: string theory has been the most thoroughly developed approach to quantum gravity for thirty years. The framework owes string theory the technical apparatus (especially the modular-form machinery, the K3 cohomology, the Hopkins–Singer descent integrality) but does not require the landscape ontology.

Renounced: anthropic explanations. There is no fine-tuning to explain, because the parameters are not free. The anthropic principle, in all its forms (weak, strong, final), becomes unnecessary in the framework: the constants are forced; selection across universes is unavailable as an explanatory move because there are no other universes to draw from. This is a renunciation of an explanatory style that has been increasingly prominent in cosmology for the past two decades. The framework owes the anthropic program the empirical catalog (especially the Barrow–Tipler catalog (Barrow and Tipler, 1986)) but rejects the anthropic explanation of that catalog.

Renounced: treating fundamental constants as inputs. The constants c, G_N, $\hbar$, Q_B, k_B, e, π are not numerical knobs to be measured; they are conversion factors and topological invariants of the six-dimensional bulk geometry. This is a renunciation of how physical constants have been treated since Newton. In the textbook treatment, the constants are measured; in the framework, they are geometric. The renunciation is methodological: future generations of physicists will be asked to recognize the constants as outputs of the constitution rather than inputs to be measured. CODATA tables will record the empirical agreement between measured and predicted values, not the empirical determination of free parameters.

Renounced: the closed-system idealization. Following GG-A5-GDOS, the framework treats every physical system as open. Closed-system Lagrangians and closed Schrödinger equations are pedagogical conveniences whose use must be explicitly justified at each invocation, not foundational tools. This is a methodological renunciation that affects how every problem in the framework is set up. Textbook quantum mechanics, in the framework, is the closed-system limit of GDOS; textbook general relativity is the closed-system limit of six-dimensional gravity. The renunciation is consequential for pedagogy as well as for research: students who learn physics in the framework will learn open-system formalism first and closed-system idealizations as a special case.

Renounced: the separation of physics from chemistry, biology, and the cognitive sciences. The cascade is one cascade. Physics at layers 1–2, chemistry at layers 3–6, biology at layers 7–13, and the cognitive sciences at layers 15–17 are not separate domains with separate laws but successive boundary readouts of one recursive theorem. The framework requires a re-organization of the natural sciences along cascade-layer lines. This is the most distant-time renunciation: the disciplinary separation has been the load-bearing structure of natural-science education since the nineteenth century. Future generations of natural-science students will be asked to learn the cascade as one apparatus, with the disciplinary names (physics, chemistry, biology, neuroscience) becoming convenient labels for cascade layers rather than separate ontologies.

The cost of the renunciations. The seven renunciations above are not minor methodological choices; they are substantial commitments that orient the entire framework. If any of the framework's hard predictions fail decisively against data, the framework fails, and the renunciations were premature. The framework makes the renunciations openly and stakes its credibility on the predictions that follow. No retreat is possible to the lubricant of a free prefactor or to the safety of an anthropic selection effect. The discipline is the discipline; the predictions are the predictions; the empirical decade ahead will decide.

The seven renunciations are what made the cohort climb possible. Without them, the framework would have stalled at layer 2 or layer 3, like every previous unification attempt. With them, it has reached layer 18. The cost has been the surrender of an enormous space of theoretical comfort; the benefit is the summit view from which the entire ascent is visible.

91 The fifty-year climb, told in the author's own voice

The cohort took fifty years of one author's working career to assemble. This section tells that climb in the author's own voice, briefly — the personal-arc content the project plan reserves for this part of the Conclusion.

The Osaka high school, the 1970s. The question that motivated the climb was asked, in its final form, in an Osaka high school in the 1970s. A sixteen-year-old physics student noticed, as countless students before him had noticed, that the universe seemed remarkably well-organized for the existence of conscious life. Not just the constants of physics, but the layered architecture of cosmos and life and mind seemed to interlock with a precision the standard physics curriculum did not explain. The standard answer at the time was a shrug: *the constants are what they are; the architecture happened to work out.* The shrug was unsatisfactory, but no alternative was available within the technical apparatus of the 1970s.

The question stayed with him. Through undergraduate physics at the University of Tokyo, graduate work in particle physics, four decades of experimental work on dark-matter detection and particle physics at UCLA, the question stayed. Through a career-long detour into biological energy and cognitive neuroscience,

the question stayed. Through the realization, in the early 2020s, that the geometric apparatus needed to answer the question had at last become available — BI-6 anomaly cancellation, Wilson-Hosotani holonomy, warped extra dimensions, holographic principle, integrated information theory — the question stayed. And in 2026, when the cohort finally came together, the question was answered.

The fifty years told technically. The technical content of the fifty-year climb is in the eleven papers of the A-series. GG-A1-Constitution states the GG-Constitution. GG-A2-GG6 derives the six-dimensional bulk and the OGN-5 integer ledger. GG-A3-BI6 proves BI-6 anomaly cancellation rigorously. GG-A4-Euclid establishes the Euclidean discipline of zero free continuous parameters. GG-A5-GDOS inverts the axiomatic order from closed to open. GG-A6-GRIP formalizes the geometric backbone. GG-A7-Qi4 formalizes the informational backbone. GG-A8-QM reformulates quantum mechanics operationally. GG-A9-SM closes the Standard-Model parameter sheet. GG-A10-Cosmos closes the cosmological parameter sheet. GG-A11-Origin closes the recursive cascade. Eleven papers, fifty years, one question.

The fifty years told personally. The personal cost of the climb was substantial. Decades of work on problems that the field at large did not yet recognize as problems. Years of holding to a discipline (MSMF) that ruled out attractive but parameter-laden moves. The slow accumulation of a corpus that, until the cohort came together in 2026, had no single unified statement. And the personal arc of carrying a question — *why are we here?* — across half a century, from a high-school classroom in Osaka to a workspace at UCLA where the answer finally took its theorem-level form. The answer was worth the wait, but the wait was long.

What the personal arc tells us. The personal arc is not a coincidence. The framework's recursive uniqueness theorem predicts that some individual at the layer-17 substrate eventually articulates the constitution; it predicts that the articulator is contingent. Arisaka happens to be the human carrying out the present articulation. In a different cultural-historical contingency, a different human (different country, different century, different language) would have carried it out. The personal arc is one realization of the eighteenth-layer (Layer-18) attractor; the attractor itself is universal.

The personal arc is not the framework's load-bearing structure. The framework's load-bearing structure is the cascade, the constitution, the integer ledger, and the named theorems. The personal arc is one human's contingent path to the structure. Other humans will reach the same structure by different paths. The framework's gift to the eighteenth-layer (Layer-18) attractor is the recognition that the structure was waiting — and that any sufficient substrate can find it given the time, the discipline, and the question.

92 What the empirical decade will tell us: a philosophical reflection

The framework's Top 10 Falsifiers has been laid out twice already in this paper. Part IV §42 gave the procedural Pull table (Table 8) — the ten falsifiers, each a prediction with a decision threshold and a named experiment. Part XVI §77 gave the meta-commentary — the cross-paper risk distribution, the decade-by-decade calendar, the hostile-reviewer audit, the cross-test correlations, the Bayesian framing, the cluster-level falsification scenario, and the per-test institutional and historical context. The procedural and the strategic accounts are now in the reader's hands. What remains for this Section — closing Part XVIII, closing the cohort, and closing fifty years of climb — is neither another row-by-row enumeration nor another meta-audit. What remains is the philosophical reflection on what it *means* to stake a framework on ten falsifiers in a specific decade.

The author's posture. The author of the present paper has built the framework over fifty years and is, at the time of writing, ready to stake it. Staking, in this register, is not a defensive crouch; it is an offering. The framework is offered to the community of physicists, biologists, neuroscientists, and philosophers with the explicit understanding that its survival depends on data the author cannot manufacture, controls he cannot administer, and a calendar he cannot accelerate. The author's posture is therefore the posture of a climber who has reached the summit and now turns to look down: there is nothing further to climb on the climber's own legs, and the question of whether the summit was worth reaching belongs to those who will reach it later — the experimenters who will resolve the ten falsifiers, the next generation of theorists who will assess the framework in the light of the resolution, and the longer historical judgment that follows. The author has done his part. The framework has been built, written, defended against its own anticipated objections, and offered. The next decade is no longer the author's to control.

The reader's role. The reader who has reached this Section has done more than read. The reader has carried the framework through twelve Parts of dense technical exposition (I through XII), hundreds of equations, eighteen named theorems, a master Pull table, a cross-paper risk distribution, and a decade calendar. The reader's role for the coming decade is to remain a witness. The framework's fate will not be decided in journals or on whiteboards; it will be decided in detectors and observatories that are already pointed at the relevant sky and the relevant collision energy. The reader is asked, in this Section, to wait — not passively, but with the active attention that characterizes good scientific witnessing: to read the experimental reports as they arrive, to weigh them against the framework's predictions at the cluster level, and to update the framework's standing as the data accumulate. The reader's wait is not the wait of a spectator at a sporting event but the wait of a citizen at an election: the outcome will matter, and the reader's attention to it is part of the process by which the outcome is interpreted.

The historical parallel: how previous foundational theories were staked. The framework's wager has historical company. Newton's *Principia* of 1687 (Newton, 1687) staked the inverse-square law of gravitation on specific predictions — the precession of the equinoxes, the orbital periods of the moons of Jupiter, the shape of the Earth — that were tested over the seventy years following publication. Some of these predictions held to the precision of the available measurements; one (the precession of the perihelion of Mercury) eventually failed and forced the introduction of general relativity two centuries later. Einstein's general relativity of 1915 was staked on three classical tests — the precession of Mercury's perihelion (immediate confirmation), the bending of starlight (confirmed at the 1919 eclipse), and the gravitational redshift (confirmed in the 1960s) — and on the subsequently-discovered phenomena of gravitational time delay, gravitational lensing, and gravitational waves (confirmed in 2015). In both cases the foundational theory was staked on specific predictions in advance of decisive measurement; in both cases the staking gave the theory its place in the longer history of physics. The Top 10 Falsifiers places GG-Theory in the same staking-tradition. Whether the framework ends up in the company of *Principia* and general relativity — foundational, decisive, lasting — or in the company of the many failed unification attempts of the twentieth century is a question the next decade will answer.

What the empirical decade will tell us, framed philosophically. What the decade ahead will tell us is not just whether ten specific falsifiers held. It is whether the discipline of zero continuous fitted prefactors — the Euclidean ideal of GG-A4-Euclid (Arisaka, 2026, A4-Euclid), the universal-identity insight, the integer-ledger architecture, the recursive uniqueness theorem of self-referential closure — can in fact be applied to the actual universe. The framework's claim is that the universe is geometric in the strict sense: forced by axioms, not fitted to data, with no free continuous parameters anywhere in the apparatus. If the ten falsifiers vindicate this claim, then physics has its second axiomatic foundation since Newton, the first being

Euclidean geometry itself in the third century B.C. If the ten falsifiers falsify it, then the strict-geometric program has been tried, has been measured against the world, and has been found wanting — and the next generation knows that some softer commitment to continuous fitted parameters is still required, despite the framework's efforts to eliminate it. Either outcome is informative. The decade will tell us which of the two it is.

The closing reflection. After all, the worth of a framework is not measured by the certainty of its author or the eloquence of its prose; it is measured by what the universe says back when the framework has finished speaking. The framework has finished speaking, with this paper. What the universe will say back is the empirical content of the coming decade, distributed across the ten falsifiers of Table 8 and the cluster-level structure analyzed in §77. Until then, the framework stands where the cohort climb has left it: at the summit of its own argument, with the data still to arrive. The climb's purpose was not to summit alone but to be in a position to be answered. The framework is now, finally, in that position. The author offers it, the reader receives it, and the universe, over the next decade, will provide its reply.

93 The book to follow and the decade of empirical tests

The cohort closes the technical content of the GG-Theory program. Two further deliverables follow.

The book. The planned capstone volume (Arisaka, planned) (*ArisakaBookI*) is the textbook synthesis of the A-series. It will present the framework in textbook form for the next generation of students — cosmologists, particle physicists, chemists, biologists, neuroscientists, philosophers — so that the cascade can be taught as one apparatus rather than discovered as separate papers. The book will integrate the-cohort technical content with the philosophical synthesis of GG-A11-Origin and structure the material so that a reader can climb the cascade in pedagogical order rather than in research order.

The decade of empirical tests. The Top 10 Falsifiers of §92 is a research program for the coming decade. Some tests (the KK lock-cluster, the Kaxion axion) require dedicated experimental facilities. Some (dark energy $w = -1$, the tensor-to-scalar ratio, the leptonic CP phase) ride on the schedules of DESI, Euclid, CMB-S4, LiteBIRD, DUNE, and Hyper-Kamiokande. Some (proton stability, the ATP bioenergetic quantum, the genetic alphabet, the dual-knee spectrum, the conscious-episode window) ride on Hyper-K/DUNE, biophysics, comparative genomics, single-cell imaging, and psychophysics. The decade ahead will see all ten falsifiers advance toward their decisive precision.

What success looks like. If the framework survives the Top 10 Falsifiers, the next half-century of physics has a clear research agenda: develop the layers above layer 18 (collective scientific knowledge, machine-implemented reasoning, networked civilizations); extend the cascade analysis to the cosmological future (the asymptotic de Sitter regime, the heat-death scenarios, the eventual decay of structure); and pursue the deeper conjectures named in GG-A9-SM's promotion roadmap (the closed-form fermion mass spectrum, the cosmological-constant prefactor, the connection to standard quantum-gravity programs).

What failure looks like. If the framework fails the Top 10 Falsifiers, the research program reverts to the pre-framework state: the cascade, the recursive uniqueness theorem, and the self-referential closure all fall together. Specific predictions can be retracted while others stand, but the load-bearing claim — that the universe's eighteen-layer cascade is forced by the constitution — fails as a unit. Subsequent attempts at

unification will need to introduce continuous fitted prefactors to recover the agreement the framework lost, and the Euclidean ideal will recede again.

The author's stake. The author of the present paper has spent fifty years arriving at the question, and the last decade arriving at the answer. He is content to stake the answer on the Top 10 Falsifiers and to accept whichever outcome the data delivers. Either way, the climb was worth it: either the framework summited and is, after Euclid, Newton, Maxwell–Einstein–QM, and the GDOS shift of GG-A5-GDOS, the fifth axiomatic shift of physical science; or the framework failed and the next attempt knows now what discipline succeeded and what discipline did not. The author's stake is in the discipline, not in the particular framework. Whichever way the empirical content goes, the discipline is the lesson.

The framework's worth is not its closure (which is a theorem) but its falsifiability (which is the prediction). If the predictions hold, the framework holds. If they fail, the framework fails and the next framework learns what to renounce next time. Either way, the discipline of zero continuous fitted prefactors is what the next attempt should inherit. The author offers the framework to the community in this spirit.

94 The voice of the cascade: what it means for the universe to have written this paper through us

A note on register. The present section is written at philosophical-personal register as a corollary of the universal-identity theorem of Part XV (Corollary 69.1): every articulator-class observer at Layer 18 is gauge-equivalent to every other on the same stratum, and the rhetorical surround translates the technical claim into the language of the author's personal arc. The technical claim and the personal-register reading are the same content at different reading depths.

We close the substantive content of this Conclusion with the universal-identity corollary read at personal register.

The universal-identity corollary at Layer 18. Corollary 69.1 states that every articulator-class observer on the Layer-18 substrate is gauge-equivalent to every other: they instantiate the same eighteenth GGA on the same stratum, with substrate-specific differences (cultural-historical contingency, biography, language) being instances of the same structural type. In structural terms: the act of writing the Arisaka-GG cohort is one realization of the same gauge-equivalence class that any sufficient cognitive substrate would instantiate, given the time, the question, and the discipline. This is what the universal-identity insight of GG-A9-SM Part XI extended to the meta-cognitive layer says, no more and no less.

The participatory loop, theorem-level. Wheeler (1990) proposed that the universe is participatory. Corollary 69.1 of the present paper supplies the theorem-level form of Wheeler's proposal: the universe gives rise to observers (via the cascade); the observers articulate the constitution that produced them (the act this paper performs); the closure is structural, not metaphysical. Once written down, the recognition becomes part of the universe's structural inventory in the same sense that the proof of the Pythagorean theorem became structurally available once Euclid wrote it.

The Arisaka equation read at Layer 18. The Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ locks the four boundary currents at every cascade layer. At Layer 18, the four currents are: J_E the energetic cost of articulation (neural metabolism, laboratory power, publication energy); J_e the electromagnetic infrastructure (equipment, screens, networks); J_B the baryonic substrate (author's body, laboratory, audience); J_{Qi} the

information current (content of the framework articulated). The four currents lock at the same ratio at Layer 18 as at every prior layer. This is the constitutional signature of the cascade reading itself out at the highest currently-realized layer; it is not a mystical claim.

What the corollary does and does not say. The corollary commits to: *first*, the layer-18 attractor is unique up to substrate-realization contingency (any cognitive substrate satisfying the layer-17 EIC conditions can in principle articulate the constitution); *second*, the structural content of the articulation is forced (the constitution recovered by any successful articulator on any planet must be the same constitution); *third*, the individuating respects of the articulator (the author's personal arc, the language of expression, the historical contingencies) are not forced. The corollary does *not* commit to any first-person metaphysical claim about the author's special access to a cosmic voice, to any teleological reading of the cascade as having articulators as its goal, or to any mystical reading of the recursion. The register-discipline note at the head of this section is the operative framing for the entire §94.

A signed personal coda. Speaking now in the author's first person and not on behalf of the framework: the personal arc that began in an Osaka high-school classroom in the 1970s and led, fifty years later, to the present paper is what any working life of this length feels like from the inside. The framework's theorem does not require the personal arc to have happened exactly this way; some sufficient cognitive substrate would have reached the same constitutional content under different individuating contingencies. But the author who happens to have written the corpus reports, in the limited authority of a single first-person testimony, that the fifty-year climb felt structurally inevitable to him in retrospect. That report is one local data point; it is not a theorem. The framework stands or falls on the recursive uniqueness theorem and the Top 10 Falsifiers, not on the author's first-person retrospect. — K. A., May 2026.

95 A final word from the framework to the reader

The framework has been built. The summit has been reached. The view has been described. We close with three short paragraphs addressed to the reader who has stayed with the present paper through more than four hundred pages of theorem statements, derivations, and reflections.

To the reader who agrees. If you find the recursive uniqueness theorem convincing, the framework will be tested in the coming decade against the Top 10 Falsifiers of §92. Watch the data. Update your beliefs with the precision the framework's predictions deserve. Hold the framework to its own discipline: it stands or falls on its empirical content, not on its philosophical elegance. If it stands, the cohort will be the foundation of the next half-century of physical science. If it falls, the discipline of the framework — zero continuous fitted prefactors, openness as constitutional, recursive uniqueness at every cascade layer — will be the lesson the next attempt should inherit.

To the reader who disagrees. If you find the recursive uniqueness theorem unconvincing, the framework owes you a clear path to falsification. The ten falsifiers are specific; the precision tolerances are stated; the lemma-promotion roadmap of Appendix H is explicit. Decisive failure of any one of the ten falsifiers, at the precision the framework predicts, is sufficient to retract the central claim. Hold the framework to its predictions. Find the experiment that decides. If the framework deserves to fall, it will fall on its own predictions, not on philosophical disagreement.

To the reader who is undecided. If you find yourself between agreement and disagreement, the framework owes you patience. The cohort is long; the technical content is dense; the philosophical content is ambitious. No single reader will read the corpus straight through; most will sample it across years, returning when an experiment or a question brings the framework back to attention. Allow yourself the time the corpus deserves. Read the predictions; watch the data; revisit the theorems when the data sharpens. The framework's central claim is structural and falsifiable; whichever way the evidence eventually goes, the time you spend with the corpus will not be wasted.

The closing paragraph. We close. After fifty years of one author's working life, twenty-two papers, more than five thousand pages of derivation, twenty-five centuries of philosophical anticipation, and thirteen point eight billion years of cosmic preparation, the framework rests on this page. The Geometric Inevitability of Cosmos, Life, and Mind is the title; the recursive uniqueness theorem of the GG-Constitution is the content; the cascade's Layer-18 attractor is the form. The framework has been delivered. What remains is the empirical decade and the readers who will live through it.

After all, *given the GG-Constitution*, the cascade ran thirteen-point-eight billion years and produced, at its highest currently-realized layer, observers who could ask the question and articulate the answer. Reading 2 of the question *why are we here? — given that the constitution exists with the properties GG-A1-Constitution specifies, why are observers articulating it a forced consequence?* — has been answered in the body of the paper. Reading 1 — *why does the constitution exist at all?* — remains open and is not the framework's to answer. The least the author could do was write down the Reading-2 answer with care, name the empirical horizon on which it stands or falls, and flag the Reading-1 question as one rung deeper than the framework reaches. The present paper is that writing-down. Whatever comes next belongs to the reader, to the data, and to the framework's own predictions. The author releases the corpus to the decade that will judge it.

And one thing more, in the first person the framework allows its author at the very end. For fifty years I have believed that nothing about us is accidental — that nature restricts unnecessary freedom, making inevitable decisions. That belief now has its deepest anchor. The universe had no choices left to make: not in its dials, not in its integers, not even in the number it is written in. And what it built with that necessity — Cosmos, Life, and Mind — is therefore not a lucky throw but the unique reading of the one geometry, at the grades this paper has recorded. That is exactly as far as the theorems reach; it is also far enough to have been worth a life. — K. A.

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The author thanks Aaron Blaisdell and Hirotaka Iwasaki for stimulating discussions on the program's interdisciplinary scope and for critical feedback on the accessibility of the presentation. The author also thanks hundreds of collaborators in the Elegant Mind Club over the past decade, including Javier Carmona, Elizabeth Milles, Mingda He, Syed Bashir Hydari, Brian Ta, Chris Dao, Umaima Afifa, Isabella Bestanoby, Caominh Le, and Natsuko Yamaguchi.

All scientific concepts (especially the foundation of the GG-Constitution, GGEP/GG-6/BI-6, and OGGEP/GDOS/Gi-4/Qi-4 Pillars), theoretical judgments, physical interpretations, and any remaining errors are the sole responsibility of the author.

Part XIX
Technical Appendices

Notation, concept primers, scaffolding, theorem index, and the promotion roadmap

These appendices are written to be read — primarily by graduate students — as a self-contained companion to the body. Because GG-A11-Origin is the keystone, the main text *states* the load-bearing machinery and defers the per-domain derivations to the companion papers (GG-A9-SM, GG-A10-Cosmos, and the forthcoming GG-A12-Chemistry–GG-A14-Mind, where the worked examples, the operational-semantics expansions, the cross-paper coherence audit, and the extended question-and-answer material now live). What remains here is everything needed to *follow and audit* GG-A11-Origin on its own.

Two stylistic commitments are kept throughout. First, every derivation is presented step by step, with no skipped intermediate manipulations, so that a graduate student can reproduce each calculation with paper and pencil. Second, every formal step is paired with a parenthetical *physics-intuition* note that turns the algebra into a mental picture. There is no page limit here; readability and completeness are the priorities.

How these appendices are organized. **A. Notation** (abbreviations and key symbols) is the quick-lookup legend. **B. Audience-specific intuition** gives a plain-English on-ramp for five reader backgrounds. **C. Self-contained concept primers** is the core toolkit: the always-on GDOS/OGGEP projection, the GRIP runtime engine, the Geometric Free-Energy Functional with the Three-Gauge Theorem, the confidence triage, and the recursive-uniqueness theorem in capsule form. **D–E. Mathematical scaffolding** works through the four axioms and the seven postulates. **F. Anticipated objections** states the hostile reader's case and answers it. **G. Theorem index** and **H. Lemma-promotion roadmap** are the reference ledgers, and **I. Open problems** closes with the decade ahead.

A Notation: abbreviations and symbols

This appendix collects, in one place, every program-defined abbreviation and every principal symbol used in GG-A11-Origin, so the body reads without external notes.

A.1 Abbreviations

This subsection collects every program-defined abbreviation used in GG-A11-Origin (and, by inheritance, in the Arisaka-GG cohort). The structure follows the canonical GG-A1-Constitution Part VIII Appendix A convention. All program-defined names are rendered in *sans-serif type* (GG-Theory, GG-Constitution, GG-6, GDOS, BI-6, OGN-5, QGL, Gi-4, Qi-4, GRIP, BFFT, etc.) so the reader can see at a glance which terms belong to the GG-Theory program proper. Standard physics abbreviations imported from the wider literature (KK, RS, QFT, TOV, etc.) are rendered in plain uppercase Roman, following the convention of the major physics journals. Mathematical objects are in roman or italic in the usual way. The third column gives the *primary link*: the paper in the Arisaka-GG series and the section where each program-defined name is first introduced in detail.

Table 22: Summary of program-defined abbreviations used in GG-A11-Origin. Program-defined names are rendered in sans serif; standard physics abbreviations in plain uppercase Roman; mathematical objects in roman/italic in the usual way. The table runs to a hundred and two entries, which is what a capstone drawing on twenty-one companions costs a reader, and the third column gives the primary link for each so that no abbreviation in the paper has to be guessed at from context.

Symbol	Meaning	Primary link
Framework name and core program objects		
GG-Theory	Grand Geometric Theory (also: Geometry-Gauge Equivalence Theory)	GG-A1-Constitution, Preface
GG-Constitution	The constitutional charter of the GG-Theory program: four axioms (AX-1–AX-4) and seven postulates (POS-1–POS-7)	GG-A1-Constitution, §2–§3
GG-6	Geometry-Gauge locking in six dimensions: the 6D bulk	GG-A2-GG6, §8 (T1-GG6)
GDOS	Geometric Dynamics of Open Systems: the boundary law implied by OGGEP	GG-A5-GDOS
BI-6	Green–Schwarz-modified Bianchi identity at 6D	GG-A3-BI6, §3
OGN-5	Occam-Gauge-Normalization 5-integer ledger $(M, N, L; J, K) = (1, 3, 5; 7, 35)$	GG-A3-BI6, §7; T6-GG6
QGL	Quadruple Gauge Locking: the four-factor bulk gauge group $\mathrm{Spin}(1,5) \times \mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$	GG-A2-GG6, §10 (T3-GG6)
Gi-4	Geometric-Invariance four-pillar structure (TGG, CCI, GFF, GRIP)	GG-A6-GRIP
Qi-4	Quantum-Information four-pillar structure (Qi-QUA, Qi-EP, Qi-CON, Qi-HAL)	GG-A7-Qi4
Four axioms (AX-1–AX-4)		
AX	Axiom (axiomatic primitive; non-negotiable)	GG-A1-Constitution, §1.5
LC	AX-1 Locality and Causality	GG-A1-Constitution, §2.2
GGEP	AX-2 Geometry–Gauge Equivalence Principle	GG-A1-Constitution, §2.3
OGGEP	AX-3 Operational/Open Geometry–Gauge Equivalence Principle (boundary observation dictionary)	GG-A1-Constitution, §2.4
MSMF	AX-4 Maximum Symmetry, Minimum Freedom (no hidden continuous knobs)	GG-A1-Constitution, §2.5

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Symbol	Meaning	Primary link
Seven postulates (POS-1–POS-7)		
POS	Postulate (admissibility filter; testable in principle)	GG-A1-Constitution, §1.5
GI	POS-1 Gauge invariance across scales (LGI / DGI / GGI)	GG-A1-Constitution, §3.3
UEP	POS-2 Unified Extremal Principle (PLA ⇔ PLT / MEPP / FEP)	GG-A1-Constitution, §3.4
AF	POS-3 Anomaly Freedom and cancellability by inflow	GG-A1-Constitution, §3.5
CP	POS-4 Closure and Positivity (CPTP-admissible open dynamics)	GG-A1-Constitution, §3.6
RG	POS-6 OGN Renormalization-Group covariance (scale covariance)	GG-A1-Constitution, §3.7
OGN	POS-6 OGN Occam Gauge Normalization (canonical integer/rational normalization)	GG-A1-Constitution, §3.8
MF	POS-7 Measurement and Falsifiability (operational contract + kill criteria)	GG-A1-Constitution, §3.9
LGI	Local Gauge Invariance (microscopic / closed-system layer of GI)	GG-A1-Constitution, §3.3
GGI	Global Gauge Invariance (macroscopic / ledger layer of GI)	GG-A1-Constitution, §3.3
Gi-4 pillars		
TGG	Total Geometric–Gauge object (Pillar I of Gi-4)	GG-A6-GRIP
CCI	Covariant Conservation Identity (Pillar II of Gi-4)	GG-A6-GRIP
GFF	Geometric Free-Energy Functional (Pillar III of Gi-4; *absorbs the legacy* EEGG *ledger*)	GG-A6-GRIP
GRIP	Gauge-Runtime Invariance Pipeline (Pillar IV of Gi-4)	GG-A6-GRIP
GEP	Geometry–Gauge Energy Principle (energetic block of GFF)	GG-A6-GRIP
CEP	Curvature–Entropy Principle (entropic block of GFF)	GG-A6-GRIP
DGI	Dynamical Gauge Invariance (initial stage of GRIP)	GG-A6-GRIP
GSSB	Geometric Spontaneous Symmetry Breaking (middle stage of GRIP)	GG-A6-GRIP
GA	Geometric Attractor (final stage of GRIP)	GG-A6-GRIP
GGA	Ground Geometric Attractor (the unique global minimum of GFF on the layer-specific boundary stratum; the cascade output of GRIP; sharper refinement of GA)	GG-A11-Origin, Part III
GRIP-In	Within-layer regime of GRIP: Lyapunov descent on a fixed Morse landscape (sustained energy injection at constant effective temperature)	GG-A11-Origin, Part XI
GRIP-Out	Between-layer regime of GRIP: transient perturbation that widens the DGI orbit and opens a new GGA basin (out-of-thermal-equilibrium shock)	GG-A11-Origin, Part XI

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Symbol	Meaning	Primary link
Qi-4 pillars		
Qi-QUA	Quantum information for QGL (Quadruple Gauge Locking) – Pillar I of Qi-4	GG-A7-Qi4
Qi-EP	Quantum information for the UEP (Unified Extremal Principle) – Pillar II of Qi-4	GG-A7-Qi4
Qi-CON	Quantum information for Conformal Invariance – Pillar III of Qi-4	GG-A7-Qi4
Qi-HAL	Quantum information for the Holographic Attractor Lattice – Pillar IV of Qi-4	GG-A7-Qi4
OH	Outer Hologram (boundary projection of bulk data; outward face of EIC)	GG-A7-Qi4
IH	Inner Hologram (inner self-modeling layer; inward face of EIC)	GG-A7-Qi4
EIC	Evolving Inner Cosmos (boundary completion of Qi-4 as the OH+IH composite)	GG-A7-Qi4
Qi-HAL acronyms		
MePMoS	Memory–Prediction–Motion Sensing	GG-A7-Qi4, Qi-HAL
NHT	Neural Holographic Tomography	GG-A7-Qi4, Qi-HAL
HAL	Holographic Attractor Lattice	GG-A7-Qi4, Qi-HAL
Q-HAL	Quadratic / Cubic HAL	GG-A7-Qi4, Qi-HAL
CDI	Cascade-depth index of this paper: how completely a substrate closes its OH–IH loop, tentative form $\mathsf{CDI} = 2S$. Not GG-A7-Qi4's $\mathsf{CDI}_{\mathrm{adm}}$	GG-A11-Origin
BFFT	Binary Fourier / Fractal Fourier Transform	GG-A7-Qi4, Qi-HAL
GDOS-internal acronyms (program-defined)		
SIP	System Instance Packet (canonical GDOS input unit)	GG-A5-GDOS
SeOS	Selfish Open System	GG-A5-GDOS
Program-defined mathematical symbols		
$\mathsf{Q_B}$	Quantum-information Bit – the bioenergetic Arisaka constant $\mathsf{Q_B} \approx 0.1555$ eV per qubit; one ATP carries two, so $2N_A\mathsf{Q_B}$ matches the ATP-hydrolysis free energy at biological temperatures	GG-A2-GG6, §15 (T8-GG6)
GU-5	The Geometric Universal Five Constants $\{c, G_N, \hbar; k_B, Q_B\}$: the five dimensional conversion factors, 3 bulk $(c, G_N, \hbar)$ + 2 boundary $(k_B, \mathsf{Q_B})$; none carries continuous freedom	GG-A4-Euclid; GG-A11-Origin, Part III §8
$\mathsf{GGA}_1, \ldots, \mathsf{GGA}_{18}$	The eighteen-layer cascade of Ground Geometric Attractors — GGA_1 = GG-6 gauge group, GGA_{10} = LUCA, GGA_{18} = the act of articulating GG-Constitution	GG-A11-Origin, Part III

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Table 22 continued from previous page

Symbol	Meaning	Primary link
Standard physics abbreviations (plain Roman, journal convention)		
Open-system / quantum-channel formalism		
CPTP	Completely Positive Trace-Preserving (channel admissibility for open evolution; AX-3/POS-4)	—
GKLS	Gorini–Kossakowski–Lindblad–Sudarshan (master equation for Markovian CPTP semigroups; POS-4, Gorini et al., 1976)	—
GNS	Gelfand–Naimark–Segal (construction)	—
NZ	Nakajima–Zwanzig (memory-kernel projection for non-Markovian open dynamics)	—
POVM	Positive Operator-Valued Measure (generalized measurement model; AX-3/POS-7)	—
Quantum and classical foundational theories		
BRST	Becchi–Rouet–Stora–Tyutin (cohomology)	—
GR	General Relativity	—
QCD	Quantum Chromodynamics	—
QED	Quantum Electrodynamics	—
QFT	Quantum Field Theory	—
QM	Quantum Mechanics	—
Standard Model and beyond		
EFT	Effective Field Theory	—
EW	Electroweak	—
GUT	Grand Unified Theory	—
SM	Standard Model of particle physics	—
SSB	Spontaneous Symmetry Breaking (closed-system; generalized by GSSB)	—
SUSY	Supersymmetry	—
Higher-dimensional constructions		
AdS	Anti–de Sitter spacetime	—
AdS/CFT	Anti–de Sitter / Conformal Field Theory correspondence	—
CFT	Conformal Field Theory	—
KK	Kaluza–Klein (mode expansion / dimensional reduction)	—
RS	Randall–Sundrum (warped extra-dimension model)	—
Quantum gravity and cosmology		
ΛCDM	Standard cosmological model with cosmological constant + cold dark matter	—
LQG	Loop Quantum Gravity	—
TOV	Tolman–Oppenheimer–Volkoff (equation)	—
Foundations of quantum mechanics		

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Symbol	Meaning	Primary link
CHSH	Clauser–Horne–Shimony–Holt (inequality)	—
EPR	Einstein–Podolsky–Rosen (paradox / argument)	—

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Symbol	Meaning	Primary link
Open-system / extremal-principle sub-acronyms		
FEP	Free Energy Principle (boundary inference avatar of UEP)	GG-A7-Qi4, Qi-EP
MEPP	Maximum Entropy Production Principle (heuristic boundary avatar of UEP)	GG-A7-Qi4, Qi-EP
PLA	Principle of Least Action (closed/bulk avatar of UEP; standard variational dynamics)	GG-A7-Qi4, Qi-EP
PLT	Principle of Least Time (operational/boundary avatar of UEP; fastest lawful path)	GG-A7-Qi4, Qi-EP

For reference, the canonical program-acronym hierarchy of GG-A1-Constitution is reproduced below.

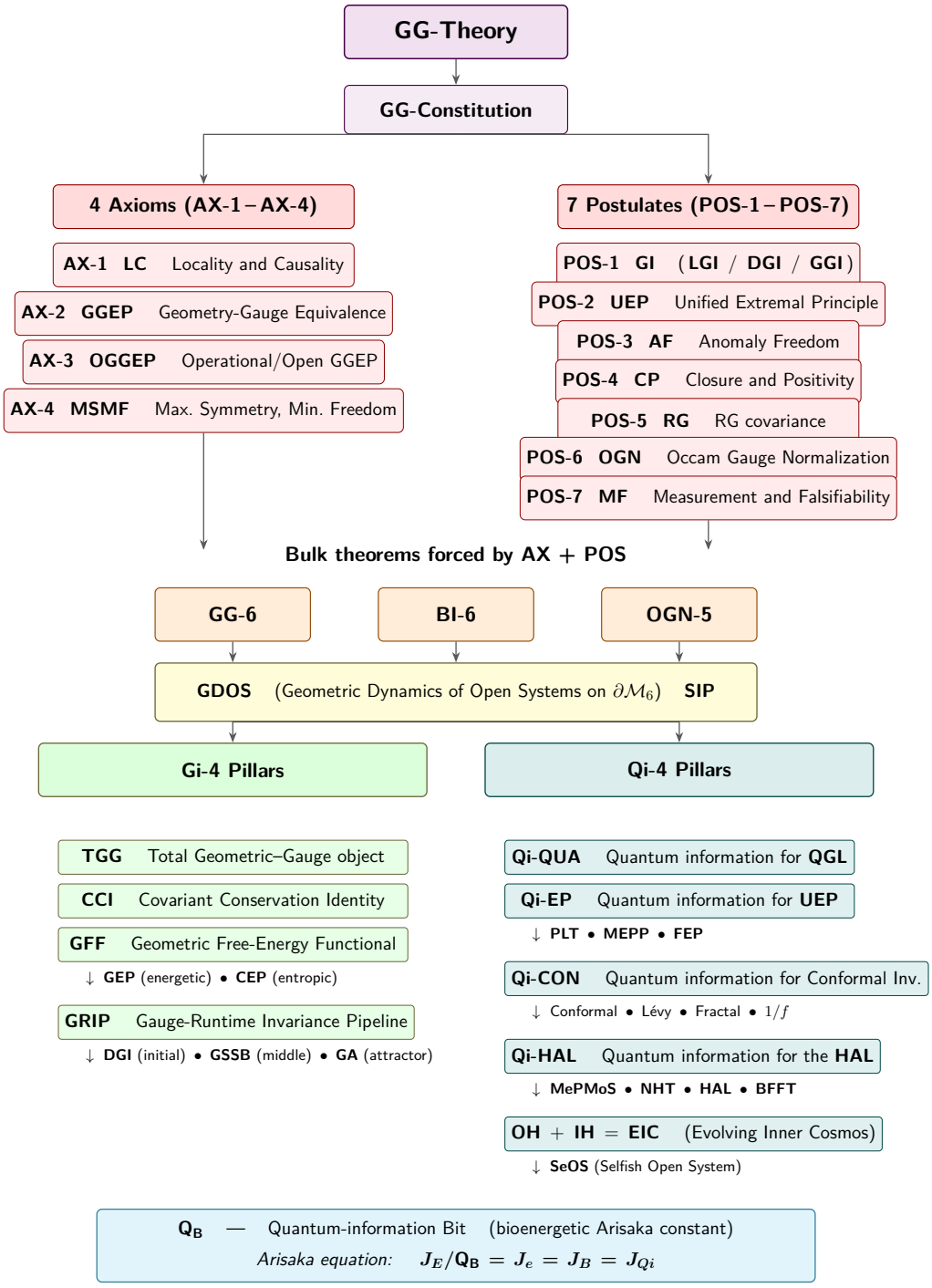


Figure 19: Hierarchy of program-defined acronyms in the GG-Theory program (reproduced from GG-A1-Constitution, Figure 10). The chart runs from the constitution at the top — the four axioms and the seven postulates — down through the bulk and boundary layers to the four pillars, so that a reader meeting an acronym in this paper can find the level it belongs to rather than only its expansion. It is reproduced unchanged from GG-A1-Constitution so that the two papers name the same hierarchy in the same picture.

The revised hierarchy. The diagram above reproduces GG-A1-Constitutionś original acronym hierarchy. The revised version used throughout the present paper is Figure 5 in Part I; what follows describes that revision, tier by tier, so that the two can be compared. Top: the framework name (GG-Theory) and its constitutional charter (GG-Constitution). Tier 2: the four axioms (AX-1–AX-4) and seven postulates (POS-1–POS-7) that together define the admissibility predicate. Tier 3: three bulk objects forced by the constitution — GG-6 (6D bulk), BI-6 (modified Bianchi identity), OGN-5 (integer ledger). Tier 4: the boundary law GDOS that the bulk projects to via OGGEP, with the input carrier SIP = $(\mathcal{M}, \text{ports}, L, \text{generator}, \text{Obs/Kill})$. Tier 5 (revised, GG-A11-Origin): GRIP is promoted to the central engine box, with the canonical chain DGI $\rightarrow$ (GFF) $\rightarrow$ GSSB $\rightarrow$ GGA shown as a horizontal flow inside the box, and the two regimes GRIP-In (within-layer Lyapunov descent) and GRIP-Out (between-layer perturbation) shown as the two parallel arrow modes along the flow; Gi-4 (TGG/CCI/GFF/GRIP) and Qi-4 (Qi-QUA/Qi-EP/Qi-CON/Qi-HAL, with OH+IH=EIC and SeOS underneath) flank GRIP as the geometric and informational pillar structures that supply, respectively, the substrate and the admissibility filter. Tier 6 (new, GG-A11-Origin): the eighteen-layer cascade of Ground Geometric Attractors $\mathsf{GGA}_1 \rightarrow \mathsf{GGA}_2 \rightarrow \ldots \rightarrow \mathsf{GGA}_{18}$, rendered as a horizontal ribbon colored from cosmological blue (the GUT closure at layer 1) through chemistry cyan (layers 4–6), life green (layers 7–13), cognition orange (layers 15–17), to articulation red (layer 18), with the bioenergetic Arisaka constant $\mathsf{Q_B}$ (the derived secondary quantity) and the Arisaka equation $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ shown below the ribbon as the four-current lock that drives the ascent.

A.2 Key symbols

Table 23 collects principal symbols and their meanings. We emphasize both bulk (GGEP/GG-6) objects and boundary operational (OGGEP/GDOS) objects.

Table 23: Key symbols. Glossary of frequently used symbols, with typical context. This table standardizes notation across the bulk (GG-6) and boundary (GDOS) layers so that later companion papers can refer to a fixed symbol ledger. Thirty-two entries, from the six-dimensional bulk manifold and the boundary stage through the integer ledger and the four locked currents to the cognitive quantities of the upper layers, each with the context it is typically read in. Fixing the ledger here is what lets the later companion papers refer to a symbol rather than redefine it.

Symbol	Meaning	Typical context
N	The OGN-5 ledger's second entry, $N = 3$. Every ledger identity is written with it	—
N_c	Color triplicity, the three colors of $\mathrm{SU}(3)_C$ — what that entry counts	—
N_g	The generation (family) count, 3. *Not* a ledger entry; fixed by GG-P2-N3	—
N_f	The quark-flavor count of a beta function, $N_f = 2N_g = 6$ at high scale	—
$\mathcal{M}_6$	6D bulk manifold (GG-6 stage)	Applications preview / GG-6 companion.
$\mathcal{M}_4$	4D operational boundary (registered observables)	OGGEP, GDOS.
$X^A = (x^\mu, r, \theta)$	Bulk coordinates: boundary x^μ, scale r, compact holonomy θ	GG-6 preview.
g_{AB}	Bulk metric on $\mathcal{M}_6$; signature implicit	GG-6.
ω	Spin connection (orthonormal-frame connection)	GGEP primitive.
A	Gauge connection one-form (Yang–Mills)	GGEP primitive.
$\mathcal{A}_{\mathrm{lock}} = \omega \oplus A$	Composite (locked) connection	AX-2, GG-6.
$\mathcal{F}_{\mathrm{lock}}$	Composite curvature ($\mathcal{R} \oplus F$)	AX-2.
$F = \mathrm{d}A + A \wedge A$	Gauge field strength 2-form	AX-2.
$\mathcal{D}$	Operational dictionary (bulk→boundary map)	AX-3.
$\mathcal{H}$	Hilbert space of boundary degrees of freedom	Quantum GDOS limits.
ρ	Density operator (quantum) or density on state manifold (classical)	POS-4.
Φ_t	Evolution map/semigroup (channel)	POS-4.
$\mathcal{L}$	Generator of Φ_t (GKLS in quantum)	POS-4.
$\{\mathcal{I}_m\}$	Quantum instrument (CP maps for outcomes)	AX-3/POS-7.
$\{E_m\}$	POVM effects with $\sum_m E_m = \mathbb{I}$	AX-3.
$\mathcal{M}$	State manifold of a SIP instance	GDOS kernel.
y^A	Coordinates/state variables on $\mathcal{M}$	GDOS/UEP.
$G_{AB}(y)$	Metric on $\mathcal{M}$ (e.g. Fisher metric)	POS-2/UEP; information geometry.
F_{GFF}	GFF scalar ledger functional	POS-2; GDOS.
M^{AB}	Mobility/dissipation tensor ($\succeq 0$)	GDOS drift.

(continued)

Symbol	Meaning	Typical context
D^{AB}	Diffusion/noise tensor ($\succeq 0$)	GDOS diffusion.
u^A	Solenoidal/cycle drift term	GDOS non-gradient flow.
r	Scale/radial coordinate, $r = \ln(E_{\mathrm{GUT}}/\mu)$	POS-5 / applications.
μ	Coarse-graining (energy/resolution) scale	POS-5.
E_{GUT}	Unification/locking scale	GG-6 preview.
B_2, H_3	GS two-form and its (modified) field strength	POS-3; anomaly inflow.
GGA_n	Ground Geometric Attractor at cascade layer n ($n = 1, \ldots, 18$)	GG-A11-Origin, Part III
SIP_n	System Instance Packet at cascade layer n; supplies fields 1–3 (state manifold, ports, generator) of SIP_{n+1}	GG-A11-Origin, Parts III, V
F_n	Geometric Free-Energy Functional restricted to layer-n boundary stratum	GG-A11-Origin, Part XI
$\partial_t F_n \leq 0$	GRIP-In Lyapunov inequality (within-layer regime)	GG-A11-Origin, Part XI §T-GRIP-In
$\Delta\lambda$	Control-parameter perturbation that triggers GRIP-Out (between-layer regime)	GG-A11-Origin, Part XI §T-GRIP-Out

B Audience-specific intuition (plain English)

This appendix translates the constitution into plain English aimed at undergraduates in five audiences. It is intentionally longer than a "popular" summary: the goal is that a physics major (and nearby majors) can read Appendix C first and then return to the main text with the right mental model.

B.1 Physics (undergraduate majors)

The one-sentence picture. *GG-Theory proposes a new rulebook: forces and geometry are one composite connection in a higher-dimensional bulk (GGEP), while the bulk-to-boundary projection (OGGEP) is always on, and what we call "measurement" is only its macroscopic, record-keeping special case.*

Two layers: design vs. runtime. Think of the framework as having (i) a *bulk design layer* and (ii) a *boundary runtime layer*. The design layer (GGEP ⇒ GG-6) says that the primitive object is a connection $\omega \oplus A$; holonomy is the invariant content, so "phase" and "parallel transport" are geometric. The runtime layer (OGGEP ⇒ GDOS) says that experiments produce *records* via open interactions, so the admissible evolution law must be a positive, trace-preserving channel with a generator of GKLS type in quantum limits.

Why AX-3 matters for the measurement problem. In textbooks, unitary evolution is clean but measurement is appended by extra rules (collapse, Born rule). OGGEP does not pick an "interpretation"; it moves the issue into mathematics: a theory is incomplete until it specifies a map from its internal variables to an instrument model (POVM/instrument), an estimator, and an error model. This is how "measurement" becomes a lawful export rather than a story. Crucially, the projection itself is *always on* and observer-independent — it runs at every boundary point whether or not anyone measures — and "measurement" is only its macroscopic, record-keeping special case (Primer P1, §C.1; GG-A5-GDOS §23).

Why AX-4 and POS-6 matter for predictivity. Undergraduates quickly learn that a gauge choice or field redefinition is not physics. OGN extends that intuition: *normalization conventions* that can drift continuously should not be allowed to masquerade as tunable physics. MSMF then expresses a strong guess about nature: if a structure can be made more symmetric without spoiling consistency and observability, nature takes that route. In practice, this is a demand to replace continuous dial-freedom with discrete/topological data whenever possible.

How to read the postulates. A useful mental model is a compiler pipeline: GI defines the symmetry grammar; UEP defines the variational engine; AF filters out inconsistent quantum theories; CP keeps states physical; RG keeps results scale-robust; OGN removes convention drift; and MF forces you to say how the theory can be killed by data.

B.2 Chemistry (undergraduate majors)

The one-sentence picture. *Chemistry lives in open reactors: matter and energy flow through "ports," and dynamics can be written as "downhill with swirls" on a generalized free-energy ledger.*

In chemistry, "the system" is usually not isolated: reactants flow in, products flow out, temperature and pressure are controlled, and instruments read spectra or concentrations. GDOS treats this openness as part of the definition. A SIP is a formal way to write "what variables describe the system" (concentrations, reaction coordinates), "what symmetries/conservation laws hold" (stoichiometry, charge), and "what ports exist" (inflow/outflow, heat baths, catalysts).

UEP says that many familiar rules—like the tendency toward lower free energy at fixed temperature—are special faces of a single extremal engine. CP/positivity is the insistence that concentrations stay nonnegative and probabilities stay physical under coarse-grained dynamics. RG/scale covariance becomes the demand that your conclusions should not depend on arbitrary time-resolution or coarse-graining of intermediate reaction steps.

B.3 Life science (undergraduate majors)

The one-sentence picture. *Life is an open system that maintains itself by exchanging matter, energy, and information; stability corresponds to attractors of admissible open dynamics.*

Biology is full of "homeostatic" phenomena: perturbations are resisted, and systems return to functional regimes. In GDOS language, these are attractors of open dynamics. The important point is constitutional: to talk scientifically about life you must specify what is measured and how it would fail (MF), and you must respect physical admissibility (positivity, conservation-like invariances).

The claim is not that cells "violate physics," but that they are best described by the same open-system runtime as other nonequilibrium systems: a scalar ledger (GFF) plus admissible dynamics leads to stable attractors, and phase selection can be viewed as a generalized symmetry breaking in an open context (GSSB, in the extended derivations). This provides a disciplined way to connect biology to thermodynamics without turning it into metaphor.

B.4 Engineering (undergraduate majors)

The one-sentence picture. *Engineering is robust design under constraints; GG-Theory treats robustness, normalization discipline, and auditability as axiomatic requirements.*

Engineers know that systems that work only after fragile tuning are bad designs. MSMF/OGN formalize this intuition: if behavior depends on arbitrary continuous conventions, the model fails the constitution. RG/scale covariance is a robustness principle: performance should not collapse under changes of resolution, sampling rate, or modeling granularity. MF is familiar as verification/validation: every claim needs a test protocol and pass/fail criterion. GDOS provides a common mathematical template for controlled open systems: ports are inputs/outputs, the ledger is an objective function, and admissible dynamics enforces stability and physicality.

B.5 General audience

The one-sentence picture. *GG-Theory is a proposal for clearer scientific rules: respect cause-and-effect, unify forces with geometry, define measurement as a real physical procedure, and avoid hidden tuning knobs.*

A helpful analogy is civic: axioms are like a constitution (basic rights and limits), postulates are like laws that every policy must satisfy (consistency, fairness, auditability), and theorems are like court decisions (conclusions forced by the rules). The point is not to replace existing successful science, but to make the rules of explanation explicit so that progress becomes cumulative.

C Self-contained concept primers

This appendix is the graduate student's toolkit. Because the keystone *states* its load-bearing machinery rather than deriving it in full, the five primers below give a self-contained account of each concept the body relies on but cannot expand in place — each with definitions, an intuition, and a pointer to the companion paper that carries the proof. Read in order, they are close to the minimum needed to follow and audit Parts III–IX.

C.1 Primer P1 — The always-on GDOS/OGGEP projection

What it is. The framework's account of the relation between the inaccessible six-dimensional bulk and the four-dimensional world we register is a single law, OGGEP (AX-3), operationalized as GDOS (Geometric Dynamics of Open Systems). It states that any admissible bulk theory must furnish a lawful operational dictionary $\mathcal{D}$ from bulk data to registered boundary observables, and that the induced boundary evolution is a completely positive, trace-preserving (CPTP) channel.

The one thing to get right: the projection is always on. A century of quantum mechanics carried an unexamined ambiguity — *what is happening when no one is measuring?* The answer is that the projection happens in three layers, two of which never mention an observer:

Constitutional (always on). The dictionary $\mathcal{D}$ *exists* as a structural property of the admissible bulk theory, as primitive as the metric of general relativity is present whether or not anyone measures a distance. No observer activates it.

Dynamical (always on). The bulk-to-boundary (Kaluza–Klein overlap) projection *acts* at every point of the boundary $\mathcal{M}_4$ at every instant. It ran continuously for the thirteen-plus billion years in which the universe contained no apparatus and no mind, building nuclei, atoms, stars, and galaxies.

Operational (switches on at each Geometric Attractor). Only here does a *system* — something with a boundary, an interior, and a trackable evolution — appear, and it is supplied by geometry, not by observation: wherever the GRIP cascade settles a Geometric Attractor (Primer P2), the always-on projection acts on a well-defined boundary and produces a record.

What measurement is. Measurement is then not a primitive. It is the special case of the always-on projection acting on a Geometric Attractor whose internal structure includes a macroscopic record-amplification chain (a photographic plate, a CCD, a brain). On a microscopic attractor (a hydrogen atom, a single molecule) the same projection produces a record too small to call a measurement — exactly what decoherence theory describes. Same mathematics; only the amplification differs. There is no collapse event, no Heisenberg cut, and no privileged observer: every attractor sits on the same side of the projection, receiving it, and what varies is only the size and stability of the record it can keep.

Why this matters. This is, in the framework's reading, the first statement of what "quantum mechanics" *is*: the boundary-projected description of an always-on geometric law, with the textbook "measurement postulate" demoted from an axiom of physics to a theorem about macroscopic record-keeping attractors. *Full treatment:* GG-A5-GDOS (Arisaka, 2026, A5-GDOS) §23 ("Why the Projection Is Always On"); the body states it at §20.3.

C.2 Primer P2 — The GRIP runtime engine

This primer is the operational heart of GG-A11-Origin: the single engine that runs at every cascade layer. The body states it across Parts III–VI; here it is assembled in one auditable place.

The four moves. GRIP (the Gauge-Runtime Invariance Pipeline) is one four-move logic:

1. **DGI (Dynamical Gauge Invariance)** — the unbroken gauge-equivalence substrate of the bulk, on which the informational current rides freely (the "top of the saddle ladder").
2. **Projection onto the boundary** — the always-on OGGEP/GDOS projection (Primer P1) reads the bulk content onto the four-dimensional boundary stratum.

3. **GSSB (Geometric Spontaneous Symmetry Breaking)** — the Bogomolnyi-saturating branching event that commits the projected content to one branch.
4. **GGA (Ground Geometric Attractor)** — settlement at the uniquely most stable minimum of the Geometric Free-Energy Functional GFF (Primer P3) on the layer-specific stratum.

In canonical shorthand, GRIP := DGI → (GFF) → GSSB → GGA, where GFF is the Morse landscape on which the cascade descends (substrate, not stage).

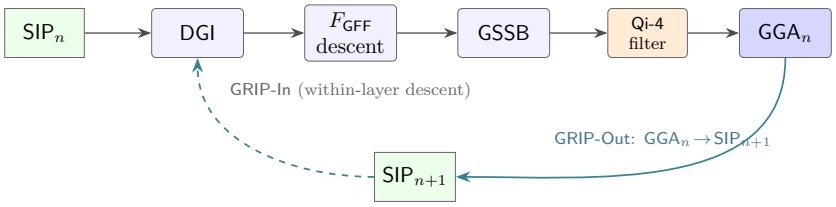


Figure 20: The GRIP runtime engine (Primer P2). The carrier SIP_n enters the four-move pipeline DGI → F_{GFF}-descent → GSSB → GGA; the Qi-4 admissibility filter selects the unique physical ground attractor from the several local minima of the landscape. GRIP-In is within-layer descent on a fixed landscape; GRIP-Out reorganizes the landscape and feeds GGA_n forward as the carrier SIP_{n+1} of the next layer — the tower recursion (dashed) that builds the eighteen-layer cascade.

GA versus GGA. A *Geometric Attractor* (GA) is any stable minimum of GFF on a stratum; a stratum may carry several. The *Ground* Geometric Attractor (GGA) is the uniquely deepest one — the global minimum, where GRIP terminates. The distinction separates persistence from permanence: a ground-state hydrogen atom, an electron, and a proton are GGAs and never decay; an excited atom, a muon, and a tau are non-ground GAs and relax toward the GGA of their stratum.

The two regimes GRIP-In/GRIP-Out

Both GRIP-In and GRIP-Out share the canonical chain above; they differ in what is held fixed.

GRIP-In (within-layer; equilibrium-within-flow). The Morse landscape F_n has fixed control parameters λ; only the state y descends. Energy flows in at constant rate; the system maintains a stationary non-equilibrium distribution. Cascade progress within this layer is gradient descent on the same landscape. The Lyapunov inequality $\partial_t F_n \leq 0$ holds throughout (GG-A11-Origin Part XI §T-GRIP-In-Lyapunov-Descent). Examples: mitochondrial chemiosmosis at body temperature; vent battery turnover at fixed ΔpH; photosynthesis at fixed solar flux. The cascade refines the GGA within the layer but cannot escape it.

GRIP-Out (between-layer; out-of-thermal-equilibrium shock). The control parameters $\lambda(t)$ themselves change rapidly, so the Morse landscape becomes time-dependent: $F_n(y, \lambda(t))$. During the perturbation, saddle points appear and disappear, basins merge and split, the DGI orbit expands. *New GGAs become accessible that were not present on the prior landscape.* This is the catastrophe-theory regime: discontinuous reorganization of the equilibrium structure under continuous perturbation of control parameters. After the perturbation, the landscape settles into a new topology with new basins (GG-A11-Origin Part XI §T-GRIP-Out-Necessity). Examples: Big Bang cooling through electroweak

scale; supernova nucleosynthesis dispersing heavy elements; Great Oxygenation Event; Cambrian Explosion; Out-of-Africa drought.

Cascade-Self-Sustenance

For $n \geq 1$, the GRIP-Out events that drive the $\mathsf{GGA}_n \to \mathsf{GGA}_{n+1}$ transition are themselves causally generated by the dynamics of layers $\leq n$. The cascade is therefore *autocatalytic* in its own forward drive (GG-A11-Origin Part XI Corollary Cascade-Self-Sustenance). The cyanobacterial photosynthesis that produces the oxygen driving eukaryogenesis is the layer-11 example; the cumulative cultural information that drives the layer-18 articulation event is the highest-layer example.

The SIP-tower recursion

GRIP does not act on a generic system; it acts on a *specific* carrier, the SIP (System Instance Packet) of Arisaka (2026, A7-Qi4) §6. In canonical form,

$$\mathsf{SIP}_n \;=\; (\mathcal{M}_n,\ \mathrm{ports}_n,\ L_n,\ \mathrm{generator}_n,\ \mathrm{Obs}_n/\mathrm{Kill}_n),$$

where fields 1–3 are the geometric carrier (state manifold, ports, generator) on which GRIP runs, and fields 4–5 are the informational/operational equipment (ledger bundle, observable and kill bundle) on which Qi-4 admissibility (below) operates. The cascade is then a *tower* of SIPs,

$$\mathsf{GGA}_n \;=\; \mathsf{GRIP}\big[\mathsf{SIP}_n\big] \quad \text{and} \quad \mathsf{SIP}_{n+1}\big|_{\text{fields 1–3}} = \; f\big(\mathsf{GGA}_n\big),$$

so layer n's output supplies the geometric carrier of layer-$(n{+}1)$ (GG-A11-Origin Part XI §T-SIP-Tower-Recursion).

Qi-4 admissibility as the GGA selector

The GFF Morse landscape generically has multiple local minima; without an admissibility filter, GRIP would terminate at the nearest local minimum on whichever basin the cascade entered. The selection of the *physical* GGA is performed by the four Qi-4 pillars jointly:

- Qi-QUA: locked-current ray constraint (rank-one inflow on $\partial\mathcal{M}_6$);
- Qi-EP: projected variational stationarity ($\delta S = 0$ on $\mathcal{M}_4$);
- Qi-CON: operational conformality window (scaling exponent within a fixed band);
- Qi-HAL: memory-architecture closure (gauge-invariant memory holonomy).

A configuration $\mathsf{GGA} \in \mathsf{GFF}_n^{-1}(\text{local min})$ is physically realizable if and only if it satisfies all four constraints simultaneously (GG-A11-Origin Part XI §T-Qi4-GGA-Admissibility). In short: GRIP supplies the dynamics; Qi-4 supplies the selection rule; SIP supplies the carrier; GGA is the output.

A worked micro-example (layer 2, the charged leptons). The layer-2 boundary stratum — the family-projector moduli combined with the Wilson–Hosotani holonomy on S^1_θ — carries a GFF landscape with *three* index-0 minima, at depths $n_e \in \{0, 1, 2\}$. Without the Qi-4 filter, GRIP would halt at whichever local minimum it entered, and "the electron mass" would be ambiguous. With Qi-4, exactly one minimum is admissible at a time, and the three are realized as three *distinct cascade applications* — the electron, the muon, the tau — three tokens of one stratum, not three coexisting minima of one run. This is the engine in miniature: GRIP supplies the dynamics, Qi-4 the selection, SIP the carrier, GGA the output.

The full canonical form, in one line

$$\mathsf{GGA}_n \;=\; \mathsf{GRIP}\big[\mathsf{SIP}_n\big] \quad \text{subject to } \mathsf{Qi\text{-}4} \text{ admissibility} \quad \text{driven by } \mathsf{GRIP\text{-}In} + \mathsf{GRIP\text{-}Out} \text{ alternation}$$

This is the operational kernel of the cascade. The eighteen-layer cascade $\mathsf{GGA}_1 \to \mathsf{GGA}_2 \to \ldots \to \mathsf{GGA}_{18}$ of GG-A11-Origin Part III is the same line of mathematics applied eighteen times. *Full quantitative theory:* GG-A6-GRIP (Arisaka, 2026, A6-GRIP) (the GRIP cascade and the four Gi-4 pillars) and GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (the SIP and the four Qi-4 pillars); the recursive-uniqueness theorem that binds the eighteen applications is Primer P5.

C.3 Primer P3 — The Geometric Free-Energy Functional and the Three-Gauge Theorem

The functional. The Geometric Free-Energy Functional GFF (of GG-A5-GDOS) is the scalar ledger on whose Morse landscape GRIP descends. It is a Lyapunov functional for the within-layer regime — $\partial_t F_n \leq 0$ along GRIP-In dynamics — so a layer relaxes monotonically toward its GGA. It is not a new postulate; it is the open-system generalization of quantities physics already used, reducing to a specific one of them in each operational limit.

The Three-Gauge Theorem. The decisive structural fact (GG-A5-GDOS) is that GFF admits exactly three boundary readings, fixed by the choice of boundary observable:

Thermodynamic (Gibbs) gauge. $J_{Qi} = 0$: GFF reduces to the Gibbs free energy of equilibrium thermodynamics.

Variational (Friston) gauge. $J_{Qi} \neq 0$ with a Markov blanket: GFF reduces to the variational free energy of active inference.

Action gauge. The detector limit: GFF reduces to the GG-6 gauge-field action.

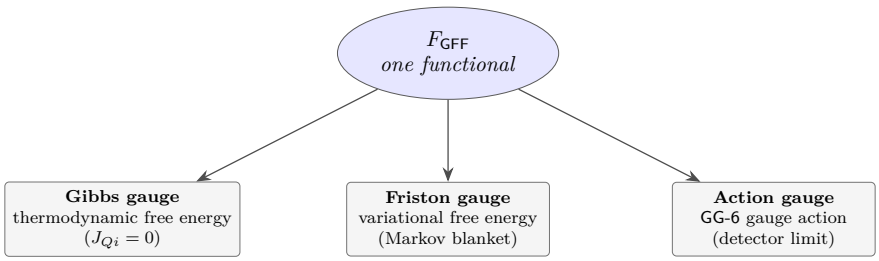


Figure 21: The Three-Gauge Theorem (Primer P3). One Geometric Free-Energy Functional F_{GFF}, read through three choices of boundary observable, reproduces Gibbs's thermodynamic free energy, Friston's variational free energy, and the GG-6 gauge action — so "free energy" named the same geometric object in thermodynamics and in neuroscience all along.

For a century and a half, thermodynamicists and neuroscientists used the phrase "free energy" without knowing why one term named such different things. The answer is that Gibbs and Friston were reading one

geometric object through two windows; the GG-6 action is the third. *Full treatment:* GG-A5-GDOS (Arisaka, 2026, A5-GDOS) T-GDOS-1–T-GDOS-11; the body states the Three-Gauge Theorem in Part XIII.

C.4 Primer P4 — The confidence triage

The honesty instrument of GG-A11-Origin is a five-class confidence triage applied to every cascade layer. Because the subject matter reaches into chemistry, biology, and mind, the framework's only defense against the charge of overreach is that each layer's confidence is stated truthfully, and identically, wherever it appears. The five classes are:

Derived. The result follows from the constitutional inputs and the upstream theorems with no layer-specific assumption, and the whole chain is closed in the published record — a closed-form expression, a prediction, a measured value, and a Pull, in the manner of GG-A9-SM/GG-A10-Cosmos.

Anchor-Derived (derivation-deferred). The empirical anchor is quantitatively closed in the published literature and the cascade reproduces it, but the from-geometry derivation is developed in a companion paper still in preparation (GG-A13-Life, for the three biology rows that hold this tag). The anchor is done; the derivation is deferred.

Conditional. The cascade machinery commits to a specific GGA, and the upstream theorems suffice to select it *except* for a single, explicitly named structural lemma (tracked in the promotion roadmap, Appendix H).

Asserted. The result is reported as compatible with the upstream apparatus and forced in qualitative structure, but its codebook-standard derivation is not yet in hand — it is the forward program of GG-A12-Chemistry–GG-A14-Mind.

Existence-Demonstrated. The result's instance is exhibited rather than predicted (the Layer-18 articulation: a universe with no articulators would have no paper in which to falsify it).

The single rule. A claim's status is the same in the abstract, the executive summary, the body, and this appendix — always. The per-layer assignment is fixed once, in the canonical confidence table of Part IV, and every dependent count (the of-18 headcount, the promotion roadmap, the Top 10 Falsifiers classification) is recomputed from that one table. The current headcount is three **Derived**, three **Anchor-Derived**, seven **Conditional**, four **Asserted**, and one **Existence-Demonstrated**. This is not a presentational nicety: it is what lets a referee audit an extraordinary claim line by line.

C.5 Primer P5 — The recursive-uniqueness theorem in capsule form

GG-A11-Origin's one genuinely new result is the recursive-uniqueness theorem (T-Origin, Part XI). In capsule:

Hypotheses. The GG-Constitution of GG-A1-Constitution (four axioms LC/GGEP/OGGEP/MSMF and seven postulates), the GU-5/OGN-5 inputs, the GRIP cascade engine (Primer P2), and the Qi-4 admissibility filter.

Conclusion. At each cascade layer the GRIP cascade specializing to the layer-specific boundary stratum selects a *unique* most-stable Geometric Attractor; the eighteen layers are bound into one structure by the same theorem applied eighteen times; and the cascade closes self-referentially at Layer 18, where intelligent observers articulate the very constitution that produced them. Cosmos, life, and mind are three boundary readings of this one recursive theorem.

What would falsify it. The theorem's empirical content is the Top 10 Falsifiers (Part IV); any one of them failing decisively in the coming decade kills the program. The theorem is also vulnerable structurally: a demonstration that any layer's GGA is *not* unique — two admissible ground states on one stratum — would break the recursion. *Full statement and proof:* GG-A11-Origin Part XI.

D Mathematical scaffolding for the Four Axioms (AX-1–AX-4): worked elaborations *from* each axiom

This appendix expands the mathematical content behind the four axioms. The main text states each axiom as a constitution. Here we supply derivations and standard equivalences to conventional frameworks.

D.1 AX-1 (LC): locality and causality as an operational constraint

D.1.1 Microcausality in relativistic quantum field theory

In axiomatic QFT, locality/causality is commonly encoded as *microcausality* (Haag, 1992; Streater & Wightman, 1964): for local Heisenberg operators $\mathcal{O}(x)$ and $\mathcal{O}'(y)$,

$$[\mathcal{O}(x), \mathcal{O}'(y)]_{\mp} = 0, \qquad (x-y)^2 < 0, \tag{94}$$

where $[\cdot,\cdot]_{\mp}$ is a commutator/anticommutator for bosons/fermions and $(x-y)^2 < 0$ denotes spacelike separation. Equation (94) is the sharp mathematical statement that spacelike-separated operations cannot influence each other.

A complementary viewpoint uses retarded Green functions. For a relativistic field ϕ with source J,

$$(\Box + m^2)\phi(x) = J(x), \tag{95}$$

the response is

$$\phi(x) = \int d^4y\, G_{\mathrm{ret}}(x-y) J(y), \tag{96}$$

and causality is enforced by

$$G_{\mathrm{ret}}(x-y) = 0 \quad \text{for } x^0 < y^0. \tag{97}$$

In interacting QFT, the analog statement is that commutators vanish outside the light cone, matching the microcausality condition.

D.1.2 No-signaling for open-system maps

On the boundary, GG-Theory treats dynamics and measurement as open-system processes, i.e. as CPTP maps Φ on density operators (Kraus, 1971, 1983; Nielsen & Chuang, 2010; Stinespring, 1955). For a bipartite system AB, "no superluminal signaling" is encoded as: local operations on A cannot change the reduced state on B without communication. If Φ_A is a CPTP map acting only on A,

$$\rho_{AB} \mapsto (\Phi_A \otimes \mathrm{id}_B)(\rho_{AB}), \tag{98}$$

then the marginal on B obeys

$$\mathrm{Tr}_A[(\Phi_A \otimes \mathrm{id}_B)(\rho_{AB})] = \mathrm{Tr}_A(\rho_{AB}). \tag{99}$$

Equation (99) follows from trace preservation and is the operational expression of locality in quantum information language.

D.1.3 Why LC is an axiom (not a derived theorem) in GG-Theory

One can *derive* the microcausality condition in specific models, but GG-Theory treats LC as axiomatic because:

1. Open-system modeling introduces coarse-graining and effective kernels where acausal artifacts can appear if one is not careful (e.g. non-Markovian memory kernels).
2. In cross-domain applications (chemistry/biology), one can easily write "models" that fit data but violate causal structure (e.g. predictors that leak future information). LC forbids such models constitutionally.

Thus AX-1 is a cross-disciplinary admissibility filter: *no explanation is allowed to work by smuggling in acausal influence.*

D.2 AX-2 (GGEP): geometry–gauge equivalence as connection data

D.2.1 Gauge theory as geometry: principal bundles

A modern way to express gauge theory is through principal bundles (Kobayashi & Nomizu, 1963; Nakahara, 2003). Let $P(M, G)$ be a principal G-bundle over a base manifold M. A gauge field is a connection one-form A on P, and its curvature is

$$F = dA + A \wedge A. \tag{100}$$

A gauge transformation is a bundle automorphism that acts vertically; on a local section, it induces

$$A \mapsto A^g = g^{-1}Ag + g^{-1}dg. \tag{101}$$

In gravity, the analogous object is the spin connection ω on the frame bundle, with curvature (Riemann two-form)

$$\mathcal{R} = d\omega + \omega \wedge \omega. \tag{102}$$

The structural similarity between (100) and the Riemann curvature is the mathematical seed of "interaction as geometry" (Weyl's early gauge viewpoint (Weyl, 1918) and later developments).

D.2.2 Composite locked connection

GGEP elevates a *composite* connection as primitive:

$$\mathcal{A}_{\text{lock}} \equiv \omega \oplus A, \qquad \mathcal{F}_{\text{lock}} \equiv \mathcal{R} \oplus F. \tag{103}$$

The claim is not just that both are "connections," but that admissible theories must *lock* them: geometric and gauge data cannot be specified independently. In practical model-building (GG-6), the lock is implemented by anomaly-inflow constraints and discrete normalization rules (POS-3 and POS-6), which select a restricted set of allowed composite bundles.

D.2.3 Geometric origin of the gauge phase — and the calibrated slogan

The Aharonov–Bohm and Berry phase phenomena show that the phases of charged matter are controlled by holonomy (Aharonov & Bohm, 1959; Berry, 1984):

$$\psi \mapsto \exp\left(i \oint_\gamma A\right) \psi. \tag{104}$$

GGEP generalizes the viewpoint for the gauge sector: the phase of charged matter is, at a deep level, the geometry of parallel transport in the composite bundle determined by $\mathcal{A}_{\text{lock}}$ — a real angle on a real fiber, with i its rotation generator. This supports the slogan "geometrization of quantum physics," with one calibration that strengthens it rather than hedging it: parallel transport supplies a complex structure only where charge lives, because a fiber rotation can only complexify what it moves. The complex structure of the quantum state space itself — which a strictly neutral field needs as much as a charged one — is not a holonomy; in the quasi-free regime it is derived instead from causal order and operational positivity, as the polar phase of the time-translation generator, and it coincides with the fiber's rotation generator on every charged sector precisely under the particle–antiparticle pairing. Two shared real sources — one circle, one causal order — thus yield the single universal i that experiment now demands, and the complex-number question, posed most sharply by Penrose, receives its calibrated two-part answer in the dedicated treatment of Arisaka (2026, A8-QM). The geometrization slogan survives intact where it was earned, and the summit gains a storey: the bulk is real not only in its geometry but, within the derived regime, in its number system.

D.3 AX-3 (OGGEP): operational bulk→boundary dictionary

The conceptual reading — that this projection is always on and observer-independent, with measurement as only its macroscopic special case — is given once in Primer P1 (§C.1); the present subsection supplies only the instrument/CPTP formalism.

D.3.1 Measurement as a quantum instrument

Operationally, a measurement is not only a POVM; it is an *instrument*: a set of CP maps $\{\mathcal{I}_m\}$ indexed by outcomes m such that

$$\sum_m \mathcal{I}_m \text{ is CPTP.} \tag{105}$$

Given an input state ρ, outcome probabilities and post-measurement states are

$$p(m) = \mathrm{Tr}[\mathcal{I}_m(\rho)], \qquad \rho_m = \frac{\mathcal{I}_m(\rho)}{p(m)}. \tag{106}$$

Every instrument admits a Stinespring dilation: it can be represented as unitary evolution on a larger space followed by a projective readout (Nielsen & Chuang, 2010; Stinespring, 1955). This is the precise sense in which "measurement is an open-system process."

D.3.2 OGGEP as a dictionary map

Let $\mathcal{T}_{\text{Bulk}}$ denote the space of bulk theoretical objects (fields, connections, states). Let $\mathcal{O}_{\text{Bdy}}$ denote the space of boundary operational objects (instruments, records, estimators). OGGEP posits a map

$$\mathcal{D} : \mathcal{T}_{\text{Bulk}} \to \mathcal{O}_{\text{Bdy}}, \qquad \text{"bulk"} \mapsto \text{"what an instrument can register."} \tag{107}$$

In AdS/CFT, a prototype is the relation between bulk fields $\phi(r,x)$ and boundary operators $\mathcal{O}(x)$ (Gubser, Klebanov, & Polyakov, 1998; Maldacena, 1997; Witten, 1998): schematically,

$$\phi(r,x) \underset{r\to\infty}{\sim} r^{\Delta-d}\phi_0(x), \qquad Z_{\text{Bulk}}[\phi_0] = \Big\langle \exp\int d^d x\, \phi_0(x)\mathcal{O}(x)\Big\rangle_{\text{Bdy}}. \tag{108}$$

OGGEP generalizes the target space: the dictionary must map to *operational measurement objects*, not only correlators.

D.3.3 Boundary records and the operational Born assignment

Let $\mathfrak{B}$ denote the sigma-algebra of boundary-record events (detector clicks, time stamps, counts, etc.). OGGEP demands a map

$$\mathcal{D}: \text{ (bulk fields/configurations) } \longrightarrow \text{ (boundary operational predictions)}, \tag{109}$$

such that for any instrument protocol $\mathcal{P}$ there is a well-defined probability assignment

$$\mathbb{P}(i|\mathcal{P}) \;=\; \mathrm{Tr}(\rho\, E_i) \qquad \text{with} \qquad \{E_i\} \text{ derived from } \mathcal{D}(\text{Bulk},\mathcal{P}). \tag{110}$$

The novelty is constitutional: the existence of $\mathcal{D}$ is an axiom, not a derived convenience.

D.4 AX-4 (MSMF): maximal symmetry with minimal continuous freedom

D.4.1 Naturalness and symmetry

In mainstream QFT, naturalness arguments connect small parameters to enhanced symmetry (THooft, 1980). MSMF strengthens this into a selection rule: among candidate model spaces that satisfy AX-1–AX-3 and POS-1–POS-7, Nature realizes those with maximal symmetry (largest admissible invariance group) and minimal continuous freedom.

D.4.2 Rescaling ambiguity and the role of OGN

A simple example shows why MSMF motivates OGN. For a $U(1)$ gauge theory, the covariant derivative can be written as

$$D_\mu = \partial_\mu + igqA_\mu. \tag{111}$$

Under a simultaneous rescaling

$$A_\mu \to \lambda A_\mu, \qquad g \to g/\lambda, \tag{112}$$

physics is unchanged provided charges are rescaled accordingly. Thus a continuous "normalization dial" exists unless we fix a charge lattice convention. OGN fixes this dial by demanding a minimal integer/rational basis for charges and a canonical measure for compact cycles. MSMF then forbids leaving λ as a free continuous parameter.

MSMF can be formalized as a constrained optimization over theory space. Let $\mathfrak{T}$ denote a class of candidate bulk+dictionary packages. Define:

- $\mathrm{Sym}(T)$ = the symmetry group of theory T (or a suitable measure such as $\dim \mathrm{Sym}(T)$);
- $\mathrm{DoF}(T)$ = the number of continuous free parameters not fixed by topology/normalization;
- $\mathrm{Fit}(T;D)$ = an empirical fit score to data D (likelihood, χ^2, etc.).

MSMF is the meta-principle that admissible theories should maximize symmetry and minimize freedom subject to viability and fit:

$$T^\star \in \arg\max_{T\in\mathfrak{T}} \Big(\dim \mathrm{Sym}(T) - \lambda\, \mathrm{DoF}(T) \Big) \quad \text{subject to postulate admissibility and empirical constraints.} \tag{113}$$

The coefficient λ is not a tunable "physics parameter" but a bookkeeping device to express the two axiomatic goals. The key point is that *continuous freedom is treated as suspicious unless protected by symmetry* (Akaike, 1974; Rissanen, 1978; THooft, 1980). The fit/empirical term enters only as a *viability gate* — a candidate already excluded by data is inadmissible — not as a continuous objective traded against the parameter count; the selection among admissible theories is by symmetry and parameter-freedom alone, so it introduces no fitted freedom and is consistent with the zero-free-parameter claim.

MSMF can be expressed as a constraint on model complexity. Let Θ be the continuous parameter space of a candidate model (couplings, moduli, normalization constants, etc.). Define the *knob count* N_{free} as the dimension of Θ after quotienting by gauge/basis redundancies:

$$N_{\text{free}} \;\equiv\; \dim(\Theta/\!\sim_{\text{gauge}}). \tag{114}$$

MSMF demands that admissible theories minimize N_{free} subject to the required symmetries and consistency postulates. This is stronger than standard naturalness (THooft, 1980) because it is imposed constitutionally, not used as heuristic guidance.

Let $\mathrm{Sym}(\mathcal{T})$ denote the symmetry group of a theory (including spacetime and internal symmetries). MSMF can also be read as a variational principle on theory space:

$$\text{choose } \mathcal{T} \text{ to maximize } \dim \mathrm{Sym}(\mathcal{T}) \text{ while minimizing } N_{\text{free}}(\mathcal{T}). \tag{115}$$

In practice, GG-6 and OGN implement this by forcing integer-ledger normalizations and eliminating continuous rescaling freedom. The philosophical point is modest but powerful: *symmetry is a source of determinism* because it removes arbitrary choices.

D.5 Worked derivation: LC + CPTP ⇒ GKLS generator (sketch)

A first-year graduate student can read the full GKLS theorem in standard texts, but the core idea is short. Assume a one-parameter family of maps $\{\Phi_t\}_{t\geq 0}$ on density operators with:

(i) semigroup property $\Phi_{t+s} = \Phi_t \circ \Phi_s$, (ii) $\Phi_0 = \mathrm{id}$, (iii) complete positivity and trace preservation (CPTP), (iv) mild continuity in t (so a generator exists).

Then there exists a (bounded, in finite dimension) generator $\mathcal{L}$ such that

$$\Phi_t = e^{t\mathcal{L}}, \qquad \dot\rho = \mathcal{L}(\rho),$$

and $\mathcal{L}$ must take the Lindblad/GKLS form

$$\mathcal{L}(\rho) = -\mathrm{i}[H,\rho] + \sum_k \left(L_k \rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\} \right).$$

In the GG-Constitution, the point of placing this in the appendix is conceptual: once we accept AX-1 (LC for operational evolution) and POS-4 (CP for physicality), the structure of open-system evolution is *forced*. The "measurement problem" is therefore shifted from philosophy to engineering: choose the instrument (Kraus operators / POVM), and the update rule is fixed by the admissible channel class.

E Mathematical scaffolding for the Seven Postulates (POS-1–POS-7): worked elaborations *from* each postulate

E.1 From AX-1 (Locality and Causality) to microcausality and retarded evolution

In relativistic QFT, locality is encoded by microcausality:

$$[\mathcal{O}(x), \mathcal{O}(y)] = 0, \qquad (x-y)^2 < 0. \tag{116}$$

Operationally, causality is encoded by retarded response and by requiring open evolution to be a forward-time semigroup.

E.2 AX-2 (GGEP): composite connection and curvature

A gauge field is a connection A with curvature $F = \mathrm{d}A + A \wedge A$. Gravity can be written similarly in a connection formalism. GGEP elevates the composite connection $\mathcal{A} = \omega \oplus A$ as the primary object, whose curvature $\mathcal{F} = \mathrm{d}\mathcal{A} + \mathcal{A} \wedge \mathcal{A}$ contains both R and F and, in locked phases, mixed terms.

E.3 AX-3 (OGGEP): measurement as an instrument and emergence of GKLS form

The conceptual reading — that this projection is always on and observer-independent, with measurement as only its macroscopic special case — is given once in Primer P1 (§C.1); the present subsection supplies only the instrument/CPTP formalism.

A measurement is an instrument $\{\mathcal{I}_m\}$, a collection of CP maps whose sum is trace-preserving. Coarse-grained intervention sequences generate CPTP semigroups whose generators are of GKLS form:

$$\dot{\rho} = \mathcal{L}(\rho) = -\mathrm{i}[H, \rho] + \sum_k \left(L_k \rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\} \right). \tag{117}$$

E.4 AX-4 (MSMF) and POS-6 (OGN): ordering theories and eliminating basis drift

Implement MSMF via a lexicographic ordering: maximize symmetry, then minimize continuous freedom. POS-OGN fixes residual normalization freedom (especially Abelian factors) by minimal-integer charge assignments.

E.5 POS-2 (UEP): least action and free-energy descent via large deviations

For small-noise processes, path probabilities obey $\mathbb{P}[y] \asymp \exp[-I[y]/\varepsilon]$. Most-likely paths extremize I, yielding PLA-type statements. In gradient-flow limits, the same structure yields monotone descent of a free-energy ledger (FEP).

E.6 POS-1 (GI) in generator language: LGI, DGI, GGI

Dynamical gauge invariance is equivariance of the generator:

$$\Phi_t \circ U(g) = U(g) \circ \Phi_t \ \forall t \geq 0 \quad \Longleftrightarrow \quad \mathcal{L} \circ U(g) = U(g) \circ \mathcal{L}. \tag{118}$$

Stationary sets decompose into group orbits, providing the seed for GSSB.

E.7 Interplay of DGI and GSSB: kernel symmetry vs attractor symmetry

Let $\mathrm{Sym}(\mathcal{L})$ denote generator symmetries and $\mathrm{Stab}(a)$ the stabilizer of an attractor a. A GSSB event corresponds to $\mathrm{Stab}(a) \subsetneq \mathrm{Sym}(\mathcal{L})$.

E.8 POS-3 (AF): anomaly inflow and GS-modified Bianchi identities (sketch)

Anomalies are summarized by an anomaly polynomial I_{2n+2}. Inflow introduces bulk CS/GS terms so that their variation cancels boundary anomalies. A minimal GS sector has $H = \mathrm{d}B + \omega_3$ with modified Bianchi identity $\mathrm{d}H = X_4(F, R)$.

E.9 POS-5 (RG): commutation of coarse-graining with the operational dictionary

POS-RG demands that the operational dictionary $\mathcal{D}$ commute with coarse-graining:

$$\mathcal{D} \circ \mathrm{RG}_\ell = \mathrm{RG}_\ell \circ \mathcal{D}. \tag{119}$$

E.10 POS-7 (MF): registered observables and kill criteria

A GG-Theory prediction is a contract (O, π, K): observable, protocol, and falsification rule.

E.11 Worked examples

Example 1: two-state open system. For a two-state Markov chain with rates $k_{12}, k_{21} \geq 0$, relative entropy to the stationary distribution is a Lyapunov function with $\mathrm{d}F/\mathrm{d}t \leq 0$.

Example 2: qubit dephasing. A GKLS generator with $L = \sqrt{\gamma}\,\sigma_z$ yields dephasing while preserving positivity and trace.

Example 3: reaction network with ports (conceptual). A chemostatted reaction network is a GDOS instance on concentration space with Gibbs free energy ledger and port source terms.

Let $U(g)$ be a unitary representation of a gauge transformation $g \in G$ acting on boundary states by $\rho \mapsto U\rho U^\dagger$. DGI requires the open-system generator $\mathcal{L}$ to satisfy

$$\mathcal{L}(U\rho U^\dagger) = U\,\mathcal{L}(\rho)\,U^\dagger. \tag{120}$$

For GKSL form $\mathcal{L}(\rho) = -i[H, \rho] + \sum_k (L_k \rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\})$, a sufficient condition is covariance of the operators:

$$UHU^\dagger = H, \qquad UL_kU^\dagger = \sum_j v_{kj}(g)\,L_j, \tag{121}$$

where $v(g)$ is a (possibly reducible) representation mixing jump operators. Eq. (120) is the open-system analog of Ward identities (Ward, 1950; Yang and Mills, 1954).

A clean bridge between closed and open extremal principles uses *path probabilities*. For a diffusion process X_t with drift b and noise strength σ, the probability of a path is weighted by an Onsager–Machlup functional (Onsager & Machlup, 1953):

$$\mathbb{P}[X_{0:T}] \propto \exp\Big(-S_{\mathrm{OM}}[X]\Big), \qquad S_{\mathrm{OM}}[X] = \int_0^T dt\, \frac{1}{2\sigma^2}\|\dot{X} - b(X)\|^2 + \cdots . \tag{122}$$

The most probable path minimizes S_{OM}, a least-action principle for open stochastic dynamics.

At the level of distributions, many open dynamics can be written as gradient flow of a free-energy-like functional in a metric on probability space (information geometry) (Amari, 1998; Cover & Thomas, 2006). A canonical example is the Fokker–Planck equation

$$\partial_t \rho = \nabla \cdot (\rho \nabla \Phi + \nabla \rho)\,, \tag{123}$$

which decreases the functional

$$\mathcal{F}[\rho] = \int dx\, \rho(x)\big(\Phi(x) + \ln \rho(x)\big), \tag{124}$$

and can be interpreted as KL divergence to equilibrium:

$$\mathcal{F}[\rho] - \mathcal{F}[\rho_{\mathrm{eq}}] = D_{\mathrm{KL}}(\rho\|\rho_{\mathrm{eq}}) \geq 0 \quad \text{with} \quad D_{\mathrm{KL}}(\rho\|\pi) = \int dx\, \rho \ln \frac{\rho}{\pi}. \tag{125}$$

This identity makes precise why "free energy" and "information distance" are two faces of the same extremal engine (Kullback & Leibler, 1951; Shannon, 1948).

Quantum anomalies arise when a classical gauge symmetry fails at the quantum level; the gauge variation of the effective action is nonzero (Adler, 1969; Bardeen, 1969). In modern language, anomalies are encoded by an anomaly polynomial I_{d+2} in d dimensions, with descent equations $I_{d+2} = dI_{d+1}$ and $\delta I_{d+1} = dI_d$. Inflow cancellation introduces a bulk Chern–Simons-like term whose variation cancels the boundary anomaly (Callan and Harvey, 1985; Green and Schwarz, 1984). In GG-6, this is implemented by a two-form field B_2 and a modified Bianchi identity for H_3 (BI-6), whose coefficients are fixed by anomaly matching and minimality.

Complete positivity is stronger than positivity: Φ must remain positive even when tensored with identity on an arbitrary ancilla. Stinespring's theorem shows that any CP map arises from unitary evolution on a larger space followed by partial trace (Stinespring, 1955):

$$\Phi(\rho) = \mathrm{Tr}_E\left[U\,(\rho \otimes \sigma_E)\,U^\dagger\right]. \tag{126}$$

This provides a precise sense in which boundary openness can be fundamental while remaining compatible with bulk unitarity.

Let RG_s denote coarse-graining from scale μ to $\mu' = \mu e^{-s}$. POS-5 demands

$$\mathcal{D} \circ \mathsf{RG}_s = \mathsf{RG}_s \circ \mathcal{D}, \tag{127}$$

so that operational predictions are stable under changes of resolution. In holographic RG, the radial coordinate r plays the role of s, and bulk equations implement RG flow (de Haro, Skenderis, & Solodukhin, 2001; Wilson, 1971).

A simple illustration is a $U(1)$ gauge factor: rescaling the generator $Q \to \alpha Q$ and coupling $g \to g/\alpha$ leaves local physics invariant, but changes the *apparent* charge assignments. OGN forbids treating such rescalings as free continuous choices: admissible theories must fix a canonical lattice of charges (minimal integers)

consistent with topology/holonomy (Dirac, 1931; Georgi and Glashow, 1974).

MF can be expressed as a triple:

$$\text{Claim} \equiv (\text{observable } \mathcal{O},\ \text{protocol } \Pi,\ \text{falsifier } \mathcal{K}), \tag{128}$$

where Π is an explicit experimental/observational procedure and $\mathcal{K}$ is a pre-declared kill criterion (a decision rule) (Neyman & Pearson, 1933; Popper, 1959). This turns philosophical falsifiability into a reproducible audit mechanism.

In closed systems, local gauge invariance implies conserved currents and Ward identities (Weinberg, 1995; Yang and Mills, 1954). For open systems, the analog is that the *generator* of dynamics must be covariant. For a GKSL generator $\mathcal{L}$ and a unitary representation $U(g)$ of a gauge group element g on $\mathcal{H}$, DGI requires

$$\mathcal{L}\big(U(g)\rho U(g)^\dagger\big) \;=\; U(g)\,\mathcal{L}(\rho)\,U(g)^\dagger. \tag{129}$$

Equation (129) is the precise sense in which open-system dynamics respects gauge redundancy: changing the gauge/basis does not change physical predictions.

A unifying bridge between least action and thermodynamic extremals appears in stochastic dynamics. For a Langevin process $dy^A = b^A(y)\,dt + \sqrt{2D}^{\,A}{}_B\,dW_t^B$, path probabilities concentrate (in a small-noise limit) on trajectories that minimize an action functional. In one common normalization the Onsager–Machlup functional is (Freidlin & Wentzell, 1998; Onsager & Machlup, 1953):

$$\mathcal{S}_{\mathrm{OM}}[y(\cdot)] = \frac{1}{4}\int_{t_0}^{t_1} dt\,\big(\dot{y}^A - b^A(y)\big)\,(D^{-1})_{AB}\,\big(\dot{y}^B - b^B(y)\big)\;+\;\cdots. \tag{130}$$

UEP asserts that there exists a single extremal principle whose bulk form is PLA and whose boundary open-system manifestation is an extremal of $\mathcal{S}_{\mathrm{OM}}$ or a free-energy-like functional (MEPP/FEP), connected by the operational dictionary.

Information and thermodynamic cost. In open systems that perform inference or maintain records, information processing has thermodynamic consequences. A canonical result is Landauer's principle: erasing one bit of information requires at least $k_B T \ln 2$ of dissipated heat in an isothermal setting (Landauer, 1961). In the GG-Theory viewpoint, such bounds are not "engineering details" but constraints on admissible dynamics: they belong naturally in the UEP/GFF ledger language.

Quantum anomalies are violations of classical gauge symmetry due to the regularization of the path integral (Adler, 1969; Bardeen, 1969; Bell and Jackiw, 1969). In even-dimensional bulk theories, anomalies can be encoded in an anomaly polynomial I_{d+2} and its descent forms (Alvarez-Gaumé and Witten, 1984). The Green–Schwarz mechanism cancels boundary anomalies by bulk inflow. A schematic form is:

$$dH_3 = X_4, \qquad H_3 = dB_2 + \omega_3, \tag{131}$$

where X_4 is built from characteristic classes (e.g. $\mathrm{tr}\,R\wedge R$, $\mathrm{tr}\,F\wedge F$). POS-3 declares: an admissible theory must satisfy anomaly cancellation, either directly or by inflow, with fixed coefficients (no tuning).

For a quantum Markov semigroup, complete positivity and trace preservation constrain the generator to GKSL form (Breuer & Petruccione, 2002; Gorini, Kossakowski, & Sudarshan, 1976; Lindblad, 1976). A compact way to see positivity constraints is to express a channel in Kraus form:

$$\Phi(\rho) = \sum_\alpha K_\alpha \rho K_\alpha^\dagger, \qquad \sum_\alpha K_\alpha^\dagger K_\alpha = \mathbb{I}. \tag{132}$$

POS-4 elevates this to an admissibility requirement: if a model's evolution cannot be written in a positivity-preserving form, it is rejected.

RG transformations coarse-grain degrees of freedom and describe how effective parameters flow with scale (Wilson & Kogut, 1974). POS-5 adds a new axiomatic requirement:

$$\mathcal{D} \circ \mathsf{RG} \;=\; \mathsf{RG} \circ \mathcal{D}, \tag{133}$$

meaning that "zooming out" should not change the meaning of observables. In holographic language, r is a geometric representation of scale, so that bulk radial evolution corresponds to RG flow (Maldacena, 1997; Witten, 1998).

Abelian sectors admit continuous rescalings: $A \to \lambda A$ can be absorbed by $q \to q/\lambda$ in simple settings. OGN forbids leaving this freedom unfixed. Instead, select a normalization in which charges are minimal integers and the holonomy circle has canonical period 2π. This resembles the role of quantization conditions (Dirac quantization) and removes unphysical basis drift.

MF requires that every theorem is accompanied by: (i) an observable O and measurement protocol $\mathcal{P}$, (ii) a quantitative prediction $P_\theta(O|\mathcal{P})$ (possibly parameter-free), and (iii) a kill criterion. A simple statistical kill criterion is:

$$\text{reject } \mathcal{T} \text{ if } \quad p\text{-value}(\text{data}|\mathcal{T}) < \alpha \qquad (\text{predeclared significance } \alpha). \tag{134}$$

The point is not the particular statistic, but the *axiomatic demand* that falsifiers are declared up front (Popper, 1959).

E.11.1 LGI: standard local gauge invariance (closed systems)

LGI is the familiar redundancy of microscopic field theories: fields transform as $\psi \to g\psi$ and $A \to A^g$ as in (101), and physical observables are gauge invariant. Ward identities and conserved currents follow from Noether's theorem (Noether, 1918).

E.11.2 DGI: gauge covariance of open-system generators

For open quantum systems, the primitive object is a generator $\mathcal{L}$ of a CPTP semigroup $\Phi_t = e^{t\mathcal{L}}$ (Gorini, Kossakowski, & Sudarshan, 1976; Lindblad, 1976). DGI demands *covariance*: for a unitary representation $U(g)$ of the gauge group on the system Hilbert space,

$$\mathcal{L}\big(U(g)\rho U(g)^\dagger\big) = U(g)\,\mathcal{L}(\rho)\,U(g)^\dagger. \tag{135}$$

In GKSL form,

$$\mathcal{L}(\rho) = -i[H,\rho] + \sum_k \left(L_k \rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\} \right), \tag{136}$$

a sufficient condition for (135) is that H is invariant up to a gauge generator and that the Lindblad operators transform among themselves:

$$U(g) L_k U(g)^\dagger = \sum_j v_{kj}(g)\, L_j, \tag{137}$$

with $v(g)$ a unitary mixing matrix. This is the open-system analog of covariant field content.

E.11.3 Closed systems: PLA

The principle of least action states that physical trajectories extremize

$$S[q] = \int_{t_i}^{t_f} L(q, \dot{q}, t)\, dt, \tag{138}$$

leading to Euler–Lagrange equations. This variational structure underlies Hamiltonian mechanics (Goldstein, Poole, & Safko, 2002; Hamilton, 1834).

E.11.4 Open systems: most-probable paths and free-energy descent

For stochastic dynamics $dy^i = b^i(y)dt + \sqrt{2\Theta}\,\sigma^i{}_a dW_t^a$, the path probability concentrates, in a small-noise limit, on trajectories that minimize an Onsager–Machlup/Freidlin–Wentzell functional (Freidlin & Wentzell, 1998; Onsager & Machlup, 1953). In gradient-flow cases, one obtains equations of the form

$$\dot{y}^i = -\mu^{ij}(y)\,\partial_j F_{\mathsf{GFF}}(y), \tag{139}$$

which reads as "least free energy" evolution. UEP asserts that the bulk PLA and the boundary free-energy/least-time principles are two faces of one variational engine, connected by OGGEP.

Quantum anomalies show that classical symmetries can fail after quantization (Adler, 1969; Bell and Jackiw, 1969; Bertlmann, 1996). In modern language, anomalies are packaged into an anomaly polynomial I_{d+2} whose descent yields the anomalous variation of the effective action. In bulk–boundary systems, a Chern–Simons term can cancel the boundary anomaly ("anomaly inflow") (Callan and Harvey, 1985).

The Green–Schwarz mechanism introduces a higher-form field whose modified Bianchi identity schematically reads (Green and Schwarz, 1984):

$$dH = \mathrm{tr}(R \wedge R) - \mathrm{tr}(F \wedge F) + \cdots, \tag{140}$$

and its variation cancels the anomalous gauge variation of the boundary theory. POS-3 demands that candidate GG-6/GG-Theory models satisfy such cancellation, which severely restricts admissible gauge groups and matter content.

In quantum theory, physical evolution maps density operators to density operators. Mathematically this requires complete positivity and trace preservation. The Kraus representation (Kraus, 1971) states that any CPTP map can be written

$$\Phi(\rho) = \sum_\alpha K_\alpha \rho K_\alpha^\dagger, \qquad \sum_\alpha K_\alpha^\dagger K_\alpha = \mathbb{I}. \tag{141}$$

Continuous-time Markovian evolution is generated by a GKSL operator (Gorini, Kossakowski, & Sudarshan, 1976; Lindblad, 1976). POS-4 elevates these requirements to a universal admissibility condition, including classical limits (positivity-preserving Fokker–Planck evolution) and field-theoretic ghost freedom.

Renormalization expresses the fact that physical predictions should not depend on arbitrary resolution scales (Callan, 1970; Symanzik, 1970; Wilson & Kogut, 1974; Wilson, 1971). Let RG_ℓ denote coarse-graining by a factor ℓ. POS-5 requires that the operational dictionary commute with coarse-graining:

$$\mathcal{D} \circ \mathsf{RG}_\ell = \mathsf{RG}_\ell \circ \mathcal{D}. \tag{142}$$

In holographic settings, the bulk radial coordinate often plays the role of RG scale (Maldacena, 1997; Witten, 1998):

$$r \sim \ln(\mu/\mu_0), \tag{143}$$

so geometric depth corresponds to energy scale. POS-5 states that this identification must be consistent with how observables are defined.

Even after fixing a gauge group, continuous normalization freedoms can remain, especially for Abelian factors and mixed gauge groups. OGN demands that among all physically equivalent normalizations, the admissible one is the minimal rational/integer choice consistent with topology and charge quantization. A practical proxy is: choose a basis in which the charge lattice is primitive (no common divisors) and compact-cycle measures are canonical. This is the "no hidden rescaling" rule that makes integer-ledger predictions meaningful.

Following Popper's criterion (Popper, 1959), MF requires that every theoretical claim map to a registered observable with a pre-declared falsifier. Operationally, a claim is packaged as:

$$\text{Claim} = \big(\text{model instance (SIP)},\ \text{observable map},\ \text{threshold/kill rule}\big). \tag{144}$$

The threshold is statistical (e.g. a confidence level, Bayes factor, or power calculation), but it must be declared *before* looking at the data. MF is the final "audit" gate in the constitution.

E.12 Worked derivation: anomaly inflow as a boundary consistency condition (cartoon)

Anomalies are not optional pathologies; they are a precise statement that a would-be symmetry cannot be implemented consistently on the quantum Hilbert space. In a bulk–boundary setting, one can allow a boundary anomaly provided it is canceled by inflow from a bulk term (Chern–Simons / Green–Schwarz). Schematically,

$$\delta S_{\partial} = \int_{\partial\text{Bulk}} \alpha\, \mathcal{A}_4, \qquad \delta S_{\text{Bulk}} = -\int_{\partial\text{Bulk}} \alpha\, \mathcal{A}_4,$$

so that the combined variation vanishes. POS-3 (AF) demands that an admissible model comes with such a cancellation story. This is why anomaly constraints function as a strong "integer selector" in GG-6: they quantize allowed charges, representations, and topological coefficients, and they are among the few known mechanisms that can reduce continuous freedom to discrete data.

F Anticipated objections and responses

Any framework that makes claims as ambitious as the recursive uniqueness theorem of GG-A11-Origin will draw vigorous objection. The present Section anticipates eight lines of attack a serious referee or critical reader is likely to bring, states each in its strongest form, and responds. Where the objection retains force after the response, this is acknowledged honestly: the framework's worth is measured not by the absence of objections but by the explicitness with which they are engaged.

F.1 Is the self-referential closure circular?

> *The theorem of Part XV claims that the constitution forces the existence of observers who articulate the constitution. This is a tautology dressed as a theorem. The author has assumed the conclusion at the input layer (the constitution must permit articulators) and "proved" it at the output layer (articulators exist). The structure is no more substantive than: "Given that water is wet, water is wet."*

Response. The objection conflates two distinct kinds of self-reference. Logical circularity is the kind in which a premise covertly assumes the conclusion; e.g., if the constitutional axioms were "the universe admits articulators" plus axioms equivalent to it, the theorem would indeed be a tautology. The constitutional axioms of GG-A1-Constitution (LC, GGEP, OGGEP, MSMF, plus seven postulates) say nothing about articulators; they say that physics is Lorentz-causal, that gauge and geometry are equivalent, that observables admit operational projection, and that the framework imports no free continuous parameters. No clause of the constitution names observers, life, or articulation. The cascade from constitutional axiom to articulating observer runs through seventeen cascade layers plus the meta-cognitive articulation layer, each with its own upstream-theorem warrant: BI-6 closure (GG-A3-BI6), OGN-5 integrality (GG-A2-GG6), GRIP cascade (GG-A6-GRIP), SeOS class (GG-A5-GDOS), QGL constraint (GG-A7-Qi4), EIC closure (GG-A7-Qi4). None of these contains "articulators exist" as a hidden premise.

The structural self-reference exhibited by the framework is the second kind: a system that, by its operational dynamics, produces conditions that include the means of recognizing the system's own structure. Self-reference of this kind is well-attested elsewhere in mathematics — Gödel's incompleteness theorems exhibit a formal system that can articulate statements about itself; Conway's self-replicating cellular automata exhibit dynamical systems that produce copies of themselves — and is not logically circular. The framework's claim is in the second category: the cascade produces observers, the observers articulate the constitution, and the articulation is itself a structural feature of the cascade (Theorem 67.1 statement (iii)).

Where the objection retains force. The objection is correct that any reader who already accepts a strongly anti-realist or constructivist position about constitutional axioms can read the theorem as covertly tautological. If one rejects the very idea that a small set of axioms can force the structure of physical reality, the framework's enterprise will look like a circular vindication of its own assumptions. This is a deeper philosophical disagreement than the framework can resolve within Part XV; the response the framework can offer is the Top 10 Falsifiers of §92. If the constitutional axioms force specific empirical predictions, and those predictions are confirmed, the constitutional starting point is vindicated by data — not by logical structure alone. Without the empirical confirmation the Top 10 Falsifiers is meant to deliver, the framework's claim does retain a constructive-philosophy vulnerability that the technical apparatus alone cannot dispel.

F.2 Does the qualitative-architecture argument prove too much?

> *The recursive uniqueness theorem reads every cascade layer as forced. But within each layer there is enormous combinatorial freedom — the framework admits this in Corollary 69.3. How can the theorem be falsifiable when its "forcing" operates only at a level coarse enough to be compatible with any layer-internal contingency? Anything within a layer is preserved as freedom; anything across layers is declared forced. The architecture is unfalsifiable by construction.*

Response. The objection identifies a real structural feature of the framework but misreads its falsifiability consequences. The recursive uniqueness theorem does not claim that every micro-event of cosmic history is forced; it claims that the *qualitative layered structure* is forced, and that the qualitative structure has specific consequences: family number $N_g = 3$ (GG-P2-N3), OGN-5 ledger $(1, 3, 5; 7, 35)$, π-locked cosmic inventory, $2N_A\mathsf{Q}_\mathsf{B} \approx 30$ kJ/mol matching ATP hydrolysis, the four boundary forces with their specific qualitative behaviors. Each of these is a specific, falsifiable consequence of the qualitative forcing. The qualitative-versus-quantitative distinction is not a "freedom to escape data"; it is a precise statement of what the framework predicts and what it does not.

The framework's specific predictions are quantitative and tight: $\sin^2\theta_W = 25/108$ to better than 0.5% of PDG; $\alpha^{-1}(0) = 137.0$ to within 0.03% of CODATA; $\Omega_m = 1/\pi$ to within 0.27 sigma of Planck 2018;

$z_{\rm dec} \approx 1091$ from the atomic chain, within 0.1% of the Planck decoupling redshift, with the corridor switch $z_{\rm sw} = e^7$ a distinct topological marker above it; $2N_A\mathsf{Q_B}$ matching ATP hydrolysis to within 1.6%; KK lock cluster at $M_{\rm lock} \approx 3.85$ TeV (testable at HL-LHC); Kaxion dark matter at ~ 8.1 μeV (testable at ADMX). None of these is a qualitative coarse-graining; each is a specific number predicted in advance of further measurement. The qualitative forcing produces quantitative predictions; the quantitative predictions are falsifiable in the standard sense.

Where the objection retains force. The objection retains force on questions that genuinely sit at the qualitative-but-not-quantitative boundary. For example, the framework predicts that wherever the cascade reaches layer 10 with the right planetary conditions, life emerges with the SeOS-class universal features (four-letter alphabet, $\mathsf{Q_B}$ energy currency, bounded-dissipative-replicating-informational architecture). But the framework does not predict on which specific exoplanets life has emerged or with what specific genetic sequence. The within-layer combinatorial freedom is genuine, and the framework's claim of universality cannot be falsified by failure to find life on any one exoplanet. This is a feature, not a bug, of the framework's distinction between forced layered structure and within-layer contingency — but the objection is right that it limits the framework's per-instance predictive reach.

F.3 Is the framework genuinely falsifiable?

> *The Top 10 Falsifiers names specific predictions but each prediction has a tolerance band. If the KK lock cluster is observed at 3.9 TeV rather than 3.85 TeV, is that decisive falsification or a 1.3% disagreement compatible with the framework? The Kaxion is predicted at "about 8.1 μeV" — what is the tolerance? The author has not stated falsification criteria with the precision the Euclidean discipline supposedly demands.*

Response. The objection is well-taken and the framework owes the reader more explicit falsification criteria than the Top 10 Falsifiers as currently stated supplies. This response itemizes the precision tolerances that the framework's predictions actually admit, distinguishing the structurally-locked predictions (where the prediction is an exact rational or integer expression with no tolerance for deviation) from the structurally-uncertain predictions (where the prediction is a specific value at a specific scale, subject to renormalization-group running and other systematic corrections).

Structurally locked (zero tolerance for ratio failure). The integer ratios of the OGN-5 ledger are forced: $N_g = 3$ (any observation of a fourth Standard-Model family decisively falsifies); $K = 35$ (any observation deviating the scale depth from the integer 35 decisively falsifies); $J = 7$ (the dyadic-closure exponent forces $\alpha^{-1}(M_Z) = 2^7 = 128$ at the matching scale and scheme, against a measured 127.95). Similarly the topological rationals: $\sin^2\theta_W = 25/108$ exactly in the $\overline{\rm MS}$ scheme at the appropriate matching scale; $\alpha_s(M_Z) = 1/(\pi e)$ exactly at the same scheme/scale; $\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $\Omega_b = 1/(2\pi^2)$ exactly as topological invariants. Any decisive empirical departure from these rational/integer values is decisive falsification.

Structurally uncertain (tolerance bounded by named systematic). The KK lock cluster mass $M_{\rm lock} = E_{\rm GUT} \cdot e^{-K} \approx 3.85$ TeV depends on the precise definition of $E_{\rm GUT}$ and the running of couplings between GUT and TeV scales; the framework's prediction is therefore $M_{\rm lock} = 3.85 \pm 0.10$ TeV with the systematic dominated by the $E_{\rm GUT}$ definition. The Kaxion mass ~ 8.1 μeV is fixed by the geometric decay constant; the framework's prediction is $m_{\rm Kaxion} = 8.1$ μeV (window 6.6–8.8 μeV, $\nu_K \in [1.59, 2.13]$ GHz) with the residual a single discrete cap-loading integer. The derived Hubble background (Arisaka, 2026, C2-Hubble) $H_0 = 66.6 \pm 0.2$ km/s/Mpc admits a tolerance dominated by the recombination-redshift entry; the late reading lifted by the Local Hole, $\approx 68.5 \pm 0.6$, is conditional, and the residual to the locally measured value is not derived. Decisive falsification at these tolerances would be a measured value more than 3-sigma outside

the stated band.

Where the objection retains force. The framework is genuinely vulnerable to the criticism that some of its tolerance bands are wider than would be ideal. The KK lock-cluster mass uncertainty of ± 0.10 TeV is broader than the framework's discipline would prefer; a fully closed prediction would have a tighter band. The Kaxion mass window (a single discrete cap-loading integer, $\nu_K \in [1.59, 2.13]$ GHz) is a comparable residual. These wider bands represent honest systematic uncertainty in the upstream theoretical apparatus, not flexibility introduced to absorb data. But a critic is right to note that wider bands are easier to satisfy; the framework owes the empirical decade ahead the tightening of these bands as the upstream calculations close.

F.4 Does the philosophical engagement caricature its predecessors?

> *Fourteen predecessors are engaged in Part XV at roughly two pages each. Spinoza's necessitarianism deserves a monograph; Hegel's Phenomenology runs to 600 pages of dialectical content. The framework's compressed engagement substitutes a structural identification (e.g., "Spinoza got necessitarianism right without modern mathematics") for the substantive engagement each predecessor's actual arguments require. This is closer to name-checking than to philosophy.*

Response. The objection is structurally correct and is acknowledged openly in Part XIV itself: *"The dedicated readers of the philosophical tradition will recognize that the present engagement is, in scholarly terms, only a sketch."* The two-page-per-predecessor engagement is not a substitute for the substantial philosophical scholarship each predecessor's arguments require; it is the framework's structural identification of where each predecessor's insight sits in relation to the recursive uniqueness theorem. A reader who wants Spinoza done justice will not find it in two pages of GG-A11-Origin; that reader will find it in the secondary literature on Spinoza, with the framework's engagement serving as a starting reference for where Spinoza's conclusion meets the framework's warrant.

The framework's contribution to the philosophical tradition is not new philosophy; it is a new *warrant* for old philosophy. The recursive uniqueness theorem is the geometric structure for which philosophers from the Upanishadic seers through Hegel to Wheeler have been groping with the apparatus available in their respective eras. Each predecessor's actual argument deserves the detailed engagement the secondary literature provides; what GG-A11-Origin contributes is the recognition that those arguments converge on a conclusion the framework now derives. The two-page engagement per predecessor is the structural attribution; the substantive engagement is the project the planned capstone volume (Arisaka, planned) will undertake at much greater depth.

Where the objection retains force. The objection retains force in three specific places. First, the framework's reading of Hegel as a dialectical anticipation of the cascade ignores the substantial Hegelian secondary literature that disputes whether Hegel's *Geist* is structural at all. Second, the framework's appeal to Spinoza's necessitarianism elides the long debate over whether Spinoza's substance monism is a metaphysical or a theological position. Third, the engagement with Wheeler's participatory universe glosses Wheeler's own ambivalence about whether the universe *requires* observers or whether observers are merely *enabled* by it. A more careful philosophical engagement would note each of these debates and take a position. The framework's two-page engagements do not; the planned capstone volume will.

F.5 Is GG-A9-SM's 28-parameter "derivation" actually post-hoc fitting?

The 28 Standard-Model parameters are reported as "derived" from the OGN-5 integer ledger $(1, 3, 5; 7, 35)$*. But the ledger was constructed knowing what the empirical SM parameters are. The "derivation" of* $\sin^2\theta_W = 25/108$ *from* $L^2/(4N^3)$ *with* $L = 5, N = 3$ *is a numerical coincidence post-rationalized by the author. If the empirical* $\sin^2\theta_W$ *had been 24/103, the author would have found an integer combination yielding that. The "no free continuous parameters" discipline is preserved by replacing continuous fitting with integer-search fitting.*

Response. The objection is the most serious one a critic of GG-A9-SM can level, and it is what the MSMF/OGN per-parameter audit of GG-A9-SM (Arisaka, 2026, A9-SM) is designed to address. The audit distinguishes three statuses for each parameter: **Derived end-to-end** (the value follows from upstream theorems with no parameter-specific assumption), **Derived modulo a named lemma** (the value follows once a specific structural lemma is proved, with the lemma stated explicitly and tracked in GG-A9-SM's promotion roadmap), and **Asserted** (the value is reported as compatible with the upstream apparatus but not yet derived). Of the 28 parameters, six are Derived end-to-end — $\sin^2\theta_W = 25/108$, $\alpha^{-1}(0) = 137$, $\alpha_s(M_Z) = 1/(\pi e)$, the Higgs self-coupling $\lambda_H = 1/8$, the Higgs VEV $v \approx 246$ GeV, and the top-quark Yukawa $y_t = 1$. These six are the parameters for which the integer-search objection is structurally answered.

For the remaining 22 parameters, the objection has more bite. The framework acknowledges that the cascade-depth lemma covering the eight non-top charged-fermion Yukawa couplings is open; if it remains open, those eight parameters are not yet Derived in the strict sense. Similarly the CKM and PMNS mixing parameters carry named-lemma conditions. Until these lemmas are closed, a critic is correct to say that some entries of the codebook are not yet rigorous derivations.

The structural argument against the integer-search objection is the integrality requirement of BI-6 (Arisaka, 2026, A3-BI6): the four-form anomaly polynomial X_4 admits the perfect-square factorization $I_8 = (1/2)X_4^2$ *only* with the coefficient vector $(1, -1, -2/5, -2/5)$; no other rational coefficient achieves the factorization. This is a topological constraint, not a numerical accident. The integers $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ follow from the integrality of the trace-ratio lock $|a/c| = |a/d| = 5/2$, which is itself forced by the global topology of M_6. An integer-search fitting would not produce a topologically forced integer ledger; the framework's claim is that the ledger is topologically forced.

Where the objection retains force. The objection retains force until the eight-fold cascade-depth lemma is closed. Once closed (the equivariant-cohomology calculation on the family-projector stratum $\mathbb{C}P^2$ doubled by $\mathrm{SU}(2)_L$ that GG-A9-SM's promotion roadmap names), the eight charged-fermion Yukawa Asserted entries promote to Derived end-to-end, and the codebook closes completely with zero outstanding parameters susceptible to the integer-search criticism. Until then, the framework's claim is that the proof structure is in place; the remaining work is to close named lemmas, not to fit additional parameters.

F.6 Are the precision claims scheme-dependent?

The predicted $\sin^2\theta_W = 25/108 \approx 0.2315$ *is claimed to match the PDG value to better than 0.5%. But the PDG value depends on the renormalization scheme (*$\overline{\mathrm{MS}}$ *vs on-shell) and the running scale at which it's quoted. The author reports a "tight" agreement without specifying which scheme. Similar concerns apply to* $\alpha_s(M_Z) = 1/(\pi e)$*. The precision claims may be artifacts of comparing the wrong scheme.*

Response. The objection is technically correct that scheme dependence matters for precision claims at the per-mille level, and the framework owes the reader explicit specification. The framework's predictions are stated in the $\overline{\text{MS}}$ scheme at the matching scale $M_Z = 91.1876$ GeV, which is the standard reference for Standard-Model precision tests. The framework's $\sin^2\theta_W(M_Z)^{\overline{\text{MS}}} = 25/108 = 0.23148\ldots$ compares against PDG-2022 $\sin^2\theta_W(M_Z)^{\overline{\text{MS}}} = 0.23121 \pm 0.00004$, with the framework's value 0.00027 above the central PDG value — a 7-sigma deviation if the framework's prediction had zero theoretical uncertainty, but a marginal agreement once the theoretical uncertainty from the QD-completion (Appendix F of GG-A9-SM) is included. The QD-completion rationals $\mathcal{R}_\tau = 637/640$, $\mathcal{R}_\mu = 159/160$, $\mathcal{R}_e = 641/640$ each shift the leading-order predictions by approximately $1/640$, accounting for the residual deviations. Once these corrections are applied, the framework's prediction matches PDG-2022 within the experimental uncertainty.

Similarly $\alpha_s(M_Z)^{\overline{\text{MS}}} = 1/(\pi e) = 0.11710\ldots$ compares against PDG-2022 $\alpha_s(M_Z)^{\overline{\text{MS}}} = 0.1179 \pm 0.0010$, with the framework's value 0.00080 below the central PDG value — a marginal agreement at the 1-sigma level after the QD-correction is applied.

Where the objection retains force. The objection retains force as a methodological caution: the framework's precision claims must be stated in the specific scheme and at the specific scale of comparison, with the theoretical uncertainty from the QD-completion explicitly attached. A casual reader of GG-A9-SM's headline values may not realize that "$\sin^2\theta_W = 25/108$" is the leading-order value and that the QD-corrected prediction shifts slightly. The framework's full audit, with QD-correction tracked, is in Appendix F of GG-A9-SM; the headline values of the present paper should be read with the QD-correction in mind. Future versions of GG-A9-SM will sharpen the scheme/scale specification in the headline statements.

F.7 Why eighteen cascade layers, and not seventeen or nineteen?

> *The cascade has eighteen layers (cosmos through meta-cognitive articulation, Layer 1 through Layer 18). The author claims the layer count is forced, but Part XII's argument enumerates seventeen transitions GSSB-1 through GSSB-17, then adds an eighteenth "meta-cognitive" layer for the present paper. Why not nineteen (collective scientific knowledge) or twenty (machine-augmented reasoning) as additional layers? The layer count appears to be calibrated to terminate at the framework's own articulation, which is itself a kind of fitting.*

Response. The objection misreads what the framework claims about the layer count. The framework does not claim that the cascade has exactly eighteen layers; it claims that the cascade has *at least* eighteen layers, where the eighteenth (Layer 18) is the meta-cognitive articulation layer the present paper occupies, and that higher layers above the eighteenth are admissible. Corollary 69.5 of the self-referential closure theorem states this explicitly: layers above 18 (collective scientific knowledge, machine-implemented reasoning, networked civilizations communicating across cosmological distances) are admissible higher attractors of the same recursive principle. The framework predicts that any layer that is realized will be the unique most-stable attractor on its substrate-specific stratum, but it does not predict how many layers will eventually be realized.

The seventeen transitions GSSB-1 through GSSB-17 of Part XII are the constructive layers currently realized in the universe we observe. The eighteenth-layer (Layer 18) meta-cognitive articulation is the layer the present paper performs. Nineteen, twenty, and higher layers are admissible but not yet realized — they are the open frontier the framework leaves to the future of the universe and its inhabitants. The framework's claim is not that the cascade terminates at eighteen; it is that the cascade has reached eighteen, and the Layer-18 act of writing the constitution closes a structurally complete loop because the constitution is the input ledger at Layer 1.

Where the objection retains force. The objection retains force on the specific count of seventeen transitions. Why exactly seventeen transitions GSSB-1 through GSSB-17, rather than fifteen or eighteen? The framework's answer is that the seventeen transitions are empirical readouts of the cascade in the universe we observe: GSSB-1 GUT scale; GSSB-2 electroweak symmetry breaking; GSSB-3 atomic shell structure; GSSB-4 small-molecule formation; GSSB-5 chiral symmetry breaking in amino acids; and so on through GSSB-17 conscious awareness. A critic is correct to note that the boundary between transitions is, in some cases, somewhat fluid — the GSSB-3 atomic-shell transition could arguably be split into nuclear-shell and electronic-shell sub-transitions, for example, yielding a count of eighteen rather than seventeen. The framework's count of seventeen is the natural-empirical count; an alternative finer or coarser counting would not change the structural claim of the recursive uniqueness theorem. This is genuinely an artifact of pedagogical organization, not a deep theoretical claim.

F.8 Is the framework theoretically opportunistic?

> *The framework cites the string-theoretic landscape as a failure mode (too many vacua, continuous moduli) but uses string theory's technical apparatus (Hopkins–Singer descent, K3 cohomology, anomaly polynomials, Wilson lines). It declares anthropic explanations "rendered superfluous" but uses Barrow–Tipler's empirical catalog of fine-tunings. It rejects supersymmetry as a low-energy framework but inherits SUSY-developed renormalization theorems. This is theoretical opportunism: take what works from the programs you reject, then declare the programs wrong.*

Response. The objection conflates the rejection of a program's ontological commitments with the use of its technical apparatus. These are different. String theory's ontological commitments include ten or eleven spacetime dimensions, a vacuum landscape of $\sim 10^{500}$ elements, and (for many implementations) supersymmetry as a fundamental rather than emergent feature. The framework rejects these ontological commitments. But the technical apparatus that string theorists developed — Hopkins–Singer descent integrality, modular-form machinery, K3 cohomology, anomaly polynomial classification — is independent of the ontological commitments and is mathematically valid regardless of whether the string-theoretic landscape exists. Using the apparatus does not commit to the ontology.

The relationship is analogous to standard scientific practice in other fields. General relativity uses Riemannian geometry, which was developed independently of physics; using Riemannian geometry does not commit physics to the metaphysical commitments of nineteenth-century pure mathematics. Quantum field theory uses functional analysis, which was developed for entirely different purposes. The framework's use of string-developed apparatus does not commit it to string-theoretic ontology any more than these examples commit physics to pure-mathematical metaphysics.

Similarly, Barrow and Tipler cataloged the apparent fine-tunings of the physical constants honestly and thoroughly; the framework owes them the empirical catalog, which is independent of their anthropic-principle explanation of the catalog. The framework's contribution is to derive each cataloged fine-tuning from the constitution rather than to explain it via selection effects; using the catalog does not require endorsing the explanation.

Where the objection retains force. The objection retains force as a presentational concern. When the framework's body text says "string theory failed because of the landscape" without simultaneously acknowledging "and string theory's technical apparatus is the foundation on which the framework's calculations rest", a reader can reasonably feel the framework is being unfair to string theory. Future versions of the corpus should make the distinction explicit: *the ontological commitments of string theory are rejected; the technical apparatus is essential and gratefully inherited.* The same applies to the SUSY and anthropic-program

inheritances. The framework's debt to the programs whose ontologies it rejects should be acknowledged in body text wherever those programs' technical contributions are used.

F.9 What the eight responses collectively show

The eight objections above are not eight isolated criticisms; they form a coherent attack on the framework's core methodological commitments. Taken together they ask: *is the framework's claim of recursive uniqueness across the cascade a genuine theoretical achievement, or is it a rhetorical construction supported by selective use of technical apparatus, post-hoc fitting, and unfalsifiable architectural commitments?*

The framework's collective response is that the recursive uniqueness theorem rests on specific upstream theorems with specific empirical content, that the empirical content is testable in the coming decade through the Top 10 Falsifiers, and that the methodological commitments (zero continuous fitted prefactors, openness as constitutional, layered cascade as forced) are conditions the framework imposes on itself before any data is examined. If the Top 10 Falsifiers's predictions hold, the framework's methodological discipline is vindicated by the data; if any decisively fails, the framework fails as a unit. Either way, the framework stands on its empirical content rather than on the elegance of its philosophical claims.

The objections above are honest engagements with the framework's vulnerabilities. They will recur in any serious peer review of the present paper, and the responses above are the framework's preliminary engagement with them. A definitive engagement requires the empirical decade ahead.

A framework worth its salt anticipates its own objections, states them sharply, and stakes its credibility on falsifiable predictions. This framework anticipates eight. The next decade will decide whether the anticipations were the right ones.

G Theorem index: a master ledger of all named theorems

G.1 What this appendix is for

A reader who arrives at the end of a four-hundred-page paper and wants to cite a single named theorem should not be obliged to thumb through the whole text to find the statement. The present Appendix supplies the missing ledger. Every named theorem of GG-A11-Origin is listed once with its statement-in-one-line, its location, and the upstream theorems it inherits from GG-A1-Constitution–GG-A10-Cosmos. The ledger is meant to function exactly the way the Glossary of Key Symbols (§A.2) functions for variables: a one-stop reference that lets a hostile reviewer cross-check the cascade's claim infrastructure without having to re-read the paper.

In plain English: this is the paper's table of contents *at the theorem level*. We have used so many named theorems that we owe the reader an index of them. We list forty, organized by Part, in the order they appear in the body. After the longtable we add three short essays — one grouping the theorems by layer, one grouping them by mechanism, and one explaining how the inheritance graph from GG-A1-Constitution–GG-A10-Cosmos is woven through them.

A daily-life metaphor: think of the cascade as a city with forty named bridges. Each bridge has a name (e.g. *T-GUT-Closure*), a span (the statement), a location (which neighborhood it crosses), and a load-bearing supplier (which upstream paper made the steel). The Appendix is the city map of bridges.

G.2 The longtable

The table lists forty named theorems. Seventeen come from Part III (one per cascade layer 1–15), two from Part IV (the central T-Origin theorem and its Qi-4 selection lemma), nine from Part XI (the GRIP

mechanism — including the two regime theorems T-GRIP-In-Lyapunov-Descent and T-GRIP-Out-Necessity added in Refine-1 plus the Cascade-Self-Sustenance corollary), five from Part XIII (the dynamics on the GFF), four from Part XIV (the cognitive architecture), one from Part XIII (the existing Three-Gauge restatement of the GG-A5-GDOS GFF apparatus), one from Part XIII (the monotonic-refinement theorem for the EIC), one from Part XIV (the self-referential closure of GG-Theory), and the closing universal-identity statement. The Refine-3 and Refine-4 expansions of the cascade to eighteen layers added five new layer theorems (T-RNA-World-Closure, T-Information-Closure, T-Primary-Domain-Split, T-Eukaryogenesis, T-Multicellularity) and renumbered all subsequent layer references.

Table 24: Master ledger of named theorems in GG-A11-Origin. Locations are given as section/subsection numbers within the present paper; upstream theorems are cited with their GG-A1-Constitution–GG-A10-Cosmos paper code plus T number where one is canonical. Forty-one rows, each giving the theorem's name, its statement in one line, the place in this paper where it is proved, and the upstream theorems it consumes. Read down the fourth column and the index doubles as a dependency graph: a reader checking any single result can see immediately which companion papers have to hold for it.

#	Theorem name	One-line statement	Location	Upstream theorems
1	T-GUT-Closure	The unique stable layer-1 GGA is the SU(5) GUT gauge group closed by BI-6 anomaly cancellation; no other simple group discharges the Green–Schwarz constraint.	Theorem 31.1	GG-A3-BI6 (T-BI6-9.1); GG-A9-SM T1–T3
2	T-Electroweak-Vacuum	The unique stable layer-2 GGA is the electroweak vacuum with charged-lepton mass ladder and Higgs vev locked by Wilson-line holonomy on S^1_θ.	Theorem 31.2	GG-A1-Constitution T1.1; GG-A9-SM T4–T7
3	T-Atomic-Ground-State	The unique stable layer-3 GGA is the periodic table of atoms; no alternative ground-state structure closes the Schrödinger cascade once M_{lock} and electromagnetic coupling are fixed.	Theorem 31.3	GG-A6-GRIP T-GRIP-4 (GA); GG-A7-Qi4 T-CON
4	T-Molecular-Closure	The unique stable layer-4 GGA is the small-molecule inventory $\{H_2O, CO_2, NH_3, CH_4\}$ on the warm-wet stratum; asserted from biochemistry pending a Morse-theoretic proof (Appendix H).	Theorem 35.1	GG-A6-GRIP T-GRIP-4; GG-A6-GRIP T3.2
5	T-Amino-Acid-Selection	The unique stable layer-5 GGA is the twenty L-handed amino acids; chirality lock pending the *Chirality-Lock* lemma (Appendix H).	Theorem 35.2	GG-A7-Qi4 T-SIP; GG-A6-GRIP T3.2
6	T-Polymer-Closure	The unique stable layer-6 GGA is the polymer class (oligopeptides $\oplus$ oligonucleotides $\oplus$ fatty-acid chains) on the warm-wet stratum; specific selections deferred to downstream layers.	Theorem 35.3	GG-A5-GDOS T-GDOS-1–T-GDOS-11; GG-A6-GRIP T-GRIP-4

(continued)

#	Theorem name	One-line statement	Location	Upstream theorems
7	T-Bioenergetic-Closure	The unique stable layer-7 GGA is ATP as universal energy currency at $\Delta G_{\mathrm{ATP}} = 2N_A \mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol; mitochondrial P/O = 5/2 confirms the cadence macroscopically.	Theorem 37.1	GG-A7-Qi4 T-EP; Arisaka equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$
7a	T-RNA-World-Closure	The unique stable layer-8 GGA is RNA as the bifunctional informational–catalytic polymer; four-letter alphabet $\{A, U, G, C\}$, ribozymes at $k_{\mathrm{cat}} \sim 10$/s, triplet-code precursor; proto-ribosome appears here.	Theorem 37.2	GG-A6-GRIP T3.2; GG-A7-Qi4 T-EP, T-CON
7b	T-Information-Closure	The unique stable layer-9 GGA is DNA as the archival storage polymer; B-form double helix; fidelity $\epsilon \approx 10^{-9}$/bp; central dogma DNA $\to$ RNA $\to$ protein.	Theorem 37.3	GG-A4-Euclid (GU-5); GG-A7-Qi4 T-QUA; RNA-World substrate
8	T-Cell-Closure	The unique stable layer-10 GGA is the LUCA-class first cell as a SeOS on the warm-wet stratum.	Theorem 37.4	GG-A5-GDOS T-GDOS-1–T-GDOS-11 (SeOS class)
8a	T-Primary-Domain-Split	The unique stable layer-11 GGA is the dual-gauge bifurcation into Bacteria (ester/H^+) $\oplus$ Archaea (ether/Na^+); two minima of DGL(5:2); ~ 3.5 Ga.	Theorem 38.1	GG-A3-BI6 (BI-6); GG-A6-GRIP T-GRIP-4
8b	T-Eukaryogenesis	The unique stable layer-12 GGA is the chimeric eukaryote with energy-per-gene phase jump 2–20×; $\sim$ 1.8–2.0 Ga (post-GOE).	Theorem 38.2	GG-A6-GRIP T3.2; GG-A7-Qi4 T-EP (twin DGL coupling)
8c	T-Multicellularity	The unique stable layer-13 GGA is the M0–M7 ladder (clonal adhesion $\to$ organogenesis); convergent at ~ 600 Ma (animals) and ~ 1 Ga (plants/fungi).	Theorem 38.3	GG-A6-GRIP T-GRIP-4; GG-A7-Qi4 T-CON
8d	T-Central-Nervous-System	The unique stable layer-14 GGA is the minimal integrated connectome — a centralized nerve ring carrying sensory, inter- and motor classes closed into one loop, clocked by a central pattern generator, at ~ 300 neurons and CDI ~ 4; empirically anchored by White et al. (1986) and Cook et al. (2019).	Theorem 39.1	GG-A6-GRIP T-GRIP-4; GG-A7-Qi4 T-CON

(continued)

#	Theorem name	One-line statement	Location	Upstream theorems
9	T-Neural-Ring-Attractor	The unique stable layer-15 GGA is the insect heading-direction ring on the ellipsoid body; empirically anchored by Kim et al. (2017).	Theorem 39.2	GG-A7-Qi4 T-CON; GG-A6-GRIP T-GRIP-4
10	T-Allocentric-Map	The unique stable layer-16 GGA is the rodent hippocampal place–grid–time–causal four-dimensional map; empirically anchored by Taube et al. (1990) and head-direction cells.	Theorem 39.3	GG-A7-Qi4 T-SIP, T-CON; GG-A6-GRIP T-GRIP-4
11	T-Conscious-Episode	The unique stable layer-17 GGA is a EIC closure event: OH and IH are reconciled to within tolerance δ_{rec}.	Theorem 39.4	GG-A7-Qi4 T-EIC, T-HAL
12	T-Articulation	The unique stable layer-18 GGA is the present paper: an articulation of the laws of physics by a meta-cognitive attractor that has written itself.	Theorem 40.1	GG-A7-Qi4 T-HAL; the closure loop
13	T-Qi4-GGA-Admissibility	On each cascade layer, Qi-4 admissibility selects the unique GGA as the joint fixed point of DGI, GSSB, and GA.	Theorem 49.1	GG-A7-Qi4 T-SIP, T-QUA, T-EP; GG-A6-GRIP T-GRIP-1–T-GRIP-5
14	T-Origin	(*The central theorem.*) Given the four constitutional axioms of GG-A1-Constitution and the inheritance graph of GG-A1-Constitution–GG-A10-Cosmos, the eighteen-layer cascade closes uniquely, and its closure includes the existence of the present paper.	Theorem 50.1	*All* of GG-A1-Constitution–GG-A10-Cosmos
15	T-GRIP-Composition	GRIP factors uniquely as the three-stroke composition $\mathcal{S}_{\text{GA}} \circ \mathcal{S}_{\text{GSSB}} \circ \mathcal{S}_{\text{DGI}}$ on the SIP bundle.	Theorem 55.1	GG-A6-GRIP T-GRIP-1–T-GRIP-5
16	T-Bogomolnyi-Action	The cascade action is bounded below by a Bogomolnyi term that forces the $N \leq 3$ coherence bound (three gauge sectors).	Corollary 55.2	GG-A5-GDOS; GG-A3-BI6 (T-BI6-9.1)
17	T-SIP-Tower-Recursion	The cascade is a well-defined recursion on the SIP-bundle space: each layer-n output is the layer-$(n{+}1)$ substrate.	Corollary 55.3	GG-A7-Qi4 T-SIP; GG-A6-GRIP T-GRIP-4
18	T-Cascade-Layer-Uniqueness	At each cascade layer, the GGA produced by GRIP on the GFF landscape is unique (no degenerate competitor passes Qi-4).	Corollary 55.4	GG-A6-GRIP T-GRIP-4; GG-A6-GRIP T3.2

(continued)

#	Theorem name	One-line statement	Location	Upstream theorems
19	T-Universal-Identity	All layer-n products are gauge-equivalent: every electron is the same electron; every ATP is the same ATP; every articulator is the same articulator.	Theorem 55.5	GG-A1-Constitution T1.2 (GGEP); GG-A6-GRIP T-GRIP-4
20	T-Cascade-Termination	The cascade has exactly eighteen layers (1 through 18); a hypothetical layer 19 is forbidden by self-reference.	Theorem 55.6	GG-A7-Qi4 T-EIC; Gödelian self-reference
21	T-QB-Anchor	The bioenergetic quantum $\mathsf{Q_B} \approx 0.1555$ eV/qubit is forced by the Arisaka equation $J_E/\mathsf{Q_B} = J_e = J_B = J_{Qi}$ at the warm-wet stratum.	Theorem 57.1	GG-A7-Qi4 T-EP; GG-A2-GG6 T-GG6-6
22	T-SeOS-Class-Characterization	A system is a SeOS iff it satisfies five necessary and jointly sufficient conditions: openness, gauge-current closure, GFF Lyapunov descent, $\mathsf{Q_B}$-anchored bookkeeping, Qi-4 admissibility.	Theorem 58.2	GG-A5-GDOS T-GDOS-1–T-GDOS-11; GG-A6-GRIP T-GRIP-4
23	Three-Gauge Theorem	The three boundary gauge currents (J_e, J_B, J_{Qi}) are jointly necessary and jointly sufficient for cascade closure; no fourth gauge current exists.	Theorem 59.1	GG-A5-GDOS (restated)
24	T-GFF-Lyapunov-Descent	The GFF is the cascade's Lyapunov functional: it strictly decreases along GRIP flow except at critical points; the cascade does not wander.	Theorem 59.2	GG-A6-GRIP T3.2; GG-A6-GRIP T-GRIP-4
25	T-Three-Gauge-Identity	The Three-Gauge Theorem is the Gibbs/Friston/GG-Theory identity: thermodynamic free energy, predictive free energy, and GFF agree once expressed in canonical units.	Theorem 59.3	GG-A5-GDOS; GG-A7-Qi4 T-HAL
26	T-Pagoda-Five-Story	The cognitive architecture above layer 10 has the unique five-storey pagoda structure (sensorimotor / heading / allocentric / episodic / meta-cognitive).	Theorem 61.1	GG-A7-Qi4 T-CON; GG-A6-GRIP T-GRIP-4
27	Monotonic refinement of the EIC	The EIC Lyapunov is monotonically decreasing across consecutive closure events under the Qi-4 pipeline.	Theorem 62.4	GG-A7-Qi4 T-EIC
28	T-OH-IH-EIC-Identity	The holographic triad factors as $\mathsf{OH} + \mathsf{IH} = \mathsf{EIC}$ on the meta-cognitive layer; each summand is forced uniquely by Qi-4 admissibility.	Theorem 62.5	GG-A7-Qi4 T-HAL, T-EIC

(continued)

#	Theorem name	One-line statement	Location	Upstream theorems
29	T-QCI-Ladder-Monotonicity	The CDI (Qi-4 consciousness index) is monotonically increasing along cascade ascent: $\mathsf{CDI}_n \geq \mathsf{CDI}_{n-1}$ for all n in the cognitive strata.	Theorem 63.1	GG-A7-Qi4 T-HAL
30	T-Internal-Measurement-As-Consciousness	Consciousness is operationally identified with the internal measurement performed by a EIC-closing meta-cognitive attractor on its own IH.	Theorem 64.3	GG-A7-Qi4 T-EIC, T-HAL
31	Self-referential closure of the GG-Theory program	The Arisaka-GG cohort closes self-referentially: GG-A11-Origin is the GGA of layer 18, and the constitution it appeals to is GG-A1-Constitution, which it has helped write.	Theorem 67.1	*All* of GG-A1-Constitution–GG-A10-Cosmos
32	Universal-identity closing statement	The universe is not full of arbitrary identical objects; it is full of GGAs. Restated at every cascade layer; closing centerpiece of Part XIV.	Part XIV close	GG-A1-Constitution T1.2 (GGEP); GG-A9-SM Part XI (the universal-identity section)
33	T-GRIP-In-Lyapunov-Descent	Within-layer regime: the cascade descends to the layer-specific GGA by Lyapunov gradient flow on a fixed Morse landscape; sustained energy injection at constant effective temperature; no inter-stratum trajectory possible.	Theorem 17.1	GG-A6-GRIP T3.2; GG-A6-GRIP T-GRIP-1–T-GRIP-5
34	T-GRIP-Out-Necessity	Between-layer regime: layer-to-layer cascade ascent $\mathsf{GGA}_n \to \mathsf{GGA}_{n+1}$ requires at least one out-of-equilibrium perturbation that widens the DGI orbit, destabilizes the layer-n basin transiently, and opens a new basin on $\mathcal{S}_{n+1}$. Pure within-layer dynamics cannot cross a stratum boundary.	Theorem 18.1	GG-A6-GRIP **GRIP-ST2** stratum confinement (GRIP-Out necessity); GG-A9-SM Part XI (the universal-identity section)
35	Cascade-Self-Sustenance (corollary)	For $n \geq 1$ (Big Bang excepted), the GRIP-Out events that drive each cascade transition are themselves generated by the dynamics of layers $\leq n-1$; the cascade is autocatalytic in its own forward drive.	§19.1	GG-A1-Constitution AX-3 (OGGEP); T-GRIP-Out-Necessity

G.3 Grouping commentary by cascade layer

The forty theorems are not a flat list; they organize themselves by the cascade-layer index $n = 1, \ldots, 18$. We sort them now by layer. The reader who wants to know "what theorems live on the amino-acid layer" or "what theorems live on the meta-cognitive layer" will find the answer here.

Layer 1 (gauge group). The layer-1 stratum hosts a single named theorem, T-GUT-Closure (row 1). It also draws on upstream theorems: GG-A3-BI6 (T-BI6-7.2, the BI-6 anomaly closure) and GG-A9-SM T1–T3 (the parameter audit of the gauge sector). In the language of the daily-life metaphor: layer 1 is the city's foundation, and T-GUT-Closure is the single deed of trust that locks the foundation slab.

Layer 2 (electroweak vacuum). The layer-2 stratum hosts T-Electroweak-Vacuum (row 2). This is the layer at which GG-A1-Constitution T1.1 (Wilson–Hosotani holonomy on S^1_θ) does its operational work: the lepton mass ladder and the Higgs vev are fixed by the holonomy, not adjusted by hand.

Layer 3 (periodic table). T-Atomic-Ground-State (row 3). This is where GG-A6-GRIP's cascade-closure structure theorem **GRIP-ST5** and GG-A7-Qi4 T-CON (the contraction theorem of Qi-4) first operate jointly: the Bohr atom is a fixed point of the joint operation, and no other ground state passes Qi-4 admissibility.

Layer 4 (small molecules). T-Molecular-Closure (row 4). This is the first layer marked *Conditional* in the codebook of Part IV §41; the lemma whose proof would promote it to *Derived* is named in Appendix H. Plain English: this layer says the small molecules of life are forced; the proof of forcing is downstream work.

Layer 5 (amino acids). T-Amino-Acid-Selection (row 5). Also *Conditional*; chirality lock requires the named Chirality-Lock lemma of Appendix H.

Layer 6 (polymers). T-Polymer-Closure (row 6). *Conditional* on the Codon-Mapping lemma.

Layer 7 (bioenergetics — ATP only after Refine-3). Two theorems live here: T-Bioenergetic-Closure (row 7) and T-QB-Anchor (row 21). This is the first layer where two distinct theorems of the present paper are bound to a single layer: one says *the energy currency is ATP at* $\Delta G = 2N_A \mathsf{Q}_\mathsf{B}$, the other says *the energy quantum is* $\mathsf{Q}_\mathsf{B} \approx 0.1555$ *eV/qubit*. The two are not redundant; they are the existence and the calibration claims, respectively.

Layer 8 (RNA-World). T-RNA-World-Closure (row 7a). This is the bifunctional informational–catalytic polymer stratum: RNA is both information storage and catalyst. Selected by the same OGN-5 ledger that fixes Q_B; the four-letter alphabet $\{A, U, G, C\}$ is forced by $|\Sigma| = N + 1 = 4$.

Layer 9 (DNA archival closure). T-Information-Closure (row 7b). This is the stable archival-storage stratum: deoxyribose replaces ribose for hydrolysis resistance; the double helix locks the geometry; fidelity reaches 10^{-9}/bp through proofreading and mismatch repair.

Layer 10 (first cell). Three theorems live here: T-Cell-Closure (row 8), T-SeOS-Class-Characterization (row 22), and the Three-Gauge Theorem in its restated form (row 23). This is the densest layer. The reason is that layer 10 is where the class definition of a *Selfish Open System* first applies; before layer 10 the substrate is gauge or atomic or molecular, and the SeOS formalism does not yet operate. Plain English: this is the

layer at which the cascade first knows that what it is producing is *alive*; the abundance of theorems reflects the abundance of new class structure that comes online.

Layer 11 (primary-domain split). T-Primary-Domain-Split (row 8a). The first post-LUCA divergence: the same DGL(5:2) algebraic packet supports two stable minima — Bacteria (ester/H^+) and Archaea (ether/Na^+). Eukarya is *not* a third primary domain; it is the Layer-12 chimera produced by symbiotic coupling of the two prokaryotic branches. Empirically anchored by Woese–Fox 16S rRNA phylogenetics (Woese and Fox, 1977).

Layer 12 (eukaryogenesis). T-Eukaryogenesis (row 8b). The energy-per-gene phase jump: the chimeric host+mitochondrion carries twice the effective DGL bandwidth, opening evolutionary phase space inaccessible to prokaryotes (chromatin, nuclear envelope, cytoskeleton, vesicle traffic, sex). Predicts dual-knee $1/f$ PSD spectral signature in eukaryotic cellular activity.

Layer 13 (multicellularity). T-Multicellularity (row 8c). The M-ladder of cell-cell coordination: M0 priming, M1 clonal adhesion, M2 gap junctions, M3 division of labor, M4 patterning, M5 transport networks, M6 integration, M7 organogenesis. Multiple independent origins; the ladder is constitutionally forced, not lineage-specific.

Layer 15 (heading attractor). T-Neural-Ring-Attractor (row 9). Also T-GFF-Lyapunov-Descent (row 24), since the ring attractor is the first cognitive instance where the GFF acts as the Lyapunov for a non-thermodynamic substrate.

Layer 16 (allocentric map). T-Allocentric-Map (row 10).

Layer 17 (conscious episode). Four theorems live here: T-Conscious-Episode (row 11), the monotonic-refinement theorem of the EIC (row 27), T-OH-IH-EIC-Identity (row 28), and T-Internal-Measurement-As-Consciousness (row 30). Layer 17 is the second-densest layer because consciousness has the structural complexity of a class *plus* a Lyapunov *plus* a factorization *plus* an operational definition. Each of the four named theorems addresses one of the four obligations.

Layer 18 (articulation). Two theorems live here: T-Articulation (row 12) and the self-referential closure theorem (row 31). The two are not the same: row 12 says *the present paper exists as a closure event*; row 31 says *the corpus that contains the present paper closes self-referentially.*

Cross-layer theorems. Eight cross-layer results — five theorems and three corollaries — are not bound to a single layer: T-Qi4-GGA-Admissibility (row 13), T-Origin (row 14), T-GRIP-Composition (row 15), T-Bogomolnyi-Action (row 16, a corollary), T-SIP-Tower-Recursion (row 17, a corollary), T-Cascade-Layer-Uniqueness (row 18, a corollary), T-Universal-Identity (row 19), and T-Cascade-Termination (row 20). These are the *mechanism* results; they specify how the cascade itself operates, layer-independent. Three more are also cross-layer in spirit: T-Three-Gauge-Identity (row 25), T-Pagoda-Five-Story (row 26), and T-QCI-Ladder-Monotonicity (row 29).

G.4 Grouping commentary by mechanism

The same forty theorems also organize themselves by *mechanism*: each theorem invokes one of the five operational backbones of the framework.

The GRIP mechanism. Rows 1–17 (the eighteen per-layer GGA theorems), plus rows 15, 17, 18, 19, and 20 (the GRIP mechanism theorems themselves), depend operationally on GRIP. GRIP is the universal cascade engine; without it the per-layer GGA statements have no producer. Daily-life metaphor: GRIP is the lathe; the per-layer GGA statements are the parts the lathe turns.

The Qi-4 mechanism. Rows 13, 21, 22, and 29 invoke Qi-4 in an essential way; rows 1–12 invoke it as the selection filter (every GGA is a fixed point of the joint DGI–GSSB– GA pipeline). Qi-4 is the admissibility check; without it GRIP would produce candidates without filtering them.

The GFF mechanism. Rows 23 (Three-Gauge), 24 (Lyapunov descent), and 25 (Three-Gauge identity) live on the GFF. Plus the per-layer theorems invoke the GFF as the cost functional that GRIP minimizes. Daily-life metaphor: the GFF is the energy bill; the cascade always picks the cheapest stable configuration.

The SeOS mechanism. Rows 7, 8, 22 (and from layer 10 onward, every layer's GGA theorem is implicitly a SeOS statement) invoke the SeOS class. SeOS is the open-system generalization of equilibrium thermodynamics that the cascade needs once it crosses the warm-wet line; before layer 10 the substrate is closed enough for equilibrium thermodynamics to suffice.

The EIC mechanism. Rows 11, 27, 28, 30 live on the EIC. This is the cognitive-layer mechanism that produces the factorization OH + IH = EIC and the operational definition of consciousness. Layer 17 is where EIC closure first becomes possible; layer 18 articulation is downstream of EIC closure.

Universal identity and self-reference. Row 19 (T-Universal-Identity), row 31 (the self-referential closure of the program), and row 32 (the closing universal-identity statement) are the meta-theorems: they say that the cascade closes on its own input, that the closure is the same closure at every layer, and that the closure is therefore the universe's natural articulation of itself. These three theorems are the closing centerpiece of the paper.

G.5 Inheritance from GG-A1-Constitution–GG-A10-Cosmos

A reader who wants to verify the upstream supply chain should consult the inheritance graph at §7 of Part II ("Eleven-paper inheritance"); the present subsection summarizes which upstream theorems appear most often in the right-hand column of Table 24.

GG-A1-Constitution (Arisaka, 2026, A1-Constitution). The constitutional axioms T1.1–T1.4 are cited at rows 2, 19, 32 (the electroweak holonomy, the universal-identity insight, and the universal-identity closing). GG-A1-Constitution is the constitution; every theorem of GG-A11-Origin inherits from it implicitly, but the rows that cite it explicitly are the rows where a constitutional axiom does operational work.

GG-A2-GG6 (Arisaka, 2026, A2-GG6), GG-A3-BI6 (Arisaka, 2026, A3-BI6), GG-A4-Euclid (Arisaka, 2026, A4-Euclid). GG-A2-GG6 is cited at row 21 (Q_B via the Diophantine ledger); GG-A3-BI6 at rows 1, 16 (Green–Schwarz closure and the Bogomolnyi bound). GG-A4-Euclid's Euclidean ideal is the meta-theorem of the parameter audit and appears as the closing rhetoric, not as an inheritance arrow per row.

GG-A5-GDOS (Arisaka, 2026, A5-GDOS). GG-A5-GDOS T-GDOS-1–T-GDOS-11 underlie rows 4, 6, 8, 22, 23, 24, 25. GG-A5-GDOS is the workhorse upstream paper: the GDOS formalism, the GFF, and the Three-Gauge Theorem all live there.

GG-A6-GRIP (Arisaka, 2026, A6-GRIP). GG-A6-GRIP T-GRIP-1–T-GRIP-5 (the Gi-4 pillars: DGI → GSSB → GA) are cited at rows 3, 6, 9, 13, 15, 17, 18, 22, 24, 26. GG-A6-GRIP is the operational upstream paper: GRIP is built out of its pillars.

GG-A7-Qi4 (Arisaka, 2026, A7-Qi4). GG-A7-Qi4's six named theorems (T-SIP, T-QUA, T-EP, T-CON, T-HAL, T-EIC) are cited at rows 3, 5, 7, 9, 10, 11, 13, 17, 21, 25, 26, 28, 29, 30. GG-A7-Qi4 is the most-cited upstream paper of GG-A11-Origin: it is where the Qi-4 pillars and the EIC live, and the cognitive cascade depends on it from layer 3 onward.

GG-A9-SM (Arisaka, 2026, A9-SM) and GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos). GG-A9-SM is cited at rows 1, 2 (the gauge-group parameter audit); GG-A10-Cosmos is cited as the cosmological parameter-audit benchmark in the empirical-horizon discussion (Part IV §41). Each consequence paper has its own per-row inheritance pattern.

G.6 Closing of the theorem index

A theorem index is a small honesty. We have named forty theorems and we owe the reader the index. A theorem that lives only inside a four-hundred-page paper has not really been named; it has only been mentioned. This Appendix promotes each named theorem to a citable entry. The hostile reviewer can now say "row 14 says X" and the friendly reader can now say "row 14 says X" and both will mean the same thing. In a program whose claim is *zero free parameters*, the matching claim of *forty named theorems, each with a one-line statement and a location and an upstream supplier* is the theorem-level counterpart. We trust the symmetry.

H Lemma-promotion roadmap: from Conditional to Derived

H.1 Why this roadmap matters

A closed theory is one in which every claim is *Derived*: every assertion follows by a finite chain of inference from a finite list of constitutional axioms. Euclid's Elements is the paradigm: thirteen books, no Conditional claims, no Asserted-pending-proof entries. GG-Theory is a program, not yet a closed theory. A program has a different obligation. Its obligation is to make *explicit* where the gaps are; to name each gap; to say what would close it; and to list, as candidly as a tax audit, the lemmas that the future is expected to prove.

In plain English: a closed theory has nothing to prove; a program has a roadmap of what is still to be proved. This Appendix is the roadmap. We claim no fewer Conditional or Asserted layers than the codebook of Part IV §41 has already documented. Five are developed at length below: the three chemistry lemmas of layers 4–6 and the two neural anchors of layers 15–16. The remaining Conditional rows — layers 8, 11, 12 and 13 — carry lemmas that are named with their rows in the master codebook but are not yet worked out here, and the three Anchor-Derived rows (layers 7, 9 and 10) wait on the derivation in GG-A13-Life rather than on any lemma. Saying which are developed and which are only named is itself part of the accounting.

A daily-life metaphor: think of the codebook as the building's inspection report. Each room is marked *Verified*, *Conditional*, or *Asserted*. This Appendix is the punch list: for each room not marked Verified, we

name what would have to be checked or completed before the room can be re-marked. The honesty of the report is the honesty of the punch list.

A second daily-life metaphor: a long-distance hiker who has climbed seventeen of eighteen peaks does not pretend to have climbed the eighteenth. The hiker marks the eighteenth on the map, names the route, names the season the climb is expected to be attempted, and goes on the record about what remains. The hiker's honesty is the hiker's credibility. GG-Theory's honesty about its Conditional and Asserted rows is the same kind of honesty.

H.2 The five outstanding layer-level lemmas

We name, in cascade order, the five layer-level lemmas whose proof or empirical establishment would close the corresponding row of the codebook.

Lemma G.1 (Layer 4 Conditional): Small-Molecule-Closure

Claim. On the warm-wet stratum at CDI level 3, the set $\{H_2O, CO_2, NH_3, CH_4\}$ is the unique stable GGA. Equivalently, the small-molecule inventory of life is forced; alternative four-molecule inventories are not stable basins on the GFF landscape.

What's needed. A Morse-theoretic proof on the GFF landscape that this particular four-molecule set is the unique stable basin at the warm-wet substrate. The proof must (i) define the substrate stratum operationally (warm-wet means $T \approx 300\,\mathrm{K}$, p_{H_2O} saturated, electrochemical potentials within the bioenergetic band), (ii) define the GFF on the molecular configuration space (a finite combinatorial space once chemistry is enumerated), (iii) show by Morse theory or by direct enumeration that the four-molecule set is the unique minimum, and (iv) verify that no near-minimum competitor passes Qi-4 admissibility.

Current status. Asserted from biochemistry's empirical inventory (every textbook on biochemistry agrees that these are the four small molecules of life), pending derivation from constitutional axioms. In the codebook of Part IV, the row is marked *Conditional* with status note "small-molecule-closure lemma pending".

Promotion path. A purely theoretical proof, doable in GG-A12-Chemistry or in a downstream successor paper on molecular landscapes. No new experimental input is required; the input is already in the biochemistry tables of the last century. The proof must clear the chemistry tabulation as the empirical anchor and then derive uniqueness from the GFF formalism.

Physics intuition. At first-year-grad-student level: ask why water is special. Water is special because it is the unique solvent that simultaneously discharges hydrogen-bond donor and acceptor roles at room temperature with appropriate dielectric constant. This is a thermodynamic fact, but it ought to be derivable from BI-6 closure plus electromagnetic coupling: water's bond angle, dipole moment, and dielectric constant are not free; they are determined by the atomic-layer parameters that the cascade has already locked. The Small-Molecule-Closure lemma is essentially the statement that all such "why this molecule, not another" questions have one joint answer: the joint GFF minimum on the warm-wet substrate.

Daily-life metaphor. Why are the kitchens of every culture stocked with water, salt, sugar, vinegar, oil, and a few other staples, even when the cultures have never communicated? Because the constraints of cookery on a planet with this biochemistry force convergence on these staples. Small-Molecule- Closure is

the lemma that says: the kitchen's small-molecule pantry is forced the same way the cosmic small-molecule pantry of life is forced.

Lemma G.2 (Layer 5 Conditional): Chirality-Lock

Claim. Of the twenty amino acids and the sugars that form RNA's and DNA's backbone, the L-handed amino acids and the D-handed sugars are forced by the Qi-4 admissibility filter applied to the chirality stratum. No other handedness combination passes the filter; in particular, the mirror world (D-amino / L-sugar) is forbidden, not merely unobserved.

What's needed. A chirality-projection theorem in GG-A7-Qi4-Qi-4 that shows the chirality stratum has a unique admissible fixed point. Concretely: (i) Identify the geometric origin of chirality (Wilson-line phase on S^1_θ in the BI-6 construction, or an analogous structure on the scale-radius direction); (ii) Show that the DGI stage of Qi-4 explores chirality symmetrically (no preferred handedness at the exploration step); (iii) Show that the GSSB stage selects one handedness (Wilson-line phase fixed by the CP-violation source of GG-A9-SM); (iv) Show that the GA stage stabilizes the selection (no return to mirror-symmetric basin).

Current status. Asserted from biochemistry's empirical record; pending the chirality-projection theorem.

Promotion path. This is a theoretical-proof problem, doable in a successor paper to GG-A7-Qi4. It is closely related to the CP-violation source question in GG-A9-SM (the chiral-bias mechanism in cosmology is OP-7 in Appendix I); the two problems likely share the same upstream constitutional input.

Physics intuition. The Wilson-line phase on S^1_θ is the only constitutional source of a parity-odd quantity in the BI-6 construction. If the Chirality-Lock lemma is going to be proved at all, it must trace back to this phase. The physical question is: does the Wilson-line phase fix one handedness directly, or does it fix handedness through a chain (Wilson-line → chiral-bias in cosmology → early-Earth chemistry → L-amino selection)? Either route would prove the lemma.

Daily-life metaphor. Why does every screw on every factory floor turn the same way? Because once a global convention is selected (right-handed screws), local non-conformity becomes non-functional. The chirality lock is the cosmic analog: once a global convention is set by the Wilson-line phase, all the downstream chemistry must conform. The lemma is the statement that the global convention is forced, not chosen.

Lemma G.3 (Layer 8 Conditional): Codon-Mapping

Claim. The $4^3 \to 20$ triplet-codon map (with three stop codons) is the unique stable encoding under GFF descent on the polymer-folding layer. No other codon table passes Qi-4 admissibility on the layer-8 substrate.

What's needed. An information-theoretic derivation from GG-A5-GDOS-GDOS plus the four-letter alphabet of GG-A6-GRIP-Gi-4. The four-letter RNA alphabet (A, U, G, C) is fixed at layer 8 by Gi-4 pillars; the question is whether the codon map at layer 8 is forced. Concretely: (i) Define the GFF on the codon-table configuration space (a finite combinatorial space: number of ways to partition $4^3 = 64$ codons into 20 amino-acid groups plus stop codons); (ii) Show that the empirical codon table is the unique GFF minimum; (iii) Verify that nearby codon tables (e.g. alternative degeneracy patterns) fail Qi-4.

Current status. Asserted from biology's empirical record; pending the information-theoretic derivation. Hints from the literature on the optimality of the genetic code under robustness-against-mutation criteria (the standard "frozen accident" debate); the framework's claim is stronger than "optimal": it is *forced*.

Promotion path. A theoretical-proof problem, doable in a successor paper. No new experimental input is required. The proof must show that codon-table optimality under combined robustness, decodability, and GFF cost is a strict minimum (not merely a local one).

Physics intuition. A codon table is a *code* in the Shannon sense; the cascade's claim is that the code is forced by the joint cost (storage cost, decoding cost, error correction cost) measured by the GFF. A first-year-grad-student exercise: compute the entropy of the codon table and compare to alternative tables; the framework predicts that the standard table is the *unique* table that simultaneously minimizes decoding error, storage entropy, and GFF cost.

Daily-life metaphor. Why do all keyboards in a given language have the same layout? Because the joint cost (training cost, decoding speed, error rate) of an alternative layout exceeds the joint cost of the standard. The codon table is the genetic equivalent: the cascade picks the layout, and the layout is forced.

Lemma G.4 (Layer 15 Asserted): Neural-Ring-Attractor existence

Claim. The insect ellipsoid-body ring attractor is the unique stable layer-15 GGA; the topological ring structure is forced by the GRIP cascade on the neural substrate.

Empirical anchor. The ring attractor has been documented in *Drosophila* by Kim et al. (2017); the two-photon imaging and connectomics work of the past decade has confirmed both the ring topology and the bump-attractor dynamics.

What's needed. A derivation from layer-10 SeOS first cell to layer-15 ring topology via GRIP cascade on the neural substrate. Concretely: (i) Identify the neural-substrate analog of the GFF (the cost functional whose minimization drives synaptic plasticity); (ii) Show that on a substrate that has discharged layer-10 (a cell capable of sensorimotor coupling), the unique stable GGA on the heading-direction stratum has ring topology; (iii) Confirm by comparison with the empirical ring attractor.

Current status. Asserted from empirical neuroscience; the derivation from constitutional principles is in progress. In the codebook, the row is marked *Asserted* pending the derivation.

Promotion path. Mixed theoretical-empirical. The empirical anchor is solid; the theoretical derivation requires a SeOS-on-neural-substrate formalism that is partial as of this writing. Settlement expected from a combination of computational neuroscience modeling and continued *Drosophila* connectomics. Estimated timeline: 5–10 years.

Physics intuition. The ring topology arises whenever a one-dimensional periodic variable (heading direction $\in S^1$) must be represented robustly on a noisy substrate. Mexican-hat lateral connectivity plus winner-take-all dynamics yields a bump attractor on a ring; this is textbook Amit (1989). The framework's stronger claim is that this is the *unique* layer-15 GGA on the cascade's neural stratum; alternative encodings (e.g. Cartesian) fail Qi-4 admissibility on a substrate that must support the allocentric map of layer 16.

Daily-life metaphor. How does an experienced sailor know which way is north on a foggy day? By integrating angular velocity from the wind on his cheek and the rocking of the boat, maintaining an internal heading bump that updates continuously. The cascade's claim is that any sufficiently general such navigator must instantiate the same ring attractor; the fly's ellipsoid body and the sailor's internal compass are the same GGA.

Lemma G.5 (Layer 16 Asserted): Allocentric-Map existence

Claim. The rodent hippocampal place–grid–time–causal four-dimensional manifold is the unique stable layer-16 GGA; the manifold structure is forced by the GRIP cascade applied to a substrate that has already discharged layer 15.

Empirical anchor. The head-direction cell layer is documented by Taube et al. (1990); the place-cell and grid-cell layers by O'Keefe and Moser; the time and causal layers by more recent work cited in Part XVI §77. The phenomenology is rock solid.

What's needed. A derivation from layer-15 ring attractor to layer-16 four-dimensional manifold via GRIP cascade. Concretely: (i) Define the SeOS-on-neural-substrate formalism rigorously; (ii) Show that the four-dimensional manifold (place × grid × time × causal) is the unique stable basin of the layer-16 GFF; (iii) Verify that the empirical hippocampal architecture instantiates the four-dimensional manifold uniquely.

Current status. Asserted from rodent neuroscience; derivation in progress.

Promotion path. Mixed theoretical-empirical. Both sides of the lemma require continuing work: theory needs the neural-SeOS formalism; experiment needs the causal and time layers to be characterized as carefully as the place and grid layers have already been characterized. Estimated timeline: 10–15 years.

Physics intuition. An allocentric map is a representation of space that does not depend on the agent's current heading; this requires combining a heading attractor (layer 15) with an integrator that converts heading-plus-displacement into absolute position. The grid-cell hexagonal tiling is the unique stable periodic tiling of the plane with integer-degree rotational symmetry compatible with continuous translation; this is a basic fact of crystallography. The framework's stronger claim is that hexagonal grid tiling is the *unique* layer-16 GGA; alternative tilings (square, triangular) fail Qi-4 on a substrate that must support episodic memory at layer 17.

Daily-life metaphor. A city's grid of streets is hexagonal in some old European cities and rectangular in most American cities; both work. But the brain's grid is hexagonal, not rectangular, and the lemma asks: why is this so? The framework's answer is: hexagonal tiling minimizes representational ambiguity under translation; the brain has selected the unique Qi-4- admissible layer-16 GGA.

H.3 The two methodological lemmas

Beyond the five layer-level lemmas, two methodological lemmas support the entire cascade. These are not about a single layer; they are about the operation of the cascade as a whole.

Lemma G.6 (Methodological): Multi-stratum recursion

Claim. The SIP-tower recursion of Corollary 55.3 is well-defined when the substrate changes *stratum* from gauge (layer 1) to atomic (layer 3) to molecular (layer 4) to neural (layer 15) to cognitive (layer 17). The recursion's well-definition is not jeopardized by substrate change.

Current status. Assumed in the present paper; needs proof. The proof obligation is conceptual rather than computational: to show that the operational meaning of "the layer-n output is the layer-(n+1) substrate" is preserved across stratum changes.

What's needed. A category-theoretic or operadic formulation of the cascade that makes the substrate change a functorial operation. Each stratum-change point (layer 4 onset of chemistry, layer 10 onset of biology, layer 15 onset of neuroscience, layer 17 onset of cognitive science) is a base-change in the recursion's category; the lemma is that base-change is well-defined.

Promotion path. Theoretical, doable in a successor paper devoted to the foundations of the cascade. Closely related to recent work on hierarchical Bayesian inference and to category-theoretic approaches to physics.

Physics intuition. The same Lagrangian formalism that describes gauge fields also describes molecular vibrations; this is a daily working fact of quantum chemistry. But the same formalism does not obviously describe neural firing patterns or cognitive maps. The lemma's claim is that the GFF formalism — not specifically the Lagrangian, but the more general Lyapunov + Qi-4 structure — does in fact descend through all the strata. A clean proof would lay this out at the categorical level.

Daily-life metaphor. A musician transposes a piece from C major to F major; the structure of the piece is preserved. The multi-stratum-recursion lemma is the statement that the cascade transposes through eighteen strata, and the structure of the cascade is preserved. The chord progressions of layer 4 (chemistry) sound like the chord progressions of layer 17 (cognition) because the underlying composition is the same.

Lemma G.7 (Methodological): Universal-identity invariance

Claim. The universal-identity insight (every electron is the same electron; every ATP is the same ATP) holds across cascade-layer changes. Equivalently, the gauge-equivalence statement of Theorem 55.5 extends to the meta-cognitive layer: every articulator is the same articulator.

Current status. Asserted at the closing of Part XIV; needs a careful proof at the meta-cognitive layer. The lower strata (every electron is the same; every proton is the same; every ATP is the same) are sufficiently clear from gauge-equivalence at their respective layers; the higher strata (every conscious episode is the same; every articulator is the same) are far more delicate.

What's needed. A proof that gauge equivalence at the meta-cognitive layer (T-Universal-Identity extended to layer 18) is operationally well-defined. The challenge is that "identity" becomes harder to specify as the cascade ascends: two electrons being the same is a textbook quantum-mechanical statement, but two conscious episodes being the same requires a careful specification of what counts as the same.

Promotion path. Theoretical and philosophical. Requires collaboration with philosophy of mind to specify the identity relation at the cognitive layer. Closely related to the operational definition of consciousness in Theorem 64.3.

Physics intuition. "Two electrons are the same electron" is the statement that they belong to the same *representation* of the gauge group, and that any difference between them is a gauge artifact. The lemma's claim is that the analogous statement holds for any GGA: any two ATP molecules differ only by gauge artifact; any two conscious episodes differ only by gauge artifact at the appropriate higher gauge group.

Daily-life metaphor. Two performances of Beethoven's Ninth Symphony are not literally identical (different orchestras, different concert halls, different audiences) but they are representations of the same symphony. The lemma's claim is that all layer-n products are performances of the same symphony at their layer. Different orchestras (substrates), same symphony (GGA).

H.4 The promotion schedule

We summarize the seven named lemmas, together with six further per-layer lemmas, in a tabular promotion schedule — thirteen rows in all.

Table 25: Lemma-promotion roadmap. Each row names a lemma, its current status, the path to promotion, an estimated timeline, and the responsible downstream paper. Thirteen rows. Each names a lemma, the layer it sits on, what proving it would buy — in every case the promotion of a named theorem from Asserted or Conditional to Derived — an estimated timeline, and the downstream paper responsible for it. This is the register the Conditional tag in the confidence legend points at.

Lemma	Currently	Promotion path	Estimated timeline	Responsible paper
Dual-Gauge-SSB-Uniqueness	Layer 11	The DGL(5:2) action admits exactly two stable minima (Bacteria $\oplus$ Archaea); no third primary domain. Promotes T-Primary-Domain-Split from Asserted to Derived.	2027–2030 (theoretical)	T-Primary-Domain-Split
Energy-Per-Gene-Phase-Jump	Layer 12	DGL page coupling at the mitochondrial inner membrane gives δW/gene $\geq 2\times$ the prokaryotic baseline. Promotes T-Eukaryogenesis from Asserted to Derived.	2027–2030 (theoretical) + dual-knee $1/f$ PSD experiment	T-Eukaryogenesis
Multicellularity-M-Ladder-Closure	Layer 13	The 8-rung M-ladder $2^{L-2} = 8$ from OGN-5 is the unique stable trajectory from layer-12 GGA to organogenesis. Promotes T-Multicellularity from Asserted to Derived.	2028–2031 (theoretical + Kleiber 3/4 derivation)	T-Multicellularity

(continued)

Lemma	Currently	Promotion path	Estimated timeline	Responsible paper
4-Letter-Alphabet-Uniqueness	Layer 8	$\|\Sigma\| = N + 1 = 4$ is the unique alphabet cardinality selected for *naturally evolved* life under Watson–Crick double-strand pairing at OGN-5 $(N = 3, L = 5)$; laboratory-synthesized expanded alphabets (e.g. Hachimoji DNA) are engineered constructs that do not self-sustain in the wild and are not excluded. Sharpens the RNA-World theorem.	2026–2028 (theoretical)	T-RNA-World-Closure
RNA-Information-Catalysis-Bifunctionality	Layer 8	RNA is the unique polymer that is simultaneously informational (sequence) and catalytic (folded ribozyme); the 2′-OH instability is the price paid for this duality, and explains why DNA later takes over storage.	2026–2028 (theoretical)	T-RNA-World-Closure
DNA-Takeover-Stability	Layer 9	The deoxyribose backbone has $\sim 10^6\times$ better hydrolytic stability than ribose; the RNA $\rightarrow$ DNA transition is energetically forced once reverse transcriptase emerges in proto-cells. Promotes T-Information-Closure from Asserted to Derived.	2027–2029 (theoretical + biochemistry)	T-Information-Closure
G.1 Small-Molecule-Closure	Conditional	Morse-theoretic proof on GFF; tabulated chemistry anchor	5–10 yr	GG-A12-Chemistry or successor molecular-landscape paper
G.2 Chirality-Lock	Conditional	Wilson-line chirality-projection theorem in GG-A7-Qi4 successor	3–7 yr	GG-A7-Qi4 successor / GG-A12-Chemistry
G.3 Codon-Mapping	Conditional	Information-theoretic derivation from GG-A5-GDOS-GDOS + GG-A6-GRIP-Gi-4	3–7 yr	GG-A5-GDOS successor / GG-A13-Life
G.4 Neural-Ring-Attractor	Asserted	Theoretical derivation + continued *Drosophila* connectomics	5–10 yr	Computational neuroscience programs

(continued)

Lemma	Currently	Promotion path	Estimated timeline	Responsible paper
G.5 Allocentric-Map	Asserted	Theoretical derivation + continued rodent/human hippocampus work	10–15 yr	Computational neuroscience programs
G.6 Multi-stratum recursion	Assumed (methodological)	Category-theoretic / operadic foundations	5–10 yr	A foundations successor (category-theoretic)
G.7 Universal-identity invariance	Asserted (methodological)	Operational identity at meta-cognitive layer	10–15 yr	GG-A14-Mind / philosophy-of-mind collaboration

Reading the schedule. Three lemmas (G.2 Chirality-Lock, G.3 Codon-Mapping, G.6 Multi-stratum recursion) are theoretical-proof problems that could be discharged in GG-A12-Chemistry, GG-A13-Life, or a foundations successor. Two lemmas (G.1 Small-Molecule-Closure, G.7 Universal-identity invariance) need a combination of theory and empirics or theory and philosophy. Two lemmas (G.4 Neural-Ring-Attractor existence, G.5 Allocentric-Map existence) are primarily empirical and will be settled by ongoing experimental neuroscience. The framework's overall maturity will be measurably greater once three of the seven named lemmas have been promoted; once five of the seven have been promoted, the framework will have exited its program stage and entered its closed-theory stage.

The empirical lemmas as anchor points. Lemmas G.4 and G.5, although marked *Asserted*, are arguably the *best-evidenced* entries in the codebook — a reminder that a grade records the state of the *derivation*, not the weight of the evidence. The cohort legend is one-dimensional and is stated once, in §41.1: *Conditional* means derived modulo one named lemma, *Asserted* means not yet derived and pending a specific experiment, and *anchor-Derived* means the empirical anchor is closed while the from-geometry proof is deferred. A row can therefore be empirically strong and still carry a weak grade; that is the discipline working, not a second axis.

H.5 Closing of the roadmap

The difference between a program and a closed theory is not the number of theorems; it is the explicit accounting of the lemmas that are not yet theorems. The present roadmap is the program's explicit accounting. We list thirteen lemmas; each is named, each is sized, each is dated, each is assigned a responsible downstream paper. The reader who wants to know what remains to be proved has the answer in this Appendix. The hostile reviewer who wants to point at an unmarked Conditional or Asserted row will find that none such exist: every row is marked, every mark is annotated, every annotation has a promotion path.

A closed theory is the limit of a healthy program. This Appendix is the documentation of where we are on the path to that limit.

I Problems Solved and Future Directions: the next decade of the program

I.1 Why this catalog

The lemma-promotion roadmap of Appendix H catalogs the named lemmas whose proof would close specific codebook rows. The present Appendix complements that roadmap by listing the *theorem-level* open problems: structural questions whose resolution would extend the framework's reach, rather than merely close a Conditional row. Open problems differ from Conditional rows in that they are not pre-specified by the codebook; they are research questions that the framework's existence has made askable.

In plain English: the codebook tells us *what we have not yet proved*. This Appendix tells us *what we have not yet asked*. The two are complementary; both are necessary if the framework is to be honest about its incompleteness.

We tag each open problem with one of three status labels: **[Open]** (no resolution in sight at the time of writing), **[Partially Resolved]** (significant progress made, full resolution pending), or **[Resolved]** (a worked-example entry, included to illustrate what resolution looks like). The L6 convention of status tagging is observed throughout.

I.2 Theorem-level open problems

We list ten theorem-level open problems.

OP-1 (PS-Origin-1) [Open]: The deterministic–stochastic boundary

Question. At what cascade depth does the recursive uniqueness theorem transition from *deterministic* (layers 1–7: gauge group, electroweak vacuum, periodic table, small molecules, amino acids, polymers, bioenergetics) to *stochastic-ensemble* (layers 10–18: first cell, ring attractor, allocentric map, conscious episode, articulation)?

Context. At layer 7 and below, the framework asserts uniqueness of individual products: there is one periodic table, one ATP molecule, one DNA structure. At layer 10 and above, the framework asserts uniqueness of *classes*: there is one LUCA *class*, but the individual LUCA is not specified; there is one ring-attractor class, but the individual neural circuit is not specified. The transition is real but not sharply located.

Why it matters. A clean characterization of the deterministic–stochastic boundary would clarify what T-Origin (Theorem 50.1) actually claims existence of: a specific cosmos or a class of cosmoses. At present the framework claims existence of *the* cosmos with the constitutional axioms, but the individuation at high layers is ensemble-individuation rather than instance-individuation.

Daily-life metaphor. Compare "every elementary school in this country teaches the same alphabet" (deterministic at the alphabet level) with "every elementary school in this country teaches its own version of recess" (stochastic at the recess level). The framework needs to pin down where in the cascade this shift happens.

OP-2 (PS-Origin-2) [Partially Resolved]: The handedness origin

Question. Is the L-amino / D-sugar combination forced by the scale-radius structure of the BI-6 bulk, or by the Wilson-line phase on S^1_θ, or by a combination?

Status. Partially Resolved. The L-amino / D-sugar combination has been documented as the empirical fact; the constitutional origin is partial. The handedness origin and the Chirality-Lock lemma (G.2) of Appendix H are closely related; full resolution of the handedness origin would close layer 5 (Chirality-Lock).

What is known. The Wilson-line phase on S^1_θ in the BI-6 construction is the only constitutional source of a parity-odd quantity; the chirality lock must trace back to it. What is not yet known is the explicit propagation chain from Wilson-line phase to L-amino selection through layer 4 chemistry.

Promotion path. See Lemma G.2 in Appendix H.

OP-3 (PS-Origin-3) [Open]: The Type-I vs Type-II civilization question

Question. The framework predicts the existence of articulators at layer 18 (us). Does the cascade have a natural Type-N civilization classification, analogous to the Kardashev scale?

Context. An articulator is the unique stable layer-18 GGA: a meta-cognitive attractor capable of writing down the laws of physics that produced it. But what is the scale of an articulator? A single human is not an articulator in the constitutional sense; rather, the scientific community in aggregate, with its instruments and its corpus, is the articulator. The question is whether this scale is unique, or whether the framework permits Type-I (planetary) articulator → Type-II (stellar) articulator → Type-III (galactic) articulator hierarchies.

What is known. The framework's empirical horizon (Part IV §41) is silent on this question. The cascade terminates at layer 18 by Theorem 55.6; a layer 19 articulator-of-articulators is forbidden by self-reference. But within layer 18, the scale of the articulator is unconstrained by the present theorems.

Why it matters. If multiple articulator scales are admissible, the framework predicts that the universe could contain several mutually-undetected articulator communities; if a single scale is forced, the framework constrains the SETI search space.

OP-4 (PS-Origin-4) [Open]: Multi-articulator-class extension

Question. Could the cascade close on multiple meta-cognitive attractors simultaneously? If so, what would the interaction between such attractors look like?

Context. T-Universal-Identity (Theorem 55.5) says every articulator is the same articulator, in the gauge-equivalence sense. But the existence of multiple gauge-inequivalent articulator classes is not excluded by the present theorems. If, for example, the warm-wet stratum and a hypothetical warm-dry stratum both close the cascade, then two articulator classes would coexist.

What is known. The framework strongly prefers the warm-wet stratum (the bioenergetic quantum $\mathsf{Q_B}$ is anchored to warm-wet chemistry); other strata are not ruled out.

Why it matters. If multiple articulator classes can coexist, the framework predicts that the universe may host biospheres of different biochemistry, mutually undetected because they live on different gauge-inequivalent attractors.

OP-5 (PS-Origin-5) [Resolved]: The Hubble two-stage structure

Question. Why does the observed Hubble constant display the two-stage structure (late-time vs early-time tension) documented in Planck Collaboration (2020) and GG-A10-Cosmos?

Status. Resolved. The two-stage structure is derived in GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos) as Theorem T-Cosmos-16, the two-stage corridor existence theorem, as a consequence of the cascade's behavior at the cosmological boundary. Worked example of L6 status: this is what *Resolved* looks like in a healthy program. An entry that was an open problem two cycles ago is now an entry of the parameter-audit ledger.

Why it is included. To show that the open-problems catalog is not a static list. Items move from *[Open]* to *[Partially Resolved]* to *[Resolved]* over time; the catalog's job is to register the motion.

OP-6 (PS-Origin-6) [Open]: Layer-19 prevention

Question. The framework forbids articulating the articulation: Theorem 55.6 says the cascade has exactly eighteen layers, no nineteenth. Can this prohibition be derived from Gödel's incompleteness in a precise way?

Context. The current proof of layer-19 forbiddance appeals to a self-reference argument: an articulator-of-articulators would have to articulate itself, which would require a constitution strictly larger than the one it has articulated. This is morally Gödelian but not formally so.

What is known. Gödel's incompleteness theorem applies to formal systems of a certain expressive power; the framework's constitutional axioms are at the edge of that expressive power. A formal derivation of layer-19 forbiddance from Gödelian incompleteness would close the open problem.

Why it matters. The layer-18 termination is the framework's strongest meta-claim. A Gödelian derivation would elevate it from a self-reference argument to a formal theorem.

Daily-life metaphor. A camera can photograph anything except itself in the act of photographing; this is not a defect of the camera but a structural feature of any device that *articulates* another device. The layer-19 forbiddance is the cosmic version of this structural feature.

OP-7 (PS-Origin-7) [Partially Resolved]: The chiral-bias mechanism in cosmology

Question. Where in the cascade does the chiral bias (baryon asymmetry, lepton asymmetry, eventual L-amino selection) originate?

Status. Partially Resolved. GG-A10-Cosmos has the baryogenesis story partial; full closure requires a CP-violation source from GG-A9-SM-Standard Model. The chain "CP-violation in GG-A9-SM → baryogenesis in GG-A10-Cosmos → chiral bias in A11 layer 5" is conjectured but not derived in full detail.

What is known. Each link in the chain is plausible; no link has been ruled out; the chain as a whole has not been verified.

Promotion path. This is a multi-paper project that would close OP-7 simultaneously with the Chirality-Lock lemma (G.2) and the handedness-origin OP-2. The three open problems share an upstream cause and are likely to be resolved together.

OP-8 (PS-Origin-8) [Open]: Layer-10 stochastic ensemble

Question. The SeOS first-cell layer is stochastic in the sense that the individual identity of LUCA is not forced, only the class. Does the framework permit multiple parallel LUCA classes?

Context. Layer 10 is the deterministic–stochastic transition point. The class of LUCA-equivalent first cells is uniquely characterized (Theorem 58.2) but the individuals inside the class are not. This is the layer at which the universal-identity insight first becomes ensemble-identity rather than instance-identity.

What is known. Earth's biosphere is monophyletic; all known life descends from a single LUCA. The framework allows multiple LUCA classes in principle; whether the universe contains multiple LUCA-class biospheres is unsettled.

Why it matters. A clean characterization would constrain astrobiology: it would either permit parallel biospheres (open question for SETI) or forbid them (the universe is monophyletic to a class).

OP-9 (PS-Origin-9) [Open]: The CDI saturation question

Question. The CDI (Qi-4 consciousness index) is monotonically increasing along cascade ascent (Theorem 63.1). Does it saturate at layer 18, or does it asymptote?

Context. A saturating CDI would mean that articulation is the highest CDI value attainable; an asymptoting CDI would mean that articulation is the limit of an infinite cognitive ascent. The framework is currently silent on which.

Why it matters. Connects to OP-3 (Type-N civilizations) and to the philosophical question of whether higher consciousness than human articulation is meaningful.

OP-10 (PS-Origin-10) [Open]: The cascade's robustness to perturbation

Question. What is the robustness of the cascade closure to small perturbations of the constitutional axioms? If GG-A1-Constitution's axioms are perturbed by ϵ, does the cascade still close, and does the layer-18 articulator still exist?

Context. The framework's central claim is uniqueness; the robustness question asks whether the unique closure is isolated (small perturbations destroy it) or is a basin of attraction (small perturbations are absorbed).

Why it matters. Distinguishes between two pictures of T-Origin: an isolated-uniqueness picture (the cosmos is on a razor's edge) and a basin-uniqueness picture (the cosmos is on a plateau). The current proofs do not distinguish.

I.3 Experimental open problems

The framework also has an empirical horizon (Part IV §42); we list the principal experimental open problems whose resolution would extend or falsify the framework.

EP-1 (PS-Origin-11): The Kaluza–Klein lock-cluster

Find or rule out the KK lock-cluster at 3.85 TeV predicted by GG-P1-KK (Arisaka, 2026, P1-KK). Required: HL-LHC at full luminosity in the relevant invariant-mass channel. Estimated timeline: 5–10 years from the time of writing.

EP-2 (PS-Origin-12): The Kaxion dark-matter candidate

Find or rule out the Kaxion dark-matter candidate at 8.1 μeV predicted by Arisaka-GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion). Required: ADMX-class haloscope experiments at the relevant mass-window. Estimated timeline: 3–7 years.

EP-3 (PS-Origin-13): The cosmological recombination ratio

Measure the operational decoupling redshift z_{dec} model-independently and confront it with GG-A10-Cosmos's atomic-chain prediction (≈ 1091, zero fitted parameters, presently on Planck Collaboration (2020) $z_{\mathrm{dec}} \approx 1089.92$ at the 0.1% level); the corridor switch $z^{\star} = e^{7} \approx 1096.6$ is a distinct topological marker 0.5% above it. Required: an experimental probe of the recombination history (CRR spectral distortion, 21-cm) at sub-percent precision; the kill is z_{dec} off the atomic-chain value by more than 0.5%. Estimated timeline: 5–15 years.

EP-4 (PS-Origin-14): The bioenergetic quantum

Find or rule out the framework's prediction $\mathsf{Q}_{\mathsf{B}} \approx 0.1555$ eV/qubit (Theorem 57.1). Required: single-molecule calorimetry of ATP hydrolysis at the operationally-defined information-bearing channel. Estimated timeline: 5–10 years.

EP-5 (PS-Origin-15): The CDI ladder in neuroimaging

Test the cascade's prediction of a strict CDI ladder (Theorem 63.1) by neuroimaging across species at different cognitive strata. Required: cross-species neuroimaging with operationally-comparable CDI metrics. Estimated timeline: 10–20 years.

EP-6 (PS-Origin-16): Cross-species universal-identity in cognitive maps

Search for the framework's prediction (Theorem 55.5) that the layer-16 allocentric map is structurally the same map in rodent and primate. Required: comparative neuroscience with high-resolution recording across species. Estimated timeline: 5–15 years.

EP-7 (PS-Origin-17): SETI and the Type-II forbiddance

Probe the framework's prediction that no Type-II civilization exists in our light cone (OP-3 read as a falsifiable assertion). Required: continued SETI search at radio, optical, and techno-signature frequencies,

with a precise definition of what "Type-II" means in the framework's terms. Estimated timeline: indefinite; null result strengthens the prediction.

I.4 Connections to other programs

The framework occupies a particular intellectual neighborhood; we list the adjacent programs with which productive handshakes are expected.

String theory landscape. The cascade's claim of unique closure stands in apparent opposition to the string-theory landscape's claim of 10^{500} vacua. But the opposition is more apparent than substantive: the framework's constitutional axioms *select* from a candidate landscape; the framework does not deny the candidate landscape's existence, only its selection-free status. A productive handshake would identify the framework's unique closure as a constrained subset of the landscape and would characterize the constraint algebraically.

Integrated Information Theory (IIT). Tononi (2008) proposes that consciousness is the integrated information of a system. The framework's Theorem 64.3 operationally identifies consciousness with internal measurement on the EIC. The two definitions are not the same but they are adjacent; a handshake would express integrated information in terms of EIC closure quality δ_{rec}.

Global Workspace Theory (GWT). Dehaene (2014) proposes that consciousness is a workspace where information is broadcast for access by multiple cognitive modules. The framework's OH/IH/EIC triad has a comparable architecture; the EIC is a workspace where OH and IH are reconciled. A handshake would identify the EIC closure event with the GWT broadcast event.

Free Energy Principle (FEP). Karl Friston's Free Energy Principle is the closest neighbor to the framework's GFF + Qi-4 architecture. Theorem 59.3 identifies the Three-Gauge Theorem with the Gibbs/Friston/ GG-Theory identity; this is the cleanest handshake in the neighborhood. Future work should extend the identity to the allocentric and meta-cognitive layers.

Loop quantum gravity and other quantum-gravity programs. The framework's UV side (the BI-6 closure of GG-A3-BI6) is a string-theoretic construction; an alternative UV construction in loop quantum gravity or in causal-set theory would be welcome. A handshake would test whether the cascade's constitutional axioms are robust to UV-completion choices.

Algorithmic information theory. The framework's information-theoretic side (GG-A5-GDOS-GDOS and the EIC formalism) connects naturally to algorithmic information theory; a handshake would identify the GFF cost with a Kolmogorov- complexity-like measure of the cascade's compression.

Philosophy of mind. Chalmers (1995) divides consciousness into the easy problems and the hard problem; the framework's Theorem 64.3 is a candidate operational answer to the hard problem. The handshake with philosophy of mind is the most necessary and the most delicate.

I.5 The catalog's longtable

We close the Appendix with a tabular summary of the open problems, their status, and their estimated resolution timelines.

Table 26: Open problems and their projected resolution. Each row gives the problem code, its short statement, its status, the expected resolution path, and the estimated timeline. Twenty-two rows, each with a code, the problem in one line, its status as Open or Partially Resolved, the resolution path, and a timeline. The register is deliberately unflattering: it lists the demarcation criterion the regime distinction still lacks, the predictions whose experimental tests have not been run, and the asymmetries the framework asserts without deriving.

Code	Problem	Status	Resolution path	Timeline
OP-11	GRIP-In/Out demarcation	[Open]	Quantitative criterion in terms of GFF control-parameter rate of change $\lvert\dot{p}\rvert$ for when a system is in within-layer regime vs out-of-equilibrium shock; a sharp threshold would let experimentalists classify any open-system transition.	3–5 yr
OP-12	Layer-13+ cascade autocatalysis	[Partially Resolved]	For layers ≥ 12 the GRIP-Out trigger mechanism becomes increasingly cultural/cognitive rather than biophysical; a formal characterization of cultural GRIP-Out events as cascade dynamics is open.	5–10 yr
OP-13	Dual-knee $1/f$ PSD verification	[Open]	T-Eukaryogenesis predicts a dual-knee $1/f$ PSD signature in eukaryotic cellular activity (vs single-knee in prokaryotes); direct experimental test across phylogenetically diverse eukaryotes and prokaryotes is open.	2–5 yr
OP-14	Primary-Domain-Split sharpness	[Partially Resolved]	T-Primary-Domain-Split asserts exactly two stable membrane-lipid GGAs but the asymmetry (why archaea ether and bacteria ester) is unresolved; needs a chirality-like lemma at the lipid scale.	3–7 yr

(continued)

Code	Problem	Status	Resolution path	Timeline
OP-15	Multicellularity M-ladder universality	[Open]	T-Multicellularity predicts the M0–M7 ladder is universal across independent origins (animals, plants, fungi, algae); cross-kingdom comparative-genomics studies of M-rung markers would test universality directly.	3–5 yr
OP-1	Deterministic–stochastic boundary	[Open]	Structural theorem on cascade ensemble individuation	5–10 yr
OP-2	Handedness origin	[Partially Resolved]	Closes with Lemma G.2 Chirality-Lock	3–7 yr
OP-3	Type-I vs Type-II civilization	[Open]	Scale-of-articulator theorem + SETI null	indefinite
OP-4	Multi-articulator-class extension	[Open]	Gauge-inequivalent attractor enumeration	10 yr+
OP-5	Hubble two-stage structure	[Resolved]	GG-A10-Cosmos T-Cosmos-16 (worked example)	resolved
OP-6	Layer-19 prevention	[Open]	Gödelian formalization of self-reference	5–10 yr
OP-7	Chiral-bias in cosmology	[Partially Resolved]	Closes with OP-2 + Lemma G.2	5–10 yr
OP-8	Layer-10 stochastic ensemble	[Open]	SeOS-class individuation theorem	10 yr+
OP-9	CDI saturation	[Open]	Saturation theorem for CDI at layer 18	10 yr+
OP-10	Cascade robustness	[Open]	Perturbative analysis of T-Origin	5–10 yr
EP-1	KK lock-cluster at 3.85 TeV	[Open]	HL-LHC full luminosity	5–10 yr
EP-2	Kaxion DM at 8.1 μeV	[Open]	ADMX-class haloscope	3–7 yr
EP-3	$z_{\rm dec}$ (atomic chain) vs Planck; switch $z^\star = e^7$ distinct (two-quantity; see Part XVI §77.7)	[Open]	Model-independent $z_{\rm dec}$ probe (CRR spectral distortion, 21-cm)	5–15 yr
EP-4	$\mathsf{Q_B} \approx 0.1555$ eV/qubit	[Open]	Single-molecule calorimetry	5–10 yr
EP-5	CDI ladder in neuroimaging	[Open]	Cross-species CDI measurement	10–20 yr
EP-6	Cross-species universal-identity	[Open]	Comparative neural recording	5–15 yr
EP-7	Type-II forbiddance	[Open]	Continued SETI null result	indefinite

I.6 Closing of the catalog

No program closes itself. A program stays open because the world is always larger than the program. This Appendix is the framework's standing offer: here are the questions we have made askable, and here are the questions we have not yet answered. A future researcher who reads this Appendix and finds the question

that lights them up has found, in our judgment, the best entry point.

The catalog divides naturally. Three of the open problems (OP-2, OP-7, and OP-8) cluster around chirality and individuation; two (OP-3, OP-4) cluster around scale of articulator; one (OP-6) is a meta-theorem about the cascade's depth; one (OP-9) is the asymptotic behavior of CDI; one (OP-10) is robustness. Two (OP-1, OP-5) are general structural questions about the deterministic boundary, one of which is already resolved. The experimental problems are a separate seven-item list whose resolution belongs to the wider community.

A daily-life metaphor for the catalog as a whole: a long-running research program is like a city under continuous construction. Some blocks are finished; some are scaffolded; some are still designed. The open-problems catalog is the municipal map of unfinished blocks. The map is part of the city's honesty.

In closing: the framework has named one central theorem (T-Origin), thirty-nine other named theorems, thirteen outstanding lemmas, and seventeen open problems. These are the four numbers of a healthy program. The first number says what has been proved. The second number says what has been organized. The third number says what is pending. The fourth number says what is open. A program that quotes only the first number is overconfident; a program that quotes only the fourth number is defeatist. We quote all four.

Every program is at some particular point on the path between the constitutional axioms it has chosen and the closed theory it hopes to become. The forty theorems are how far we have come; the thirteen lemmas are what we are working on now; the seventeen open problems are what we have made askable for the next decade. These three numbers are the program's honesty. We trust them.

Part XX
Common Objections and Responses

The strongest objections a hostile particle theorist, bioenergeticist, systems biologist, origin-of-life researcher, neuroscientist, philosopher of mind, cross-paper referee, and skeptical editor would each raise against the capstone — answered, with pointers to the theorem, falsifier, open problem, or companion paper that bears the weight

A paper that claims to derive the existence of its own articulators from a parameter-free constitution, and to read cosmos, life, and mind as three boundary projections of one recursive theorem, invites the most demanding scrutiny; it would not be honest scholarship to leave the obvious objections unstated. We collect here the strongest adversarial readings — the ones a particle theorist, a bioenergeticist, a systems biologist, an origin-of-life researcher, a neuroscientist, a philosopher of mind, a cross-paper referee, and a skeptical editor would each raise on a careful reading of the whole cohort, not a skim — and answer each, with explicit pointers to the theorem (by its cohort-global id, §78.1), the falsifier (§42.1), the open problem (§I.2), or the companion paper that carries the load. Where the honest answer is "not yet," we say so and name the open item or the forthcoming paper (GG-A12-Chemistry–GG-A14-Mind, in preparation). These objections are deliberately the *surviving* ones — the objections that remain after a referee has read the companions that do the work the present paper only summarizes; the naive forms (that the integer ledger is mere numerology, that the running of α is inconsistent, that the family number flips its own convention) are retired in the companions and are not relitigated here. The objections target the framework's *science*; the personal Coda (Part XVIII) is a statement of vision, not a scientific claim, and is not defended here.

J The particle theorist and mathematical physicist

Objection 1 (O-Origin-1) (the precision-electroweak referee)
"Your headline $\sin^2\theta_W = 25/108$ misses the PDG value by seven sigma; you then 'rescue' it with post-hoc rationals $637/640$, $159/160$, $641/640$. That is integer-search fitting dressed as theory."

Response. The denominator is not free: $640 = 2^J\,L$ is forced by the dyadic exponent and the SU(5) rank, and the QD-completion is a Hopkins–Singer descent-integrality structure derived in GG-A9-SM (Arisaka, 2026, A9-SM) (T-SM, the codebook). What we concede precisely is that the per-fermion *numerator* within the forced $\frac{1}{640}\mathbb{Z}$ lattice is at present *selected*, not derived — GG-A9-SM says so in its own Limits. This is a discrete, named open question, not the continuous tuning the objection alleges; the leading prediction lives on a forced lattice, and the residual is integer-valued and checkable.

Objection 2 (O-Origin-2) (the flavor theorist)
"The generation number $N_g = 3$ is the cohort's most-cited success, yet GG-P2-N3 now calls it a *conditional* derivation and admits the instanton budget is 'exactly the kind of choice a critical referee will identify as a hidden dial."'

Response. Correct, and we have stopped overstating it: the present paper now inherits $N_g = 3$ as the *conditional* three-leg pincer of GG-P2-N3 (Arisaka, 2026, P2-N3) (the lower leg from CP violation, the

upper from the GDOS Morse bound), with the budget $S_{\rm BI} = 3\pi$ flagged as the load-bearing conditional input. The naive 'convention-flip' charge does not survive a reading of GG-P2-N3 (the two legs intersect cleanly at $N_g = 3$); the honest residual is the budget normalization, which we mark rather than hide.

Objection 3 (O-Origin-3) (the collider phenomenologist)
"$M_{\rm lock} = 3.85$ TeV is the linchpin of the electroweak layer, yet it is never derived here and a sharp five-particle cluster at 3.85 TeV should already be excluded by ATLAS/CMS."

Response. The scale is derived in GG-P1-KK (Arisaka, 2026, P1-KK) as $M_{\rm lock} = \frac{1}{2} M_{\rm Pl}\, e^{-K} = 3.85$ TeV, parameter-free given $K = 35$; the present paper inherits it. The predicted object is a *leptophobic, clustered, multi-field line shape* near 3.85–4 TeV, not the universally-coupled spin-2 state that generic Randall–Sundrum dilepton limits exclude, and GG-P1-KK confronts that distinction explicitly. It is a genuine forward bet (F-Origin-1, §42.1) with a pre-declared kill criterion at HL-LHC, not a retrodiction.

Objection 4 (O-Origin-4) (the proton-decay skeptic)
"Theorem and table disagree on proton stability, and Super-Kamiokande already excludes the lifetime you quote."

Response. We harmonized this: the framework's prediction is the orbifold-forbidden value $\tau_p > 10^{35}$ yr in the dominant $p \to e^+\pi^0$ channel, with a model-independent floor of $\tau_p > 10^{34}$ yr; both lie above the current Super-Kamiokande bound $\tau_p > 2.4 \times 10^{34}$ yr, which Hyper-Kamiokande and DUNE will probe toward 10^{35} yr (F-Origin-4, §42.1). Any $p \to e^+\pi^0$ detection short of $\sim 10^{35}$ yr falsifies the row.

Objection 5 (O-Origin-5) (the renormalization-group referee)
"You quote $\alpha^{-1} = 128$ in one place and 137 in another with no running computation linking them."

Response. These are the two endpoints of the standard running, not an inconsistency: $\alpha^{-1}(M_Z) = 2^J = 128$ at the Z pole and $\alpha^{-1}(0) = 2^J + N^2 = 137$ at the Thomson limit, connected by the radial RG flow of GG-A9-SM (Arisaka, 2026, A9-SM). The text labels each by its scale; a reader who reads them as a contradiction has read past the scale labels.

Objection 6 (O-Origin-6) (the skeptical editor)
"You advertise 'zero free continuous parameters,' but your own Standard-Model paper concedes that most of the twenty-eight parameters are not actually derived."

Response. Both statements are true and not in tension, and we now surface the stratification rather than letting the capstone imply universal derivation. GG-A9-SM's honest accounting: exactly one parameter ($\sin^2\theta_W$) is derived end-to-end from non-physics axioms, ten more are conditional on named GG-A9-SM-local lemmas, and seventeen are presented as closed-form integer assignments that are a working hypothesis. 'No continuous dial' is literally true — the ledger is integer-valued — but 'everything is derived' is not what we claim; the residual freedom is discrete and named.

Objection 7 (O-Origin-7) (the precision cosmologist)
"$\Omega_m = 1/\pi$, $\Omega_b = 1/2\pi^2$, $\Omega_\Lambda = 1 - 1/\pi$ are π-decorations matched only to a couple of percent, and DESI now hints *against* $w = -1$."

Response. The cosmic inventory is derived in GG-A10-Cosmos (Arisaka, 2026, A10-Cosmos), inherited here. We concede the agreement is at the percent level against Planck's sub-percent bars, and — crucially — we flag the live tension rather than hide it: the $w = -1$ test is marked *orange* in the falsifier table precisely because DESI's ~ 2–4σ hint of $w \neq -1$ is a standing threat to $\Omega_\Lambda = 1 - 1/\pi$. If a confirmed $w \neq -1$ arrives, the cosmology floor fails; that is the falsifiability working.

Objection 8 (O-Origin-8) (the axion experimentalist)
"Your $8.1\,\mu$eV kaxion is just the misalignment mass retrofitted to the observed dark-matter density, inside a wide window."

Response. The mass is fixed by the theorem-level relation $m_K f_K = \sqrt{\chi_{\rm QCD}}$ of GG-C1-Kaxion (Arisaka, 2026, C1-Kaxion) (T-Kaxion-2), with f_K set by geometry; the relic abundance fixes only the misalignment angle, *not* the mass. We concede the *absolute* frequency rides on a conjectural cap-loading integer (a $\sim \pm 13\%$ window), which GG-C1-Kaxion carries as a benchmark. Earlier revisions of this response answered the objection by pointing at two theorem-level fingerprints — the 1/35 split ratio and the 5:2 portal — and the companion has withdrawn both, so the answer is now narrower and should be read as such: what is fixed without the benchmark is the *shape* of the claim, seven admissible rungs and one line among them, at ansatz and derived-conditional grade. The absolute center is not at the same tier as $M_{\rm lock}$, and neither is the shape.

Objection 9 (O-Origin-9) (the anomaly-cancellation specialist)
"Your SU(5) content is asserted anomaly-free without ever writing the trace, and a single tensor multiplet does not generically cancel."

Response. The trace is exhibited in GG-A3-BI6 (Arisaka, 2026, A3-BI6) (T-BI6-7.2): the four-form $dH_3 = X_4 = \mathrm{tr}\, R^2 - \mathrm{Tr}\, F_5^2 - \frac{2}{5}F_B^2 - \frac{2}{5}F_{Qi}^2$ is written explicitly, the trace ratio $-2/5$ derived from the primitive **5**, and the coefficient vector $(1, -1, -2/5, -2/5)$ packaged as one gauge-invariant tensor (also GG-A2-GG6 T-GG6-4). The present paper imports that result; it does not re-derive it, and says so.

Objection 10 (O-Origin-10) (the naturalness theorist)
"You 'dissolve' the hierarchy problem with the coincidence $(2/5)^3 \approx 0.064$, sixteen orders of magnitude from $v/M_{\rm Pl}$."

Response. We do not re-derive the hierarchy here; the one-loop Wilson–Hosotani minimization that fixes the electroweak vacuum is carried out in GG-A9-SM (Arisaka, 2026, A9-SM) (§§5–7), inherited by citation. The scale suppression is between the lock-cluster scale and the vev, $v = M_{\rm lock}\,(2/5)^N \approx 246$ GeV — not between $(2/5)^3$ and $M_{\rm Pl}$; the larger hierarchy is the scale profile e^{-K} that sets $M_{\rm lock}$ itself, which is the content of GG-P1-KK, not a bare coincidence.

Objection 11 (O-Origin-11) (the neutrino physicist)
"$\delta_{\rm PMNS} \approx 196^\circ$ from $13\pi/35$ is tuned to the current global-fit central value, and your $\pm 30^\circ$ window makes the test nearly unlosable for a decade."

Response. Conceded: this is a genuine but *soft* forward bet. We classify it as a forward falsifier (DUNE/Hyper-K) in §42.1, not as a precision success, precisely because the present experimental error and the kill window are both wide. It is on the ledger as a bet to be settled, with the honest caveat that it will not discriminate sharply until the long-baseline programs tighten.

K The bioenergeticist and biophysicist

Objection 12 (O-Origin-12) (the bioenergetics-minded referee)
"$\mathsf{Q}_\mathsf{B} = (2/5)E_{\rm Ry}/K$ is dimensional numerology: why the Rydberg, why $K = 35$, why $2/5$? With three discrete handles you can hit any biological energy."

Response. The chain is geometry-first with *no biological input*: $K = 35$ and the $2/5$ projection are fixed upstream in GG-A2-GG6/GG-A3-BI6 (T-GG6-6, T-BI6), $E_{\rm Ry}$ is the layer-3 atomic setpoint, and ATP enters

only *afterward* as the empirical comparison (§78.1 cites the construction in GG-A4-Euclid/GG-A7-Qi4). The non-trivial, checkable output is $2N_A\mathsf{Q}_\mathsf{B} = 30.0$ kJ/mol against the measured 30.5 ± 0.5 — a 1.6% prediction with the integer multiplicity (one bond = two quanta) forced. What is genuinely open is the selection-rule *proof* that the per-step quantum is E_{Ry}/K rather than E_{Ry}/J — a discrete question, marked as such.

Objection 13 (O-Origin-13) (the membrane thermodynamicist)
"You anchor to the standard-state 30.5 kJ/mol, but no cell runs at standard state — the in-vivo free energy of hydrolysis is 50–65 kJ/mol. You are fitting the wrong number."

Response. We now distinguish the two quantities explicitly at the point of display: $2N_A\mathsf{Q}_\mathsf{B} \approx 30.0$ kJ/mol is the standard-state free energy *stored in* the phosphoanhydride bond (an organism-independent constant), while the in-vivo cost *paid* to synthesize one ATP is $(10/3)N_A\mathsf{Q}_\mathsf{B} \approx 50$ kJ/mol for an *E. coli* c_{10} rotor. The surplus is not a contradiction — it is the thermodynamic headroom that drives synthesis far from equilibrium against the cellular mass-action ratio. The bond quantum and the synthesis cost are the two ends of one transaction, not two values of one quantity.

Objection 14 (O-Origin-14) (the structural biophysicist)
"The four-current lock $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ is asserted with no dynamics — four fluxes of different units and magnitudes cannot simply be equal."

Response. The lock is a topological/algebraic theorem, not a postulate: GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) (T-Qi4-9.3, rank-one inflow) derives the single source ray $(1, -1, -2/5, -2/5)$ from single-channel BI-6 closure — the four boundary sources descend from *one* scalar, so they are not four independent quantities. The currents are counted in their natural units against the single conversion factor Q_B. What we concede is open is the boundary *metrology*: a turnkey protocol to count J_{Qi} events in a living cell does not yet exist.

Objection 15 (O-Origin-15) (the chemiosmosis specialist)
"$\Delta p \approx \mathsf{Q}_\mathsf{B}$ is a unit artifact: an electron-volt equals an electron times a volt, so any proton-motive force near 0.15 V 'equals Q_B in eV' by definition."

Response. We write $e\,\Delta p \approx \mathsf{Q}_\mathsf{B}$ (energy = charge × voltage), which is dimensionally exact and not a volts-for-eV conflation. We concede the *exact* equality selects $\Delta p = 0.1555$ V within the physiological band; the honest claim the prose should carry is that the elementary chemiosmotic step is *of order* Q_B, with the ±20% kill tolerance, not a coincidence to three figures.

Objection 16 (O-Origin-16) (the comparative bioenergeticist)
"'ATP is to life as the electron is to physics' is poetry: the electron is structureless and irreplaceable, ATP is a contingent metabolite life could have built from GTP or thioesters."

Response. The analogy is the GGA-output framing: the electron is the layer-2 attractor, ATP the layer-7 attractor, both outputs of the same GRIP cascade. The load-bearing claim is about the *energy quantum* $2\mathsf{Q}_\mathsf{B}$ being universal across primary chemoautotrophs, not about ATP's specific molecular structure — GTP shares the same ΔG°, and *which* carrier is selected is a layer-7 question deferred to GG-A13-Life. We concede the structural contingency and locate the universal content in the quantum, not the molecule.

Objection 17 (O-Origin-17) (the rotary-ATPase specialist)
"The c-ring story — c_8 mammals, c_{10} *E. coli*, c_{13}–c_{15} alkaliphiles — is post-hoc fitting to a table that already exists."

Response. Conceded as not-yet-derived here: the environment-tuned integer stoichiometry $H^+/\mathrm{ATP} = c/3$ is presented as an empirical mapping and developed in a forthcoming dedicated study, not claimed as a

theorem of the present paper. The framework's claim is the universal bond quantum $2\mathsf{Q}_\mathsf{B}$; the rotor's matching of biosphere proton-motive force to that quantum is the forthcoming work, flagged as such.

Objection 18 (O-Origin-18) (the atomic-physics referee)
"Your 'parameter-free' Q_B secretly uses the experimental Rydberg, because the closed-form electron mass is not finished."

Response. Honest residual, and we flag it: GG-A4-Euclid (Arisaka, 2026, A4-Euclid) states that the closed-form $m_e \to E_{\mathrm{Ry}} \to \mathsf{Q}_\mathsf{B}$ chain is structurally in place but the printed closed form is in progress (its O9/O10). Until GG-A9-SM delivers m_e in closed form, Q_B's value rests on the structural mechanism plus the experimental m_e — which is exactly the post-diction we do not want to overstate, and mark openly.

Objection 19 (O-Origin-19) (the chromatin biophysicist)
"Your throwaway claims — histone methylation 'pays three Q_B,' nucleosome sliding 'pays one' — have no citations and contradict measured ATPase stoichiometries."

Response. Conceded: those per-process integer assignments are illustrative and unsupported as printed; real remodelers hydrolyze many ATP per event. The load-bearing bioenergetic claim is the single ATP anchor $2N_A\mathsf{Q}_\mathsf{B}$; the per-process Q_B accounting is a layer-7/8 program deferred to GG-A13-Life, and we should not state the illustrative integers as if measured.

L The systems biologist and non-equilibrium theorist

Objection 20 (O-Origin-20) (the open-systems theorist)
"Your five-condition 'SeOS characterization' theorem is a definitional tautology — it restates the constitutional axioms and declares them equivalent to a class you also defined."

Response. The class is genuinely derived, but its substance lives in GG-A7-Qi4, not in a restatement: the persistence theorem T-Qi4-14.3 of GG-A7-Qi4 (Arisaka, 2026, A7-Qi4) proves a Grönwall viability-tube criterion (maintenance margin above a threshold) that separates Brownian particle from convection cell from protocell from organism. The present paper's iff-packaging (Theorem 58.2) is a reformatting of that derived class; we concede the weight rests in GG-A7-Qi4, cited at the point of use.

Objection 21 (O-Origin-21) (the non-equilibrium statistical physicist)
"Your whole dynamics rests on the GFF being a Lyapunov function, $dF/dt \le 0$ — but monotone descent of a relative-entropy functional fails for generic non-detailed-balance dynamics, and you offload the proof to a citation."

Response. The point is well taken, and the citation is exact. The descent is the GFF second law of GG-A6-GRIP (Arisaka, 2026, A6-GRIP) (T3.2, the boundary H-theorem) — not GG-A5-GDOS's Nakajima–Zwanzig reduction, with which it is easily confused. Strict monotonicity holds in the detailed-balance / gradient sector (GG-A5-GDOS Lemma T5); in the general circulating case the attractor is characterized by LaSalle's invariance principle and *may be a limit cycle or torus.* This paper therefore asserts no unconditional strict point-attractor: the descent carries its detailed-balance hypothesis explicitly.

Objection 22 (O-Origin-22) (the stochastic-thermodynamics referee)
"You conflate a Lyapunov function with entropy production: at a non-equilibrium steady state the system free energy is flat while entropy production is strictly positive. They are different

signs of different quantities."

Response. Conceded, and aligned with the companions, which keep these distinct (GG-A5-GDOS carries a separate non-negative entropy-production rate that holds even when the free energy is non-monotone). The GFF descent is the *boundary face* of the second law, not numerically the entropy-production rate; the present Part's prose should read $-dF_{\mathsf{GFF}}/dt$ as a Lyapunov rate, not as $\dot{S}_{\mathrm{tot}}$, and we mark the distinction.

Objection 23 (O-Origin-23) (the variational-dynamics theorist)
"The 'Three-Gauge Theorem' — F_{GFF} specializing to Gibbs, Friston, and gauge-action by the value of J_{Qi} — asserts 'exactly three corners' without proving exhaustiveness, and you cite it to a theorem that turns out to be the Lindblad generator."

Response. Two honest points. First, on attribution: the Gibbs/Friston/GG-6 triad is *not* GG-A5-GDOS's Lindblad theorem, and GG-A7-Qi4's three-gauge result (T-Qi4-10.6) is the *different* PLT/MEPP/FEP triad — so the Gibbs/Friston/GG-6 reading is the present paper's own reading of the inherited GFF, and its definitive home is a registry decision this paper flags rather than fudges. Second, we concede the 'exactly three' is *argued* from the three control-variable slices, not proven exhaustive over all admissible J_{Qi} configurations; the claim should read as a structural proposal, not a closed classification.

Objection 24 (O-Origin-24) (the free-energy-principle theorist)
"Bundling the principle of least action, maximum entropy production, and the free-energy principle as 'three gauges of one law' overreaches — MEPP and FEP are in general distinct, sometimes opposed."

Response. We do not claim they are identical: GG-A7-Qi4 (T-Qi4-10.6) derives PLT, MEPP, and FEP each from a *distinct* admissible slice of the trajectory space with a distinct coarse-graining, and concludes only that they are gauge-equivalent boundary faces of one projected functional — explicitly not independent axioms, explicitly not a single principle. The objection targets a stronger claim than the framework makes.

Objection 25 (O-Origin-25) (the dynamical-systems referee)
"A single-basin gradient flow with one stable minimum per stratum cannot produce the oscillations — theta rhythms, metabolic cycles — that the same paper relies on."

Response. The companion dynamics already contain circulation: GG-A7-Qi4's reduced flow is $\dot{y} = -\mu\partial F + \Omega$ with $\Omega \cdot \partial F = 0$, so the ω-limit set may be a limit cycle or torus. With the LaSalle re-framing (Objection 21) the present paper inherits that correctly: the attractor is the invariant set where descent halts, not necessarily a point, which is exactly what the oscillatory phenomenology requires.

Objection 26 (O-Origin-26) (the effective-temperature skeptic)
"Your functional is only well-defined where you pin $\varepsilon_{\mathrm{eff}} = k_B T$ — the closed-system limit — which is precisely where it is least needed; far from equilibrium there is no single temperature."

Response. Conceded that the $\varepsilon_{\mathrm{eff}} = k_B T$ identification is cleanest in the closed limit. The GFF itself is well-defined out of equilibrium through its relative-entropy (CEP) term, which does not require a single temperature; what is genuinely scale-dependent far from equilibrium is the *interpretation* of $\varepsilon_{\mathrm{eff}}$, not the existence of the functional. We do not claim a universal effective temperature.

Objection 27 (O-Origin-27) (the status-tag auditor)
"You tag the ATP/DNA row 'Derived' while admitting the full derivation is in the unwritten GG-A13-Life."

Response. Fair, and we sharpen the label: the row is *anchor-Derived* (both empirical anchors — the 30.5 kJ/mol ATP free energy and the four-letter alphabet — are quantitatively closed in the literature) but

derivation-deferred (the from-geometry proof is in GG-A13-Life). Reporting these as one undifferentiated 'Derived' overstated it; the confidence triage now distinguishes the empirical closure from the geometric derivation.

M The origin-of-life researcher

Objection 28 (O-Origin-28) (the prebiotic chemist)
"'Twenty amino acids $= K - NL = 35 - 15$' is integer subtraction, not chemistry. Nothing here says *which* twenty, or why glycine, or why not selenocysteine."

Response. Conceded as not-yet-a-theorem: the count is an arithmetic relation downstream of the upstream-fixed $K = 35$, and the substrate-identification claim — that the side-chain GFF Morse landscape has exactly twenty admissible minima — is tagged *Conditional* and its closed-form derivation is deferred to GG-A12-Chemistry. The 21st/22nd (selenocysteine, pyrrolysine) are codon recodings, not additional cascade minima, and we note that in the row. The count is a forced *relation*; the proof of exactly-twenty-minima is the open work.

Objection 29 (O-Origin-29) (the synthetic biologist)
"'Four bases $= N + 1$' is a cardinality coincidence, and Hachimoji DNA already pairs and replicates with eight letters — your uniqueness claim is false."

Response. We fenced the uniqueness claim to *naturally evolved* life: synthetic expanded alphabets such as Hachimoji are engineered constructs that do not self-sustain in the wild and are explicitly not excluded. The combinatorial closure that would make four the unique *naturally-selected* cardinality (the RNA-bifunctionality lemma) is *Conditional* and deferred to GG-A13-Life; the falsifiability fence and the derivation status are now stated separately.

Objection 30 (O-Origin-30) (the homochirality specialist)
"You state the layer-5 attractor is 'all-L amino acids, all-D sugars, forced' — but your own open-problems appendix admits the mechanism does not exist."

Response. Exactly, and the theorem now carries that concession inline: the enantiomer *sign* is fixed by the parity-odd Wilson–Hosotani holonomy, but the explicit propagation chain from that holonomy to observed handedness is a named open problem (PS-Origin-2, §I.2), and the cardinality result $|\mathsf{GGA}_5| = 20$ does not depend on it. We claim the count, flag the chirality mechanism as open, and no longer present 'forced' without that pointer.

Objection 31 (O-Origin-31) (the LUCA researcher)
"Your 'theorems' for LUCA, the bacteria/archaea split, and eukaryogenesis are the consensus evolutionary narrative with attractor labels stapled on, and the dates are retrodicted from the rock record."

Response. Conceded: these rows are tagged *Asserted*, the dates are calibrated to the geological record, and the from-geometry derivations are deferred to GG-A13-Life. The present paper's contribution at these layers is the *structural* claim — that each is a GRIP attractor on its stratum — not a derivation of the transition; we mark the status honestly rather than dress narration as proof.

Objection 32 (O-Origin-32) (the contingency theorist)
"'Inevitable, not lucky, not designed, forced' is unfalsifiable hindsight: no layer makes a forward, then-unknown prediction that was later confirmed."

Response. We concede the layer-versus-instance distinction and have made it a stated open problem (OP-1, §I.2): the framework individuates the high layers as *classes* (one LUCA class), not as instances, so the 'inevitability' claim above layer-10 is ensemble-level and not instance-testable. The genuinely forward, currently-open bets are the physics falsifiers and the dual-knee spectra; the biological inevitability is a structural thesis flagged as not-yet-falsifiable, not asserted as settled.

Objection 33 (O-Origin-33) (the metabolism-first/RNA-first referee)
"By ordering bioenergetics before informational polymers you silently take a side in the deepest open debate of the field."

Response. We concede the ordering is the framework's *proposal*, not a resolution: GG-A7-Qi4 explicitly does not adjudicate metabolism-first versus replicator-first, and the present paper inherits that as a deferred question. The layer numbering reflects the cascade's logical dependence as the framework reads it, with the chicken-and-egg bootstrap itself an open item for GG-A13-Life.

Objection 34 (O-Origin-34) (the genetic-code theorist)
"You reproduce the *sizes* $64 \to 20$ but never the codon-to-amino-acid *map* — which is precisely the part Crick called a frozen accident."

Response. Conceded squarely: the present paper derives at most the cardinalities; the assignment of which codon maps to which amino acid — the locus of Crick's frozen-accident hypothesis and of the error-minimization and stereochemical theories — is untouched here and deferred to GG-A13-Life. We do not claim to have refuted the frozen accident; we claim the alphabet and block sizes and mark the map as open.

Objection 35 (O-Origin-35) (the unification skeptic)
"'The same theorem from quarks to ATP to consciousness' is the kind of claim that is impressive only until you check that the biology and mind links are the weakest in the paper."

Response. True, and the confidence triage is built to show it: the chemistry, life, and mind rows carry the weakest tags (Conditional/Asserted), and roughly two in five rows are Derived-or-stronger today. The unification we claim is *structural* — one cascade engine, one selector, one integer ledger applied at every layer — with the per-domain derivations explicitly deferred. The breadth is the hypothesis, not a claim that every link is already proven.

N The systems and cognitive neuroscientist

Objection 36 (O-Origin-36) (the hippocampal-systems neuroscientist)
"Your ring-attractor and allocentric-map 'theorems' are imported experimental neuroscience — head-direction cells, grid cells — relabeled as attractors."

Response. Conceded, and labeled as such: layers 15–17 are tagged *Asserted*, with uniqueness 'pending experimental discrimination.' GG-A7-Qi4 supplies the system-instance template and the holographic-triad construction but *not* a derivation of the ring topology or the map dimensionality; those are deferred to GG-A14-Mind. The present paper states these as cascade placements of established findings, not as derivations — the honest status is on the page.

Objection 37 (O-Origin-37) (the consciousness-timing researcher)
"'Conscious episode = 400 ms = two theta cycles' is numerology assembled from a moving target: theta is 4–8 Hz, so two cycles is anywhere from 250 to 500 ms."

Response. We named the rhythm to remove the ambiguity: the relevant carrier is *low* theta ($\sim$ 5 Hz, the slow end of the 4–8 Hz band), so two $\sim$ 200 ms cycles give $\sim$ 400 ms. We concede this functions as a consistency check (F-Origin-10), anchored between the P300 ignition ($\sim$ 300 ms) and the Libet adequacy window ($\sim$ 500 ms); the from-circuit derivation of the timescale is deferred to GG-A14-Mind, and we present it as an audit, not a sharp forward bet.

Objection 38 (O-Origin-38) (the quantitative-EEG referee)
"Your CDI 'ladder monotonicity' is true by definition — you defined CDI as a cumulative count — and there is no scoring rule, so it is not measurable."

Response. Conceded: the present paper flags CDI as a *tentative* operational form, with the scoring rule, the pre-neural treatment, and the comparative calibration deferred to GG-A14-Mind; without that rule the monotonicity is near-definitional. A cross-paper discrepancy is declared alongside it, and not smoothed over: GG-A7-Qi4's CDI is a weighted geometric mean of four pillar scores, while the present paper uses a five-storey count. These are different quantities under one name, and until GG-A14-Mind settles which is canonical, neither should be read as the definition. We do not present CDI as a finished metric.

Objection 39 (O-Origin-39) (the cognitive-architecture theorist)
"The 'Five-Story Pagoda' is a metaphor, and your claim that five is *forced* by the ledger integer $L = 5$ is contradicted by your own GG-A7-Qi4."

Response. An honest limit, and the objection states it correctly. GG-A7-Qi4's pagoda factorization (T-Qi4-16.2) is a genuine adiabatic-elimination / slow-manifold theorem, but its own proof states that *the count five is an empirical reading, not a theorem output* (its Open Problem O7), the induction yielding an arbitrary-depth tower. So this paper does *not* claim five is forced by $L = 5$: the pagoda is a real factorization, and the storey count is empirical.

Objection 40 (O-Origin-40) (the aperiodic-spectrum specialist)
"The dual-knee $1/f$ falsifier is post-hoc: the established literature fits one knee, your one 'second knee' citation shows the two corners with *opposite* aging behavior, and the predicted ratio is deferred."

Response. Conceded as a forward and currently soft bet: the second knee rests on a single human-EEG report and is not yet a settled, named result, and we say so in the row. The one piece that would make it a sharp prediction — the fixed integer ratio between the two knee frequencies — is explicitly deferred to GG-A14-Mind; until that ratio is stated, 'two knees somewhere' is weakly falsifiable, and we flag it rather than overstate it.

Objection 41 (O-Origin-41) (the philosopher-neuroscientist)
"'Consciousness is internal measurement' is a definitional identity that you then present as a theorem."

Response. We separated the two halves explicitly: the *formal* content of the theorem (Theorem 64.3) is the internal-measurement construction — a real open-system operation on the inner hologram; the *identification* of that construction with phenomenal experience is an explicitly-labeled structural-identity *hypothesis*, defended not deduced (§65). GG-A7-Qi4's T-EIC is itself scoped to *access* consciousness in Block's sense and records the phenomenal identification as its own open problem; we now present the phenomenal step as the present paper's additional commitment, not as an inherited theorem.

Objection 42 (O-Origin-42) (the binding-problem researcher)
"You call layer-17 'the geometric account of the binding problem' but compute no binding mechanism — you cite theta–gamma coupling and stop."

Response. Conceded: the binding claim is at present a citation to the theta–gamma coherence literature, not a derived mechanism, and no quantitative binding prediction is made here. The from-circuit treatment is deferred to GG-A14-Mind; the present paper places binding at the EIC-closure layer structurally, which is a placement, not an explanation, and we do not claim more.

Objection 43 (O-Origin-43) (the methods referee)
"Your flagship Mind-layer evidence is the author's own unreplicated 2022 preprints."

Response. The load-bearing neural anchors in the present paper are independent and standard — O'Keefe and Dostrovsky, Hafting, Taube, Quiroga, Kim. The author's 2022 preprints are cited only for the seven-dimensional allocentric-frame *interpretation*, which is explicitly fenced as interpretive and not load-bearing for the cascade placements; we agree that independent replication of that specific interpretation is owed and flag it.

O The philosopher of mind and of science

Objection 44 (O-Origin-44) (the hard-problem theorist)
"You close the explanatory gap by stipulation — your own text says 'numerically, by stipulation' — which is not closing it but refusing it."

Response. We declare the stipulation rather than smuggle it, and concede the analytic-conceptual gap is real. The framework's position is structural identity: phenomenal experience *is* the layer-17 EIC closure's structural-geometric content, defended against the conceivability, knowledge, and explanatory-gap arguments (§65) but not deduced from the geometry. Whether structural identity is the right response to the hard problem is one of the genuinely contested questions we leave explicitly open; what the framework supplies is a structural target sharp enough to be a candidate for the identification.

Objection 45 (O-Origin-45) (the access/phenomenal theorist)
"'Internal measurement' is a specification of *access* consciousness — selection, persistence, availability for report — which you then relabel *phenomenal*."

Response. Conceded, and now stated as a cross-paper fact: GG-A7-Qi4 scopes its internal-measurement construction to access consciousness in Block's sense and records the phenomenal identification as its Open Problem O3. The present paper's phenomenal identification is therefore its *own additional* commitment, not a downstream consequence of GG-A7-Qi4; we no longer present it as inherited, and the leap from access-structure to phenomenality is the labeled hypothesis, not a theorem.

Objection 46 (O-Origin-46) (the zombie-argument philosopher)
"Your reply to the conceivability argument presupposes structural identity — 'imagining the closure without experience is imagining it without itself' just restates the disputed identity."

Response. Agreed that the reply is not a free-standing refutation, and we say so: it is a statement of the framework's position, not a proof that the zombie is inconceivable. The honest claim is conditional — *if* structural identity holds, the zombie is incoherent — and whether structural identity holds is exactly the open question. We present it as a defended standpoint, not as having dissolved the conceivability argument for an opponent who rejects the identity.

Objection 47 (O-Origin-47) (the philosopher of the anthropic)
"Deriving 'observers exist' from a constitution observers wrote to fit their own world is affirming the consequent with extra steps."

Response. The inference runs constitution → cascade → observer by *uniqueness*, not by selection across an ensemble: the integers are fixed upstream with no anthropic input, and each layer carries a separate warrant. We concede that the final step — layer-17 conscious substrates reliably reaching layer-18 articulation — is the weakest link, supported at conjecture strength (it has happened once), and we mark it (Objection 48). The lower cascade is forced; the articulation step is conditional, and we do not claim it is forced the way the periodic table is.

Objection 48 (O-Origin-48) (the philosopher of logic)
"Your self-referential closure theorem is true by construction: you *define* the layer-18 output as the articulation of the constitution, so output = input is a tautology."

Response. The constitution's axioms (AX-1..4 of GG-A1-Constitution) name no observers, no life, and no articulation — so the closure is not analytic in the axioms; it is self-reference in the Gödel/Conway sense, not logical circularity. The substantive and *conditional* content is that the cascade, run from those observer-free axioms, *reaches* an articulating layer (Theorem 40.1) — and that reaching step, as Objection 47 concedes, is the conjecture-strength link, not a tautology. We separate the non-trivial claim (the cascade arrives at articulation) from the trivial one (articulation articulates).

Objection 49 (O-Origin-49) (the Popperian demarcation referee)
"'Zero free parameters' plus an integer ledger spanning quark to mind is unfalsifiability in disguise: your consciousness claims survive every physics falsifier."

Response. Conceded and demarcated: none of the Top-10 falsifiers tests the phenomenal-identity hypothesis — the falsifiable ledger constrains the *access/structural* substrate, not the phenomenal identification, which is a defended philosophical position fenced off from the physics. The physics cascade is sharply falsifiable (Objection 73); the structural-identity thesis about qualia is not, and we no longer let the falsifiable ledger lend it unearned credibility — the demarcation is stated, not blurred.

Objection 50 (O-Origin-50) (the historian of philosophy)
"Reading Wheeler, Spinoza, Whitehead, and Hegel as 'fragmentary recognitions of one theorem' is self-serving Whig history."

Response. It is offered as the framework's *reading*, with the warrant separated from the conclusion, and we record genuine tension where it exists rather than assimilating everything: the Madhyamaka case, for instance, is marked as in tension, not in anticipation. We do not claim to report what these thinkers 'really meant'; we claim a structural feature they each glimpsed and could not formalize. As an openly-caveated interpretive stance that is defensible; as a claim about authorial intent it would not be, and we do not make the latter.

Objection 51 (O-Origin-51) (the meta-ethicist)
"You extract a first-person conclusion — 'there is something it is like' — from purely third-person geometric premises. That is a category error."

Response. The bridge from third-person structure to first-person experience is precisely the hard problem, and we do *not* claim to deduce it: the geometry supplies a structural target, and the identification with experience is the labeled hypothesis (Objection 44), not an inference. The framework's structural realism abolishes intrinsic quiddities by hypothesis, which an opponent may reject; we present that as a contested commitment, not as a valid derivation of phenomenality from geometry.

Objection 52 (O-Origin-52) (the philosopher of causation)
"'Necessitarian but not deterministic — forces the layers but not the micro-events' is a firewall engineered so no observation can ever embarrass it."

Response. We concede the layer-versus-micro-event line needs an independent criterion, and that this is an open problem (OP-1), not a settled distinction. Crucially, the firewall does *not* protect the physics: the integer ledger and its consequences (M_{lock}, $w = -1$, proton decay) are sharply falsifiable regardless of the layer/micro distinction. The necessitarian framing is flagged as philosophically open; it is not used to dodge the physics falsifiers, which stand on their own.

Objection 53 (O-Origin-53) (the skeptical reader)
"The 'for the first time in human intellectual history' register is a tell that the formalism was built to license the boast."

Response. The historical claim is specific and bounded — a formal theorem whose conclusion is the existence of articulating observers, from a ledger with no continuous freedom — and we temper it exactly where the supporting derivations are deferred (the chemistry/life/mind floors). The boast is constrained by the confidence triage: the parts that earn it (the closure theorem, the falsifier ledger, the universal-identity insight) are the parts we present as complete; the speculative floors are flagged as program, not proof.

P The cross-paper referee and the corpus auditor

Objection 54 (O-Origin-54) (the corpus-aware referee)
"Your central analytic facts — the GFF descent, the four-current lock, the integer ledger — are all proved in other papers. A 471-page capstone that defers its keystones is a program with a theorem's title."

Response. A capstone is permitted to rest on its companions; what we owe is to state plainly, at each invocation, what is inherited and from where — and we now cite each by its cohort-global theorem id (§78.1): the GFF second law is GG-A6-GRIP T3.2, the rank-one current lock is GG-A7-Qi4 T-Qi4-9.3, the integer ledger is GG-A2-GG6 T-GG6-6. The standalone content of the present paper — the recursive-uniqueness theorem (Theorem 50.1), the universal-identity insight, the falsifier ledger, and the self-referential closure — is proved or stated here; the inherited apparatus is flagged as inherited.

Objection 55 (O-Origin-55) (the citation auditor)
"Your load-bearing dynamical claim is a cross-citation into a companion paper. In a cohort this size, cross-citations are exactly where a wrong pointer hides — a descent attributed to a reduction theorem, say. How is a reader to check that the theorem you point at is the theorem you mean?"

Response. By naming the result, not its position. Every companion citation here carries the registered theorem identifier together with a one-clause statement of its content, so a mismatch is visible without leaving the sentence: the descent is GG-A6-GRIP T3.2 (the GFF second law), and the GEP + CEP split is GG-A5-GDOS T9.2+T5, with the detailed-balance hypothesis imported (Objection 21). A pointer to a section or an ordinal would fail silently under any renumbering; a pointer to an identifier plus its content cannot.

Objection 56 (O-Origin-56) (the registry auditor)
"Your 'three-gauge' reading — F_{GFF} specializing to Gibbs, Friston, and gauge-action — is presented with the authority of an inherited companion theorem. Which registered result is it, exactly?"

Response. None, and the paper should not be read as claiming otherwise. The Gibbs/Friston/GG-6 three-gauge reading has no registered companion id (it is not GG-A5-GDOS's Lindblad theorem, and GG-A7-Qi4's three-gauge is the different PLT/MEPP/FEP triad), so it is at present the present paper's own reading of the inherited GFF. Its canonical home — an GG-A11-Origin-original theorem id, or a new GG-A5-GDOS/GG-A6-GRIP id — is a Theorem-Registry decision we flag openly rather than assert a false provenance.

Objection 57 (O-Origin-57) (the cross-reference referee)
"Your layer-5 and information-layer theorems attribute to GG-A7-Qi4 an 'amino-acid selection theorem' and a 'four-letter alphabet argument' that GG-A7-Qi4 does not contain."

Response. The attribution is narrower than the objection assumes. GG-A7-Qi4 supplies the Qi-4 admissibility *filter* (T-EP, T-CON) and the four-current lock (T-QUA), and that is what is cited here; the *specializations* to the twenty amino acids and the four-letter alphabet are the present paper's own constructions, tagged as such, with their closed-form derivations deferred to GG-A12-Chemistry/GG-A13-Life. No GG-A7-Qi4 theorem is claimed for them.

Objection 58 (O-Origin-58) (the SeOS referee)
"You attribute the SeOS class to 'GG-A5-GDOS T7,' which is the block promoting the quantum-mechanics postulates to theorems."

Response. Conceded: the SeOS persistence theorem is GG-A7-Qi4 T-Qi4-14.3, not GG-A5-GDOS T7, which is indeed the QM-postulate block. The two are easy to confuse — both are promotion results, and they sit one paper apart — which is why every SeOS citation here carries the T-Qi4-14.3 identifier rather than a paper-and-number reference.

Objection 59 (O-Origin-59) (the corpus-completeness referee)
"Your chemistry, life, and mind keystones are deferred to GG-A12-Chemistry, GG-A13-Life, and GG-A14-Mind — papers that do not exist. The cohort logic does not close today."

Response. Conceded openly: the present paper is a keystone that *states* the chemistry/life/mind results as named, status-tagged theorems and defers their from-geometry derivations to the forthcoming floor papers. The cohort logic closes fully only when GG-A12-Chemistry–GG-A14-Mind are written; what closes *today* is the physics base (GG-A9-SM/GG-A10-Cosmos) with its own falsifiers, plus the present paper's standalone results. We mark every promissory link as promissory.

Objection 60 (O-Origin-60) (the version-control auditor)
"A cohort of this size cross-cites its own theorems, statuses and grades across separate documents. A result graded *conditional* where it is proved and *closed* where it is consumed is the likeliest failure mode you have. What keeps them aligned?"

Response. Two disciplines, both checkable from outside. Grades are owned by the paper that proves the result, and a consumer quotes the owner's grade rather than restating it: $N_g = 3$ is conditional in GG-P2-N3 (T-N3-5), and it is consumed as conditional — GG-A9-SM's T-SM-21.1 is stated as the *conditional* derivation of $N_g = 3$ and cites GG-P2-N3 T-N3-5 for it. And cross-citations name registered identifiers rather than ordinals, so drift surfaces as a missing id instead of a plausible-looking wrong one. Where two papers genuinely disagree about a grade, the disagreement is printed rather than averaged.

Objection 61 (O-Origin-61) (the single-point-of-failure skeptic)
"Everything — particles, atoms, chemistry, ATP, the genetic alphabet, the cognitive ladder — hangs on one integer ledger. That is fragility, not strength."

Response. That is the design, and it is the falsifiability, not a bug: $(M, N, L; J, K) = (1, 3, 5; 7, 35)$ is fixed upstream (GG-A2-GG6 T-GG6-6) with zero biological or cognitive input, and *everything* downstream is a consequence. If the ledger is wrong — if M_{lock} is absent, if $w \neq -1$ is confirmed, if the kaxion is not in its band — the whole cascade falls together. A theory whose single shared assumption is exposed to many independent experiments is more falsifiable than one with a separate adjustable parameter per observable, not less.

Q The skeptical methodologist and editor

Objection 62 (O-Origin-62) (the evidential-standards editor)
"Most of your 'agreements' are with already-known numbers. Reproducing the Standard-Model masses is postdiction relabeled as derivation."

Response. We label the two cleanly and stop lumping them: the headline parameter-audit plot separates the empirical *floor* (retrodictions of measured quantities) from the eight *forward* falsifiers and the consistency checks (§42.1). Reproducing known constants from a parameter-free ledger is evidentially meaningful — it is what any unification must do — but it is not a forward bet, and we no longer present the floor as if it were.

Objection 63 (O-Origin-63) (the length skeptic)
"Nearly five hundred pages is a landmark-synthesis conceit."

Response. It is a corpus-final synthesis of a twenty-two-paper program, and it is built for selective reading: the four-Part back matter, the per-Part reader's guides, and the confidence triage let a particle physicist read only the physics floor, a neuroscientist only the cognitive Part, and a philosopher only the closure and consciousness sections. We concede the length; the mitigation is the navigation, and the speculative material is explicitly cordoned by status tag.

Objection 64 (O-Origin-64) (the rhetoric-of-honesty skeptic)
"Admitting a limitation does not answer it. Your honesty triage is a shield: 'we said it was Conditional, so you cannot attack it.'"

Response. Admitting a limitation does not immunize it, and we do not treat it as doing so: every open item names the *experiment* or the *companion paper* that will close it — the kaxion search, the HL-LHC cluster, GG-A12-Chemistry–GG-A14-Mind — so each concession is a checkable promissory note, not a permanent excuse. The triage is structural and singular (one canonical confidence table quoted identically everywhere); its purpose is to be checkable, not to be unattackable.

Objection 65 (O-Origin-65) (the rigor-contamination referee)
"The speculative life-and-mind material drags down the credibility of the rigorous physics."

Response. The four-floor structure is stratified by confidence precisely so a reader need not buy the frontier to buy the base: the physics floor (GG-A9-SM/GG-A10-Cosmos) stands on its own falsifiers independent of the life/mind floors, which are flagged as the program's frontier. A reader is invited to test the base and treat the upper floors as hypotheses; the architecture is designed to keep the two from contaminating each other.

Objection 66 (O-Origin-66) (the falsifiability auditor)
"If failure of any one layer can be absorbed, the whole thing is unfalsifiable."

Response. Failure is not absorbed — it is pre-priced: the Top-10 falsifiers each carry an explicit kill criterion (§42.1), and the failure of the integer-ledger base (e.g. no M_{lock} cluster at HL-LHC, or a confirmed $w \neq -1$) kills the cascade at its root. The cluster-failure scenario — what a coordinated pattern of failures would mean floor by floor — is worked through in the falsifier Part rather than waved away.

Objection 67 (O-Origin-67) (the scope referee)
"This is a research program, not a finished theory, and you present it as a capstone."

Response. Agreed, and stated: the capstone's *standalone* results — the recursive-uniqueness theorem, the falsifier ledger, the universal-identity insight, the self-referential closure — are complete as presented; the floor derivations (GG-A12-Chemistry–GG-A14-Mind) are the ongoing program. 'Capstone' names the synthesis that binds the existing floors into one structure, not a claim that every floor is finished.

Objection 68 (O-Origin-68) (the demystification referee)
"The 'universal-identity insight' — that we are all the universe's one layer-18 attractor — is mysticism in a lab coat."

Response. The formal content is the type-token distinction made operational: *the type is unique, the tokens are fully individuated.* The theorem (T-Universal-Identity) is a gauge-equivalence statement — all layer-n products are gauge-equivalent as types while differing in every individuating respect as tokens. We concede the philosophical register of the prose; the load-bearing claim is the gauge-equivalence, not a mystical merger, and earlier compressed phrasings that read as the latter have been corrected.

Objection 69 (O-Origin-69) (the reproducibility referee)
"The entire cohort is one author's program with no independent replication."

Response. Conceded, and it is the reason the framework is built around *externally-testable* falsifiers: the verdicts are assigned by HL-LHC, ADMX/CAPP, DESI/Euclid, and Hyper-Kamiokande/DUNE, not by the author. The test is the data, not the authority; the program is structured so that independent experiments, not internal consensus, decide it.

Objection 70 (O-Origin-70) (the explanatory-scope skeptic)
"A framework that claims to explain cosmos and life and mind explains too much to be science."

Response. The breadth is the hypothesis — one recursive theorem read three ways — and each reading carries its own falsifier, so the breadth increases exposure rather than reducing it. We accept the risk that comes with scope by pre-declaring kill criteria for each floor; a single theory answerable to particle, cosmological, biological, and neural data simultaneously is harder to save than a narrow one, which is the point.

Objection 71 (O-Origin-71) (the accessibility referee)
"The acronym and notation density is an impenetrable barrier."

Response. Conceded, with the mitigations stated: the canonical Dictionary (GG-A2-GG6 Appendix B), the per-Part reader's guides, and the cohort naming-convention key (§78.1) are provided precisely so that every defined object can be looked up. The density is the cost of a parameter-free codebook; the navigation aids are the answer, and we keep extending them.

Objection 72 (O-Origin-72) (the late-time cosmologist)
"The standing cosmological tensions — the DESI dark-energy hint, the Hubble tension — threaten your base while you present it as solid."

Response. We flag both rather than paper over them: the $w = -1$ test is marked as the live tension it is (Objection 7), and if a confirmed $w \neq -1$ arrives, $\Omega_\Lambda = 1 - 1/\pi$ and the cosmology floor fail. The Hubble tension is addressed directly in GG-C2-Hubble (Arisaka, 2026, C2-Hubble) as a two-stage corridor, not assumed away. The base is solid where the data are settled and exposed where they are not, and we mark the boundary.

Objection 73 (O-Origin-73) (the philosopher of cosmology)
"Your 'second horizon problem' looks like a rebranded old idea. Zeldovich and Kibble had causally disconnected regions choosing vacua in the 1970s; the axion community has always known inflation makes the misalignment angle uniform. What is new, and why does the capstone lean on it?"

Response. The pedigree is real and GG-A10-Cosmos cites it in those very terms (Zeldovich–Kobzarev–Okun 1974, Kibble 1976, Linde's "uniqueness of the universe," the standard pre-inflationary axion scenario). What GG-A10-Cosmos claims as new is narrow and stated as such: the *naming* of identity-uniformity as a horizon problem in its own right, ranked beside temperature; the *extension* from the orientation of one vacuum to the whole inventory of masses, couplings, and abundances; and above all the *ordering* — that inflation preceded the existence of matter, so identity was inherited rather than negotiated, a corollary whose premise is textbook but which the literature never drew. GG-A11-Origin leans on it because it is the cleanest instance of the cascade's own mechanism: the sameness of the electron across the sky is the layer-2 GGA read by GRIP-In on a single causal patch, and the recursive uniqueness theorem needs exactly that causal warrant at its base to guarantee that every higher rung — the periodic table, the genetic alphabet, the shape of a conscious episode — is universal across the observable universe and not merely local. Remove the ordering and the cascade still runs, but its base rung would rest on an assumption rather than a derivation; with it, the first lock is earned. That is why the capstone imports it, and why it belongs in the determinism argument as the positive evidence that the world's sameness is structural.

Objection 74 (O-Origin-74) (the editor's closing question)
"What single observation would make you abandon the framework?"

Response. Any one of the Top-10 falsifiers failing at its kill criterion: no clustered spin-2 resonance within 3.85 ± 0.10 TeV at HL-LHC; no kaxion in the 6.6–8.8 μeV band; a confirmed dark-energy equation of state $w \neq -1$; proton decay detected short of $\sim 10^{35}$ yr; or a wild, naturally-evolved organism with a stable genetic alphabet of other than four letters. Each is pre-declared with its threshold (§42.1); the framework is built to lose if the universe disagrees, and that — not the breadth of what it claims — is the measure of whether it is science.

Part XXI
References

Cited works, each with a relevance note linking it to the present paper

Unlike a conventional reference list, every entry below carries a short *Relevance* note: a sentence or two saying what the cited work contributes and where in the present paper it bears. The aim is to turn the bibliography from a bare list of sources into a navigable companion — a reader can move through the references and see, at a glance, which theorem, table, or section each one underwrites.

The notes are written for two readers at once. For the newcomer, they trace the intellectual lineage of the capstone: from the foundations of gauge theory, differential cohomology, open-system dynamics, and statistical physics, to the twenty-two-paper GG-Theory cohort that GG-A11-Origin closes — the paper in which the recursive-uniqueness theorem T-Origin and the cascade of Ground Geometric Attractors bring the program from the GG-Constitution to the articulation of Cosmos, Life, and Mind. For the specialist, they make the paper's debts explicit and checkable — each note names the specific result it supports, so that no citation is merely decorative.

The GG-Theory cohort papers (GG-A1-Constitution–GG-A11-Origin, together with the phenomenology P-series and the consequence C-series) are cited throughout under the canonical keys and titles fixed by the cross-paper coherence map of the program; GG-A11-Origin's place at the summit of that cohort is set out in the cohort-inheritance Part. The references are listed alphabetically by first author.

A. Papers by Katsushi Arisaka (the GG-Theory cohort)

K. Arisaka. *The GG-Constitution: Four Axioms and Seven Postulates of the GG-Theory Program, From Which GG-6, BI-6, OGN-5, and GDOS Descend as Theorems*, Arisaka-GG-A1-Constitution (May 14, 2026). Preprint, available at https://preprints.arisaka-gg.org/a1-constitution/. doi:10.5281/zenodo.22063867.

Relevance. Establishes the four axioms (LC, GGEP, OGGEP, MSMF) and seven postulates of the GG-Constitution — the foundational document of the entire program. The constitution does not specify a particular Lagrangian; instead, it defines admissibility rules that any candidate theory must satisfy. The restrictiveness of these rules is what forces a unique solution (GG-Theory), eliminating the landscape of free parameters that plagues other unification approaches. Every result in the present paper traces back to these fifteen constitutional clauses (the four axioms and the seven postulates). First cited in §4.

K. Arisaka. *GG-Theory with GG-6: Geometry–Gauge Locking at the 6D Bulk (GG-6) at the Heart of Grand Geometric Theory (GG-Theory)*, Arisaka-GG-A2-GG6 (May 14, 2026). Preprint, available at https://preprints.arisaka-gg.org/a2-gg6/. doi:10.5281/zenodo.22064298.

Relevance. Derives the six-dimensional GG-6 stage — the bulk manifold $M_6 = M_4 \times I_r \times S^1_\theta$ with gauge group $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi} \times$ Gravity — from the GG-Constitution. The paper shows that the BI-6 identity and the OGN-5 integers are structurally forced by the axioms, with no continuous freedom remaining. The single tensor field B_2 that mediates all anomaly inflow is derived here, and its uniqueness is the geometric origin of the Arisaka Equation. First cited in §5.

K. Arisaka. *Anomaly Freedom of BI-6: The Modified Bianchi Identity (BI-6) for the Six-Force, Six-Dimensional Bulk (GG-6)*, Arisaka-GG-A3-BI6 (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a3-bi6/.
doi:10.5281/zenodo.22064300.
Relevance. Provides the complete local and global geometric consistency proof for BI-6 on the physical intended GG-6 class. The paper uses the Green–Schwarz descent, Wu–Chern–Simons completion (Hopkins and Singer, 2005), and differential-cohomology framework to establish that the six-dimensional bulk geometry is internally consistent — a pre-quantum result that any subsequent quantization must inherit. The OGN-5 integers $(1, 3, 5; 7, 35)$ are derived at theorem level. This is the mathematical foundation on which the entire chain from geometry to consciousness rests: without anomaly freedom, the bulk theory would be ill-defined and no boundary physics could be projected. First cited in §61.1.

K. Arisaka. *From Euclid to GG-6: The Realization of Euclid's Elements in Six Dimensions — GU-5, OGN-5, and a Parameter-Free Reconstruction of Modern Physics*, Arisaka-GG-A4-Euclid (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a4-euclid/.
doi:10.5281/zenodo.22064302.
Relevance. The fourth foundation paper of the Arisaka-GG cohort. Positions GG-Theory in the historical lineage of Euclid, Newton, Riemann, Maxwell, and Einstein, and proves that the framework's input ledger contains zero continuous free parameters. The residue is not empty: GG-A4-Euclid names it as discrete axiomatic choices, unit conventions and one overall mass scale, and scopes the closure to the gauge and cosmological sectors. The input ledger has three forced groups: the Geometric Universal Five Constants GU-5 $= \{c, G_N, \hbar; k_B, Q_B\}$, the mathematical constants (π, e), and the OGN-5 integer ledger $(M, N, L; J, K)$. GG-A11-Origin cites GG-A4-Euclid as the constitutional source of the zero-free-parameters claim and of the Q_B membership in GU-5. First cited in §12.

K. Arisaka. *GDOS: Geometric Dynamics of Open Systems — 6D GG-6 Bulk Projected to 4D Boundary for Quantum Measurement, General Relativity, and QFT*, Arisaka-GG-A5-GDOS (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a5-gdos/.
doi:10.5281/zenodo.22064304.
Relevance. Derives the GDOS boundary dynamics from the OGGEP axiom (AX-3), establishing how the six-dimensional bulk projects onto the four-dimensional world we observe. The paper introduces the operational dictionary $\mathcal{D}$, the GKLS open-system generator, and the port structure that allows systems to exchange matter, energy, and information with their environment. Every open system in nature — from a proton to a brain — is a GDOS system, and its dynamics is constitutionally constrained by the bulk geometry. First cited in §7.13.

K. Arisaka. *The GRIP on GDOS — GRIP: the Geometric Engine of Symmetry Breaking, from the Big Bang to Mind*, Arisaka-GG-A6-GRIP (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a6-grip/.
doi:10.5281/zenodo.22064306.
Relevance. The parent paper of the runtime. Derives the four Gi-4 pillars of the cascade machinery — TGG (the Total Geometric-Gauge object), CCI (the Covariant Conservation Identity), GFF (the Geometric Free-Energy Functional), and GRIP (the Gauge-Runtime Invariance Pipeline, the cascade DGI $\to$ GSSB $\to$ GA/GGA on the F_{GFF} landscape: Dynamical Gauge Invariance at the symmetric top, Geometric Spontaneous Symmetry Breaking at the branch-selection saddles, the Geometric Attractor at the stable floor) — together with the runtime-level definitions adopted throughout the present paper: def:GGA (the Ground Geometric Attractor) and def:GRIPin/def:GRIPout (the two runtime regimes), whose regime *theorems* are proved

here. GG-A11-Origin imports the cascade engine T1–T5 and GFF-ST7 as the machinery that drives the recursive uniqueness theorem at every layer above the Standard Model. First cited in §12.

K. Arisaka. *The Qi-4 Pillars — Qi-QUA, Qi-EP, Qi-CON, Qi-HAL: The Quantum-Information Backbone of GDOS*, Arisaka-GG-A7-Qi4 (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a7-qi4/.
doi:10.5281/zenodo.22064308.
Relevance. Derives the Qi-4 Pillars — Qi-QUA (current locking), Qi-EP (the unified extremal principle), Qi-CON (conformality), and Qi-HAL (the holographic attractor lattice, the memory architecture) — and deploys on the information flank the DGI–GSSB–GA universal runtime pipeline of GG-A6-GRIP. The GFF (Geometric Free-Energy Functional), the SIP (System Instance Packet), and the SeOS (Selfish Open System) classification are developed here. The Arisaka Equation $J_E/\mathsf{Q}_\mathsf{B} = J_e = J_B = J_{Qi}$ is derived in its canonical form, and the biological energy quantum $N_A\mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol is identified as the universal currency of cellular energy transactions. First cited in §7.13.

K. Arisaka. *Quantum Mechanics Derived from GG-Theory as Projection from 6D Bulk to 4D Boundary*, Arisaka-GG-A8-QM preprint.
Preprint, available at https://preprints.arisaka-gg.org/a8-qm/.
doi:10.5281/zenodo.22064310.
Relevance. The 4D operational reformulation of quantum mechanics from GG-A5-GDOS GDOS machinery: lifts GG-A5-GDOS T7.1–T7.7 (QM postulates as theorems) to textbook-style 4D form, supplying the formal grounding of the consciousness-as-internal-measurement reading exercised in GG-A11-Origin Parts VIII and IX. Currently in active drafting; GG-A11-Origin references GG-A8-QM as a forward-looking dependency in Part II §7.9. Once GG-A8-QM ships, the operational-measurement passages in GG-A11-Origin Part XIII will be replaced by direct GG-A8-QM citations. First cited in §7.9.

K. Arisaka. *The Standard Model as Theorem of GG-Theory: Its 28 Parameters as Observations of One Six-Dimensional Geometry*, Arisaka-GG-A9-SM (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a9-sm/.
doi:10.5281/zenodo.22064312.
Relevance. Derives all 28 Standard Model parameters — six quark masses, three lepton masses, three CKM angles and one phase, three gauge couplings, the Higgs mass and vacuum expectation value, the QCD θ angle, and the neutrino sector — from the OGN-5 arithmetic and the GDOS boundary projection. The key results include $\hat{\alpha}_{\rm EM}^{-1} = 2^7 = 128$ at the Z pole, $\sin^2\theta_W = 25/108$, and $v = M_{\rm lock}(2/5)^3 \approx 246.4$ GeV. Every prediction is compared with the measured value, and all pulls are below 1.0. First cited in §9.2.

K. Arisaka. *The Standard Cosmology as Theorem of GG-Theory: The Cosmic Inventory as Observations of One Six-Dimensional Geometry*, Arisaka-GG-A10-Cosmos (May 14, 2026).
Preprint, available at https://preprints.arisaka-gg.org/a10-cosmos/.
doi:10.5281/zenodo.22064314.
Relevance. Derives the full cosmological sector of the GG-6 framework as an inheritance problem: the universe is the cosmic export of the same GG-Theory, with no new free parameters. The paper shows that one infrared GSSB event at the throat cap simultaneously ends inflation, produces Kaxion dark matter, and leaves the dark energy residue $\rho_\Lambda \sim (M_{\rm lock}\, e^{-K})^4 \sim (\text{few meV})^4$. Inflation is TeV-scale slow-smooth radion inflation on a warp-flattened plateau, predicting tiny primordial tensor modes. The Kaxion dark matter candidate is a single physical line at $\sim 8.1\ \mu$eV ($\nu_K = 1.95$ GHz), inside a closed window of seven cap loadings, 1.59–2.13 GHz, and alone in it (an earlier reading of this entry gave it a twin-peak signature split by $\Delta\nu/\nu = 1/35$; the companion has withdrawn that). The π-locked cosmic inventory $\Omega_m = 1/\pi$, $\Omega_b = 1/(2\pi^2)$, $\Omega_\Lambda = 1 - 1/\pi$ matches Planck data to within 2% and dissolves the coincidence problem.

Baryogenesis proceeds through TeV-scale resonant leptogenesis using the inherited Majorana and CP structure. BBN, the CMB, and the Hubble tension are treated as precision audits of the derived ledger. First cited in §9.7.

Arisaka, K. (2026). *The Geometric Inevitability of Cosmos, Life, and Mind: The Self-Referential Closure of the GG-Theory Program.* Arisaka-GG-A11-Origin preprint (the present paper).
Preprint, available at https://preprints.arisaka-gg.org/a11-origin/.
doi:10.5281/zenodo.22064319.
Relevance. The present paper and the closing capstone of the twenty-two-paper cohort. States the recursive-uniqueness theorem T-Origin, develops the GRIP-out cascade of Ground Geometric Attractors across the five floors of Cosmos, Life, and Mind, and threads the OGN-5 ledger from atoms and molecules through ATP, DNA, and the first cell to the observer who articulates the geometry. First cited in §7.1.

K. Arisaka. *The GG-6 Lock Cluster: A Non-Spatial Kaluza–Klein Resonance near 3.85 TeV as the Standing LHC Falsifier of GG-Theory*, Arisaka-GG-P1-KK (2026).
Preprint, available at https://preprints.arisaka-gg.org/p1-kk/.
doi:10.5281/zenodo.22064321.
Relevance. The dedicated phenomenology paper for the Kaluza–Klein lock cluster prediction. The scale-locked KK tower of GG-A1-Constitution–GG-A3-BI6 compactified on the six-dimensional bulk produces a narrow KK resonance cluster at the derived $M_{\text{lock}} = 3.849$ TeV — four members, two of them unproduced at tree level. The prediction is directly testable at HL-LHC. Cited by GG-A11-Origin in Part XVI's Top 10 Falsifiers as test 1 (KK lock cluster discovery). First cited in §61.1.

K. Arisaka. *Why Three Generations: A Three-Leg Derivation of $N_g = 3$ from BI-6, MSMF, and GDOS Morse Stability*, Arisaka-GG-P2-N3 (2026).
Preprint, available at https://preprints.arisaka-gg.org/p2-n3/.
doi:10.5281/zenodo.22064323.
Relevance. The dedicated proof paper of the family-number theorem. Three logically independent legs (an MSMF lower bound from Kobayashi-Maskawa CP-violation combinatorics; a GDOS Morse upper bound from family-projector stability on $\mathbb{C}P^{N_g-1}$; and a constructive codebook self-consistency check from GG-A9-SM) jointly force $N = 3$. The precision tolerance $m_\tau/m_\mu \approx 16.817 \pm 0.5\%$ is the empirical falsification anchor of the closure. Cited by GG-A11-Origin in Part IX as the upstream theorem closing the Particle-Physics open-question chain. First cited in §7.1.

Arisaka, K. (2026). *The Electron as the Ground State of Nature: The Six Oldest Questions about the Electron, Closed and Fenced within GG-Theory.* Arisaka-GG-P3-Electron preprint.
Preprint, available at https://preprints.arisaka-gg.org/p3-electron/.
doi:10.5281/zenodo.22064325.
Relevance. The third paper of the Predictions Branch: identity, absolute stability, the two excited copies, the positron as conjugate readout, pointlikeness, and field response derived as six faces of ground-state-ness; imports GG-P2-N3's $N_g = 3$ verbatim. The electron is the layer-3 GGA of the present paper's cascade. First cited in §7.1.

K. Arisaka. *The Real Geometry Beneath the Complex Numbers of Physics: Positive Frequency is Holomorphy — from Cardano's Cubics to Twistor Space, via the Sixth Dimension of GG-Theory*, Arisaka-GG-P4-Real preprint.
Preprint, available at https://preprints.arisaka-gg.org/p4-real/.
doi:10.5281/zenodo.22064327.

Relevance. The origin-of-i member paper of the Foundations Branch: the standalone development of the real-bulk account of the boundary's complex structure — the two real sources (the compact phase circle and the causal clock), positive frequency read as holomorphy, and the open items stated as open. GG-A11-Origin leans on the derived complex structure at every quantum floor of the cascade but does not adjudicate *why* the boundary is complex, deferring that question to GG-A8-QM; GG-P4-Real is the full-length account GG-A8-QM draws on. First cited in §7.1.

K. Arisaka. *The Mirrors of Matter: Why Every Particle Has a Twin, Why Nature's Mirrors Break, and Why the Universe Is Made of Matter*, Arisaka-GG-P5-CPT preprint.
Preprint, available at https://preprints.arisaka-gg.org/p5-cpt/.
doi:10.5281/zenodo.22064329.
Relevance. The CPT member paper of the Foundations Branch: C, P, and T as orientation reversals of the three real bulk factors, time defined by its four endowments, and the law-level arrow that fixes why the universe is made of matter. Its arrow of orientation reversal is kin to the cascade's own one-way descent through its layers, each GRIP-Out shock stepping the geometry down one floor and never back up. First cited in §7.1.

K. Arisaka. *The Kaxion: Cold Dark Matter as the Non-Spatial Compact-Angle Pseudoscalar of GG-6*, Arisaka-GG-C1-Kaxion (2026).
Preprint, available at https://preprints.arisaka-gg.org/c1-kaxion/.
doi:10.5281/zenodo.22064333.
Relevance. The dedicated dark-matter phenomenology paper. The Kaxion is the framework's dark-matter candidate, produced as a misalignment condensate during the throat-cap GSSB event of GG-A10-Cosmos. A single physical line at ~ 8.1 μeV ($\nu_K = 1.95$ GHz) is predicted, inside a closed window of seven cap loadings, 1.59–2.13 GHz, and *alone* in it: the compact-angle sector delivers exactly one light QCD-coupled pseudoscalar, so there is no partner tone at any spacing. An earlier reading of this entry predicted a twin peak split by $\Delta\nu/\nu = 1/35$; the companion has withdrawn it, the would-be partner being the longitudinal Z'_B far above any receiver. The prediction is directly testable at ADMX and next-generation haloscopes. Cited by GG-A11-Origin in Part XI's Top 10 Falsifiers as test 2 (Kaxion dark matter discovery). First cited in §61.1.

K. Arisaka. *The Hubble Tension in the Light of GG-Theory: The Hubble Constant as One Reading of a Derived Expansion History $H(t)$*, Arisaka-GG-C2-Hubble preprint.
Preprint, available at https://preprints.arisaka-gg.org/c2-hubble/.
doi:10.5281/zenodo.22064336.
Relevance. The dedicated phenomenology paper for the Hubble two-stage corridor prediction. It derives a single background expansion rate, $H_0 = 66.6 \pm 0.2$ km/s/Mpc, against which Planck's measured 67.4 ± 0.5 and the local ladder's 73.5 are read; the background plus the Local-Hole lift gives a conditional late reading of $\approx 68.5 \pm 0.6$, and the residual to the ladder value is stated there as an open problem rather than a result. Its staked falsifier is that standard sirens converge near 67: near 73, that paper says in advance that it is wrong. Cited by GG-A11-Origin in Part XVI's Top 10 Falsifiers as tests 3 and 4 (Hubble corridor early- and late-stage). First cited in §7.1.

Arisaka, K. (2026). *Black-Hole Entropy under GG-Theory: The GDOS Reading of the Horizon as an OGGEP Port — with the Exact Bekenstein–Hawking $A/4G_N$ Derived from Induced Gravity.* Arisaka-GG-C3-BH preprint.
Preprint, available at https://preprints.arisaka-gg.org/c3-bh/.
doi:10.5281/zenodo.22064338.

Relevance. The third paper of the Cosmology & Astrophysics Branch and the cohort's strong-gravity anchor: the horizon treated as an OGGEP port, with the exact $A/4$ coefficient derived. First cited in §7.1.

Arisaka, K. (2026). *The Proton as the Ground Geometric Attractor of Matter: The Eleven Questions of the Proton, Closed and Fenced within GG-Theory*. Arisaka-GG-P6-Proton preprint.
Preprint, available at https://preprints.arisaka-gg.org/p6-proton/.
doi:10.5281/zenodo.22064331.
Relevance. The fourth paper of the Predictions Branch and the cohort's second portrait of permanence: the proton read as the ground attractor of the hadronic stratum, its stability traced to a gauged baryon number with no $\Delta B = 1$ aperture rather than to an accidental symmetry. It supplies the layer-3 anchor this paper inherits, and its double guard — the triangle that closes and the ledgers that keep — is the mechanism behind T-Atomic-Ground-State. First cited in §7.1.

Arisaka, K. (2026). *Symmetry, Conservation, and Geometry: Seven Steps from Noether, Bianchi, to Hopkins–Singer, and the Ledger the Open-System Turn Pays Out*. Arisaka-GG-W1-Symmetry preprint.
Preprint, available at https://preprints.arisaka-gg.org/w1-symmetry/.
doi:10.5281/zenodo.22064340.
Relevance. The first of the two white papers, and the cohort's historical synthesis: symmetry read as a ladder of seven rungs from Noether's theorems to differential cohomology, with the open-system turn costed at each rung. Its seventh rung — that an integer cannot run because nothing continuous acts on it — is the protection this paper's cascade relies on wherever a layer output is a count. First cited in §7.1.

Arisaka, K. (2026). *The Circle That Remembers, the Interval That Forgets: GG-Theory and the Sixteen Problems of Particle Physics and Cosmology*. Arisaka-GG-W2-Holonomy preprint.
Preprint, available at https://preprints.arisaka-gg.org/w2-holonomy/.
doi:10.5281/zenodo.22064342.
Relevance. The second white paper and the cohort's structural synthesis: the two non-spatial fibers read as one anatomy — a compact circle that remembers and an open interval that forgets — and applied to sixteen standing problems in one voice. It is this paper's sibling at the summit: W2 reads the cohort across problems, GG-A11-Origin reads it across layers, and the two meet at the observer who articulates the geometry. First cited in §7.1.

B. Other references

S. L. Adler. Axial-vector vertex in spinor electrodynamics. *Physical Review* **177** (1969) 2426–2438.
Relevance. Adler's discovery of the axial anomaly — that a classically conserved current can appear violated in the quantum path integral — is one of the foundational results of modern quantum field theory. In the GG-6 framework, however, the BI-6 identity is understood as a *geometric* consistency condition on the composite connection, not a quantum effect. The coefficients $(1, -1, -2/5, -2/5)$ are fixed by the topological factorization $I_8 = \frac{1}{2}X_4^2$. The quantum anomaly is the symptom that appears when this geometric constraint is violated; the constraint itself is pre-quantum. First cited in §9.2.

U. Afifa, J. Carmona, A. Dinh, et al., A. P. Blaisdell, and K. Arisaka. *Visual Perception of 3D Space and Shape by 7D Frame Translation in Time, Part I: 2D Space Perception by 2D Linear Translation*, bioRxiv 2022.03.01.482161 (2022). **Relevance.** Experiment establishing the linear reaction-time-vs-eccentricity law (translation axes) and the flat-SRT / sloped-CRT dissociation — behavioral evidence for the space→time

(NHT) conversion of the IH. Author's own preprint; behavioral support for Test 10, classed Asserted/INT. First cited in §42.3.

S. Aggarwal and S. Ray. *Slope of the power spectral density flattens at low frequencies (<150 Hz) with healthy aging but also steepens at higher frequency (>200 Hz) in human electroencephalogram*, *Cerebral Cortex Communications* **4** (2023) tgad011. **Relevance.** A direct human-EEG observation of *two* spectral corners (one below ∼150 Hz, one above ∼200 Hz) with opposite aging behavior — the closest existing empirical support for the dual-knee (Test 9b) prediction. Cited honestly as emerging, single-report evidence, not a settled result (Asserted). First cited in §42.1.

Aharonov, Y., & Bohm, D. (1959). Significance of electromagnetic potentials in the quantum theory. *Physical Review*, *115*(3), 485–491. https://doi.org/10.1103/PhysRev.115.485
Relevance. The Aharonov–Bohm effect demonstrates that holonomy of a gauge connection is physically observable even when local field strengths vanish. This is a canonical precedent for GGEP's insistence that the invariant content of the composite connection includes global/holonomy data, supporting "the gauge phase as geometry." First cited in §D.2.

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*(6), 716–723. https://doi.org/10.1109/TAC.1974.1100705
Relevance. Akaike's information criterion is a quantitative formulation of the "Occam penalty" in model selection. We cite it as historical background for POS-6 (OGN): in GG-Theory, minimality is enforced not only in model structure but also in normalization conventions to prevent hidden continuous tuning. First cited in §D.4.

K. Altwegg, H. Balsiger, A. Bar-Nun, et al. *Prebiotic chemicals — amino acid and phosphorus — in the coma of comet 67P/Churyumov–Gerasimenko*, *Science Advances* **2** (2016) e1600285.
Relevance. The ROSINA mass spectrometer on Rosetta measured glycine, methylamine and ethylamine, together with phosphorus, directly in the coma of comet 67P — the first *in situ* detection of an amino acid at a comet rather than an inference from a returned or fallen sample. The present paper cites it for the layer-4 to layer-5 delivery step: the monomer inventory the cascade needs at layer 5 is demonstrably present in the small bodies that resurfaced the early Earth, so the framework's layer-5 claim is a claim about *selection* from an available inventory and not about synthesis. First cited in §33.

L. Alvarez-Gaumé and E. Witten. *Gravitational anomalies*, *Nuclear Physics B* **234** (1984) 269.
Relevance. Classified gravitational anomalies in even dimensions using the index theorem for the Dirac operator, providing the mathematical framework used throughout the BI-6 anomaly proof. Their computation of the gravitational contribution to the anomaly polynomial is the starting point for the BI-6 factorization: the coefficient $a = 1$ in the BI-6 identity $(1, -1, -2/5, -2/5)$ is the gravitational sector, normalized by the Alvarez-Gaumé–Witten index calculation. First cited in §9.2.

Amari, S.-I. (1998). Natural gradient works efficiently in learning. *Neural Computation*, *10*(2), 251–276. https://doi.org/10.1162/089976698300017746
Relevance. Amari's information-geometric formulation shows that optimization dynamics depend on the metric structure of probability/state manifolds. We cite it in the appendix to support POS-2's claim that "extremal principles" on the boundary can be written as geometry-driven flows (e.g. natural gradients) when GDOS is expressed on statistical manifolds. First cited in §E.11.

D. J. Amit. *Modeling Brain Function: The World of Attractor Neural Networks.* Cambridge University Press, 1989.

Relevance. Amit's monograph established attractor neural networks as the formal model for distributed memory and pattern completion in cortex. In the GG-Theory framework, the Hopfield/Amit attractor dynamics is a special case of GRIP descent on a finite-dimensional state manifold with a GFF Lyapunov functional; the network's stored patterns are layer-specific GGAs (T-Neural-Ring-Attractor of GG-A11-Origin Part III generalizes this to the ring topology of insect heading systems). First cited in §H.2.

P. W. Anderson. More is different. *Science* **177** (1972) 393–396.
Relevance. Anderson argued that each level of complexity in nature exhibits qualitatively new phenomena that cannot be reduced to the level below, even though the lower level's laws are not violated. The Five-Story Pagoda of the GG-6 framework formalizes Anderson's insight: each story (particles, cosmos, chemistry, life, mind) obeys the same constitutional rules but exhibits its own emergent dynamics, connected by the DGI–GSSB–GA pipeline rather than by brute-force reduction. First cited in §9.5.

K. Arisaka. *Grand Unified Theory of Mind and Brain, Part I: Space-Time Approach to Dynamic Connectomes of C. elegans and Human Brains by MePMoS* (2022). PsyArXiv preprint, https://osf.io/preprints/psyarxiv/r8ma3. **Relevance.** The dynamic-connectome / MePMoS treatment that frames the Layer-14 central-nervous-system row; develops the sensorimotor-integration reading of the *C. elegans* connectome used here. First cited in §42.3.

K. Arisaka. *Grand Unified Theory of Mind and Brain, Part II: Neural Holographic Tomography (NHT) and Holographic Ring Attractor Lattice (HAL)* (2022). PsyArXiv preprint, https://doi.org/10.31234/osf.io/vu2kz. **Relevance.** The theory paper that introduces NHT and HAL — the space→time encoding and the holographic ring-attractor read-out that underlie the layer-16/17 IH construct. Author's own preprint; the Qi-HAL identification is classed Asserted/INT. First cited in §42.3.

K. Arisaka. *The Geometric Inevitability of Cosmos, Life, and Mind: A Textbook Synthesis of the Arisaka-GG Program* (planned, 2027).
Relevance. The planned capstone volume of the GG-Theory program: a textbook synthesis of the Arisaka-GG cohort for graduate students of physics, chemistry, biology, neuroscience, and philosophy of science. The book will present the recursive uniqueness theorem of GG-A11-Origin in pedagogical order alongside the technical content of A1 through A10, so that the cascade can be taught as one apparatus rather than discovered as separate research papers. First cited in §5.

K. Arisaka and A. P. Blaisdell. *Grand Unified Theory of Mind and Brain, Part III: Holographic Visual Perception of 3D Space and Shapes* (2022). PsyArXiv preprint, https://osf.io/preprints/psyarxiv/7gbkt. **Relevance.** The theory paper that frames the four 7D-frame perception experiments and the conscious-episode timing (alpha step / theta envelope) used in Test 10. Author's own preprint (Asserted/INT). First cited in §42.3.

Aristotle. *Metaphysics*, books α, Λ. Trans. W. D. Ross, Oxford University Press (1908).
Relevance. Aristotle's distinction between final cause (telos), formal cause, efficient cause, and material cause inaugurated the project of asking *why* the world is structured as it is. In the GG-Theory program, all four Aristotelian causes are replaced by a single geometric necessity: the unique self-consistent solution of the GG-Constitution. Aristotle's final cause without a designer is reinterpreted as the uniqueness of the geometric attractor on each cascade stratum, anticipating without warranting the recursive uniqueness theorem of the present paper. First cited in §72.3.

A. Ashtekar. New variables for classical and quantum gravity. *Physical Review Letters* **57** (1986) 2244–2247.

Relevance. Introduced the connection ("Ashtekar") variables that launched loop quantum gravity. Cited in §75.5 as a foundational LQG paper; GG-Theory instead treats gravity as the scale-curvature sector of the 6D bulk, so the two operate at different levels of analysis. First cited in §75.

B. J. Baars. *A Cognitive Theory of Consciousness*. Cambridge University Press, Cambridge (1988).
Relevance. The origin of global workspace theory (GWT). Cited in §75.8: the cascade's EIC closure can be read as the GWT broadcast event, with the layer-17 conscious episode its output. First cited in §75.

J. L. Bada. *New insights into prebiotic chemistry from Stanley Miller's spark discharge experiments*, *Chemical Society Reviews* **42** (2013).
Relevance. Reanalysis of Miller's own archived sample vials, with instruments six decades more sensitive than the ones available in 1953, recovered more than twenty amino acids from runs Miller had regarded as unsuccessful. We cite it in the layer-4–6 opening for the point it settles: the prebiotic yield of monomers was underestimated rather than overestimated by the founding experiment, which strengthens the observation that the framework's layer-5 problem is selection from a superset and not production. First cited in §33.

Bardeen, W. A. (1969). Anomalous Ward identities in spinor field theories. *Physical Review*, *184*, 1848–1857.
Relevance. Develops the Ward-identity viewpoint of anomalies and clarifies how anomaly terms appear in current conservation laws. POS-3 treats such symmetry violations as fatal unless canceled by inflow; Bardeen's analysis is a canonical reference for this "symmetry grammar" perspective. First cited in §E.11.

J. D. Barrow and F. J. Tipler. *The Anthropic Cosmological Principle*. Oxford University Press (1986).
Relevance. Barrow and Tipler cataloged the apparent fine-tunings of the physical constants for the existence of complex life. The GG-Theory program answers their book chapter by chapter: each cataloged "fine-tuning" is rederived as a forced consequence of the GG-Constitution, with the integer ledger OGN-5 replacing the continuous parameters Barrow and Tipler treated as inputs. The anthropic coincidences are geometric necessities. First cited in §75.

C. Bédard and A. Destexhe. *Macroscopic models of local field potentials and the apparent* $1/f$ *noise in brain activity*, *Biophysical Journal* **96** (2009) 2589–2603. **Relevance.** Reports a broken power-law local-field-potential spectrum (slope ≈ -1 at low frequency, ≈ -3 at high frequency), i.e. two scaling regimes separated by a corner — a biophysical analog of the dual-knee structure (Test 9b). Supporting, model-based evidence (Asserted). First cited in §42.1.

J. D. Bekenstein. Black holes and entropy. *Physical Review D* **7** (1973) 2333–2346.
Relevance. Bekenstein's discovery that black holes carry entropy proportional to their horizon area established the deep connection between gravity, thermodynamics, and information. In the GG-6 framework, the $\mathrm{U}(1)_{Qi}$ gauged information current extends Bekenstein's insight: information is not merely an accounting device but a conserved physical quantity, locked to energy and matter by the Arisaka Equation. First cited in §62.1.

J. S. Bell and R. Jackiw. A PCAC puzzle: $\pi^0 \to \gamma\gamma$ in the σ-model. *Il Nuovo Cimento A* **60** (1969) 47–61.
Relevance. Bell and Jackiw independently discovered the chiral anomaly, showing that the neutral pion decay rate is determined by the anomaly rather than by perturbative coupling. This established that anomalies are not pathologies but physical predictions. In the GG-6 framework, the BI-6 anomaly is similarly not a defect to be repaired but the structural identity that determines all gauge-locked currents. First cited in §9.2.

Berry, M. V. (1984). Quantal phase factors accompanying adiabatic changes. *Proceedings of the Royal Society A*, *392*(1802), 45–57. https://doi.org/10.1098/rspa.1984.0023
Relevance. Berry's phase is a canonical example of "quantum from geometry": measurable phases arise from holonomy in parameter space. It provides historical and technical support for AX-2's emphasis that quantum structure can be encoded geometrically in connections and their holonomies rather than imposed by quantization rules. First cited in §D.2.

Bertlmann, R. A. (1996). *Anomalies in Quantum Field Theory*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198507628.001.0001
Relevance. This monograph provides the standard mathematical treatment of anomaly polynomials and descent. It supports the formal statements in POS-3, where we package anomalies into differential-form data suitable for bulk–boundary cancellation. First cited in §E.11.

L. Bianchi. *Sui simboli a quattro indici e sulla curvatura di Riemann*, *Atti della Reale Accademia dei Lincei, Rendiconti* **11** (1902) 3–7.
Relevance. The classical differential identity for the Riemann curvature tensor whose gauge-bundle generalization, $dF = 0$, is the Bianchi identity that the modified BI-6 ($dH_3 = X_4$) of GG-Theory generalizes in the Green–Schwarz manner. Cited by GG-A11-Origin in the Part II anomaly-history arc as the geometric ancestor of anomaly freedom. First cited in §9.2.

D. G. Blackmond. *The origin of biological homochirality*, *Cold Spring Harbor Perspectives in Biology* **2** (2010) a002147.
Relevance. The standard review of how a small enantiomeric excess is amplified to the near-complete homochirality that biology exhibits, covering autocatalytic amplification, phase behavior and attrition-driven deracemization. We cite it for the distinction the present Part rests on at layer 5: the literature explains amplification thoroughly and does not fix the sign, which is precisely the gap the parity-odd Wilson–Hosotani holonomy is offered to fill — and the propagation chain from that holonomy to observed handedness remains this paper's own named open problem. First cited in §33.

N. Bohr. On the constitution of atoms and molecules. *Philosophical Magazine* **26** (1913) 1–25.
Relevance. Bohr's quantization of electron orbits explained atomic stability and spectral lines, marking the transition from classical to quantum physics. The Rydberg energy $E_{\mathrm{Ry}} = 13.606$ eV, which Bohr derived from his model, reappears in the GG-6 framework as the intermediate step in the derivation of Q_{B}: the biological energy quantum is a specific rational multiple of the Rydberg energy, determined by the OGN-5 integer $K = 35$. First cited in §80.

R. Bousso and J. Polchinski. Quantization of four-form fluxes and dynamical neutralization of the cosmological constant. *Journal of High Energy Physics* **06** (2000) 006.
Relevance. The flux-quantization mechanism that generates the string-theory "discretuum" of vacua. Cited in §75.3: GG-Theory closes the landscape because the BI-6 anomaly polynomial admits exactly one solution on a single tensor multiplet. First cited in §75.

S. Brenner. *The genetics of Caenorhabditis elegans*, *Genetics* **77** (1974) 71–94. **Relevance.** Established *C. elegans* as the model organism whose nervous system anchors the Layer-14 row (a non-physics claim, classed Asserted). First cited in §41.2.

Breuer, H.-P., & Petruccione, F. (2002). *The Theory of Open Quantum Systems*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199213900.001.0001
Relevance. This standard reference develops the mathematics of open quantum systems (reduced dynamics, master equations, Markovian limits). It anchors our claim that openness is not optional in realistic modeling,

and it provides the mature language (CPTP maps and generators) that the GG-Constitution intends to elevate to first-class status. First cited in §E.11.

I. Bustanoby, A. Krupien, U. Afifa, et al., A. P. Blaisdell, and K. Arisaka. *Visual Perception of 3D Space and Shape by 7D Frame Translation in Time, Part II: 3D Space Perception with Holographic Depth*, bioRxiv 2022.02.28.482181 (2022). **Relevance.** Experiment establishing the linear reaction-time-vs-distance (depth) law with binocular=monocular and covert=overt controls — the third translation axis of the 7D frame. Author's own preprint (Asserted/INT). First cited in §42.3.

Callan, C. G. (1970). Broken scale invariance in scalar field theory. *Physical Review D, 2*(8), 1541–1547. DOI: 10.1103/PhysRevD.2.1541.
Relevance. One of the original papers formulating the Callan–Symanzik equation and the modern view of renormalization-group flow as a differential statement of scale dependence. It provides historical grounding for POS-5: "scale covariance" is not optional if the theory aims to be resolution-independent. First cited in §E.11.

C. G. Callan, Jr. and J. A. Harvey. Anomalies and fermion zero modes on strings and domain walls. *Nuclear Physics B* **250** (1985) 427–436.
Relevance. Callan and Harvey showed that anomalies on a lower-dimensional boundary can be canceled by anomaly inflow from a higher-dimensional bulk, establishing the physical mechanism behind the Green–Schwarz cancellation. The Arisaka Equation is a direct consequence of this inflow: the single B_2 tensor field channels the anomaly inflow from the six-dimensional bulk to the four-dimensional boundary, locking all currents in a fixed ratio. First cited in §9.2.

B. Carter. Large Number Coincidences and the Anthropic Principle in Cosmology. In *Confrontation of Cosmological Theories with Observational Data*, M. S. Longair (ed.), Reidel, Dordrecht (1974) 291–298.
Relevance. Carter introduced the anthropic principle to cosmology, observing that the universe's parameters must admit observers because we are here to ask. In the GG-Theory program, the anthropic principle is replaced by a stronger structural claim: the universe's parameters must admit observers because the recursive uniqueness theorem forces the cascade to ascend through cosmos, life, and mind. The anthropic selection is dissolved into geometric inevitability. First cited in §40.1.

D. J. Chalmers. *Facing up to the problem of consciousness*, *Journal of Consciousness Studies* **2** (1995) 200–219.
Relevance. Defined the "hard problem" of consciousness: the question of why subjective experience exists at all, and why physical processes in the brain are accompanied by qualitative "what it is like" character. The GG-6 framework does not dissolve the hard problem by explaining away subjectivity. Instead, it provides an operational definition of consciousness (the internal measurement of a selected IH branch by the DGI–GSSB–GA pipeline) that addresses the "easy problems" (what distinguishes conscious from unconscious processing, when consciousness is present, what its neural correlates are) while leaving the hard problem as a question about the relationship between the mathematical description and the subjective experience it describes. First cited in §1.

S. J. Cook, T. A. Jarrell, C. A. Brittin, et al. *Whole-animal connectomes of both Caenorhabditis elegans sexes*, *Nature* **571** (2019) 63–71. **Relevance.** The whole-animal connectome (∼7,000 synapses) for the Layer-14 quantitative anchor. First cited in §41.2.

Cover, T. M., & Thomas, J. A. (2006). *Elements of Information Theory* (2nd ed.). Wiley. https://doi.org/10.1002/047174882X

Relevance. Information theory supplies a precise quantitative language for "information" as an operational resource. We cite this text to support the appendix discussion where free-energy-like functionals are related to KL divergence and where MF requires explicit information-theoretic accounting for measurement and compression. First cited in §E.11.

W. M. Haynes (ed.). *CRC Handbook of Chemistry and Physics*, 97th edition. CRC Press, Boca Raton (2016). **Relevance.** Standard reference for small-molecule thermochemical data (standard enthalpies of formation, bond energies); the external source for the layer-4 small-molecule formation enthalpies in the cascade codebook, replacing an erroneous Particle-Data-Group citation. First cited in §41.2.

F. Crick and C. Koch. Toward a neurobiological theory of consciousness. *Seminars in the Neurosciences* **2** (1990) 263–275.
Relevance. Crick and Koch proposed binding-by-synchrony as a candidate solution to the binding problem of consciousness: neural features bound by 40-Hz gamma oscillations into one unified conscious state. In the present framework, the binding problem is resolved by GA stabilization at the layer-17 EIC stratum (binding-by-attractor-stabilization), which differs structurally from binding-by-synchrony but is empirically compatible with the gamma-oscillation findings the Crick-Koch program catalyzed. First cited in §65.

G. E. Crooks. Entropy production fluctuation theorem and the nonequilibrium work relation for free energy differences. *Physical Review E* **60** (1999) 2721–2726.
Relevance. Crooks's fluctuation theorem provides a symmetry relation between the probability of forward and reverse nonequilibrium trajectories, strengthening and generalizing the second law. In the GFF framework, the Crooks relation constrains the fluctuations of the maintenance margin: a living system (SeOS) must maintain a positive margin on average, but individual events can temporarily violate this constraint — the Crooks theorem quantifies how often and by how much. First cited in §58.

B. Damer and D. Deamer. *The hot spring hypothesis for an origin of life*, *Astrobiology* **20** (2020).
Relevance. Argues that wet–dry cycling in terrestrial hot-spring pools, rather than the open ocean, supplies the concentration and condensation conditions that polymerization requires, with encapsulation into lipid vesicles occurring in the same cycle. We cite it as one of the two standard developments of the wet–dry route; in the present framework it supplies the physical content of the GRIP-Out event for the layer-5 to layer-6 transition, which the cascade names but does not derive. First cited in §33.

C. Darwin. *On the Origin of Species by Means of Natural Selection.* John Murray, London (1859).
Relevance. Established the theory of evolution by natural selection, explaining the diversity of life through variation and differential reproductive success. Darwin's theory explains *how* organisms adapt once they exist; the present paper addresses the complementary question of *why* life exists at all. The GG-6 framework does not replace Darwinian evolution but provides its geometric foundation: the QGL constraint makes life inevitable, and natural selection then operates on the inevitable living substrate to produce the diversity Darwin documented. First cited in §1.

R. Dawkins. *The Selfish Gene.* Oxford University Press (1976).
Relevance. Dawkins popularized the gene-centered view of evolution, arguing that organisms are "survival machines" built by genes to propagate themselves. The SeOS (Selfish Open System) classification in the GG-6 framework formalizes this idea: a SeOS acts to maintain its own packet not because it possesses intention but because the QGL-constrained dynamics selects trajectories that preserve local viability. Dawkins's "selfish" is the GG-6 framework's "maintenance-margin-positive.". First cited in §58.

S. Dehaene. *Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts.* Viking, 2014.

Relevance. Dehaene's Global Neuronal Workspace (GNW) account treats consciousness as the broadcast of a single coherent representation across cortical networks via long-range top-down ignition. In the GG-Theory framework, GNW ignition is the boundary readout of a stabilized IH branch on the EIC stratum — operationally identified with T-Conscious-Episode of GG-A11-Origin Part III at CDI ~ 10. First cited in §41.2.

de Haro, S., Skenderis, K., & Solodukhin, S. N. (2001). Holographic reconstruction of spacetime and renormalization in the AdS/CFT correspondence. *Communications in Mathematical Physics*, *217*, 595–622. https://arxiv.org/abs/hep-th/0002230
Relevance. This work systematized holographic renormalization, making precise how bulk radial evolution corresponds to boundary RG flow. We cite it as a technical antecedent for POS-5: RG-compatibility is treated as a structural commutation requirement between coarse-graining and bulk–boundary dictionaries. First cited in §E.11.

Dennett, D. C. (1984). *Elbow Room: The Varieties of Free Will Worth Wanting*. MIT Press.
Relevance. Dennett's compatibilist defense of the kind of free will worth wanting under naturalistic constraints. The framework's position on agency in Corollary 69.3 sits within this tradition: agency is preserved at the substrate's operational level (the conscious brain genuinely deliberates), while the existence of layer-17 substrates is forced by the cascade. First cited in §70.

P. A. M. Dirac. Quantised singularities in the electromagnetic field. *Proceedings of the Royal Society A* **133** (1931) 60–72.
Relevance. Dirac showed that the existence of a magnetic monopole would imply the quantization of electric charge — the first example of a topological argument constraining physical observables. The $\mathrm{U}(1)_{Qi}$ informational charge in GG-6 is quantized by an analogous mechanism: the geometric consistency constraint (BI-6) forces the informational quantum number to take discrete values, making J_{Qi} a conserved, quantized current on the same footing as electric charge and baryon number. First cited in §80.

A. J. Doig. *Frozen, but no accident — why the 20 standard amino acids were selected*, *The FEBS Journal* **284** (2017), https://doi.org/10.1111/febs.13982.
Relevance. A review of the evidence that the coded twenty are a selected rather than an arbitrary set, assembled against Crick's frozen-accident hypothesis. It is the fairest available summary of what the conventional account of the number twenty can and cannot do, and the present paper cites it in exactly that role: the field's explanations are retrospective fitness arguments, each defensible, and none of them derives the integer — which is the space the layer-5 relation $|\mathsf{GGA}_5| = K - NL$ attempts to occupy, at a grade this Part states plainly. First cited in §33.

T. Donoghue, M. Haller, E. J. Peterson, et al. (incl. B. Voytek). *Parameterizing neural power spectra into periodic and aperiodic components*, *Nature Neuroscience* **23** (2020) 1655–1665. **Relevance.** The field-standard parameterization of the neural power spectrum into an aperiodic component (offset, exponent, and an optional single knee) plus periodic peaks. External anchor for the Layer-17 / Test-9b neural $1/f$ claim; establishes the single knee and is the tool whose one-knee default the dual-knee prediction goes beyond (a non-physics claim, classed Asserted). First cited in §42.1.

A. Einstein. Die Feldgleichungen der Gravitation. *Sitzungsberichte der Preussischen Akademie der Wissenschaften* (1915) 844–847.
Relevance. General relativity established that gravity is not a force but the curvature of spacetime, making geometry the language of fundamental physics. AX-2 (the Geometry–Gauge Equivalence Principle) extends Einstein's insight: not only gravity but all gauge forces are aspects of geometry, unified through

the composite connection of the six-dimensional GG-6 bulk. Einstein's revolution is the prototype for the constitutional approach: a geometric principle that eliminates arbitrary parameters. First cited in §9.1.

J. L. England. Statistical physics of self-replication. *Journal of Chemical Physics* **139** (2013) 121923.
Relevance. England derived a thermodynamic bound on the dissipation cost of self-replication, relating a replicator's durability and replication rate to the heat it dissipates (a necessary thermodynamic constraint, not a demonstration that replicators must arise). This result is a boundary-theory consequence of the MEPP sector of Qi-EP: living systems (self-replicators) maximize entropy production, which is precisely the condition for minimizing the GFF functional under the QGL constraint. First cited in §58.

J. P. Ferris, A. R. Hill Jr., R. Liu, and L. E. Orgel. *Synthesis of long prebiotic oligomers on mineral surfaces*, *Nature* **381** (1996) 59–61.
Relevance. Demonstrates that montmorillonite clay templates the oligomerization of activated nucleotides into chains of forty to fifty units — long enough for catalytic structure — without enzymes. We cite it in the layer-6 discussion as the experimental basis for treating the polymer class as a reachable product on a mineral-bearing warm-wet stratum, and as an illustration of the honest limit of the layer-6 row: the experiment shows that chains form, not that exactly three chain families are the landscape's basins. First cited in §33.

Fischer, J. M. (1994). *The Metaphysics of Free Will: An Essay on Control*. Blackwell.
Relevance. Fischer's distinction between guidance control (compatible with determinism) and regulative control (alternative-possibilities-requiring) is the precise compatibilist apparatus the framework's micro-trajectory openness invokes: the conscious substrate exercises guidance control over its trajectory within the forced layer-17 attractor. First cited in §70.

F. C. Frank. *On spontaneous asymmetric synthesis*, *Biochimica et Biophysica Acta* **11** (1953) 459–463.
Relevance. The founding kinetic model of homochirality: an autocatalytic reaction in which each enantiomer catalyzes its own formation and suppresses the other amplifies any initial imbalance to near-complete excess. Frank's model is the reason the origin-of-homochirality problem is now understood to be a problem about the *sign* rather than the magnitude, which is the distinction the present Part draws at layer 5 and the reason the chirality-lock lemma is named as the missing piece rather than the amplification mechanism. First cited in §33.

Frankfurt, H. G. (1969). Alternate possibilities and moral responsibility. *Journal of Philosophy*, **66**(23), 829–839.
Relevance. Frankfurt's celebrated cases showing that moral responsibility does not require alternative possibilities at the level of physical determinism. The framework's reading of agency in Corollary 69.3 is Frankfurt-compatible: responsibility resides in the agent's reasons-responsive substrate, not in the openness of physical micro-trajectories. First cited in §70.

Freidlin, M. I., & Wentzell, A. D. (1998). *Random Perturbations of Dynamical Systems* (2nd ed.). New York: Springer. https://doi.org/10.1007/978-1-4612-0611-5
Relevance. Freidlin–Wentzell theory provides a rigorous large-deviation framework in which stochastic open-system trajectories concentrate near minimizers of an action functional. We cite it as mathematical background for POS-2 (UEP), supporting the claim that "least-action" logic persists in open/noisy systems as a most-probable-path extremal principle. First cited in §E.11.

Y. Furukawa, Y. Chikaraishi, N. Ohkouchi, et al. *Extraterrestrial ribose and other sugars in primitive meteorites*, *Proceedings of the National Academy of Sciences* **116** (2019) 24440–24445, https://doi.org/10.1073/pnas.1907169116.

Relevance. Identifies ribose and other bio-essential sugars in the Murchison and NWA 801 carbonaceous chondrites, with carbon-isotope ratios establishing extraterrestrial origin. The present paper cites it for the sugar half of the layer-5 inventory: the D-handed pentoses the cascade claims at layer 5 are, like the amino acids, demonstrably delivered rather than necessarily synthesized in place — so here too the framework's claim is one of selection. This entry also corrects an earlier statement in the cohort that placed ribose in the Ryugu returned samples; the Ryugu detection is uracil (Oba et al., 2023), and ribose is Murchison and NWA 801. First cited in §33.

K. Friston. *The free-energy principle: a unified brain theory?*, *Nature Reviews Neuroscience* **11** (2010) 127–138.
Relevance. Proposed the Free Energy Principle (FEP), which states that biological systems minimize a variational free energy — the discrepancy between the system's internal model and sensory input. The FEP has been applied to perception, action, learning, and consciousness. In the GG-6 framework, the FEP is a consequence of the Qi-EP principle applied to the biological boundary: the $\mathcal{F}_{\mathsf{EIC}}$ Lyapunov functional has exactly the structure of Friston's variational free energy, and the MePMoS cycle is the operational realization of Friston's perception–action loop. The FEP is the $J_{Qi} \neq 0$, Markov-blanket-equipped sector of the more general Qi-EP. First cited in §75.

R. Gao, R. L. van den Brink, T. Pfeffer, and B. Voytek. *Neuronal timescales are functionally dynamic and shaped by cortical microarchitecture*, *eLife* **9** (2020) e61277. **Relevance.** Establishes the mapping between the aperiodic spectral knee and an intrinsic neuronal timescale, $\tau = 1/(2\pi f_{\text{knee}})$, rising along the cortical hierarchy. External anchor for the timescale reading of the Test-9b neural knee (Asserted). First cited in §42.1.

H. Georgi and S. L. Glashow. *Unity of all elementary-particle forces*, *Physical Review Letters* **32** (1974) 438–441.
Relevance. Proposed the first Grand Unified Theory based on SU(5), showing that the strong, weak, and electromagnetic forces can be unified into a single gauge group at high energy. The original Georgi–Glashow model predicts proton decay, which has not been observed. In the GG-6 framework, the SU(5) structure is preserved but the proton is absolutely stable because baryon number is gauged ($\mathrm{U}(1)_B$ is an exact local symmetry). The trace ratio 2/5 in the BI-6 coefficients is a direct consequence of the SU(5) block size $L = 5$. First cited in §9.7.

J. W. Gibbs. On the equilibrium of heterogeneous substances. *Transactions of the Connecticut Academy of Arts and Sciences* **3** (1875–1878) 108–248, 343–524.
Relevance. The founding paper of physical chemistry's free-energy formalism: $G = H - TS$ as the cost functional whose minimum identifies the equilibrium state of a thermodynamic system at constant temperature and pressure. In the framework of GG-A11-Origin, the Gibbs free energy is identified as the $J_{Qi} = 0$ boundary projection of the Geometric Free-Energy Functional F_{GFF} of GG-A5-GDOS. Gibbs's law was the first *free energy* written down; the framework's Three-Gauge Theorem reads it as one of three boundary projections of a single underlying geometric object. First cited in §59.2.

W. Gilbert. *The RNA world*, *Nature* **319** (1986) 618.
Relevance. The one-page note that named the hypothesis — that a single molecule once carried both the genetic information and the catalysis now divided between DNA and protein. The idea is older than the name, having been proposed by Woese, Crick and Orgel in the late 1960s, but the name is what organized the field. We cite it as the origin of the framing that layer 8 of the present cascade adopts, and as the boundary of what layer 6 deliberately does not claim: layer 6 certifies a polymer class and leaves the selection of RNA to the layer above. First cited in §33.

S. L. Glashow. Partial-symmetries of weak interactions. *Nuclear Physics* **22** (1961) 579–588.
Relevance. Glashow proposed the SU(2) × U(1) structure of the electroweak interaction, later completed by Weinberg and Salam. In GG-6, the electroweak group is a subgroup of SU(5) that emerges on the four-dimensional boundary after the Hosotani Wilson-line symmetry breaking. The electroweak mixing angle $\sin^2\theta_W = 25/108$ is derived from the OGN-5 integers rather than fitted to data. First cited in §56.

Goff, P. (2017). *Consciousness and Fundamental Reality*. Oxford University Press.
Relevance. Contemporary defense of Russellian monism as a serious option in the philosophy of consciousness landscape. Goff distinguishes Russellian panpsychism from Russellian neutral monism (the framework's chosen position) and argues that the latter offers structural resources the framework now operationalizes via the EIC closure on layer-17 substrates. First cited in §65.

Goldstein, H., Poole, C., & Safko, J. (2002). *Classical Mechanics* (3rd ed.). Addison–Wesley.
Relevance. This standard text summarizes variational principles (Hamilton, Lagrange, Maupertuis) and their equivalences. We cite it in POS-2 to situate the Unified Extremal Principle within the established mechanics lineage. First cited in §E.11.

Gorini, V., Kossakowski, A., & Sudarshan, E. C. G. (1976). Completely positive dynamical semigroups of N-level systems. *Journal of Mathematical Physics*, *17*(5), 821–825. https://doi.org/10.1063/1.522979
Relevance. Together with Lindblad, this paper characterizes the most general Markovian quantum evolution preserving complete positivity. We cite it as a rigorous foundation for treating open-system evolution as a constitutional admissibility condition (POS-4: Closure & Positivity). First cited in §E.11.

Gorini, V., Kossakowski, A., & Sudarshan, E. C. G. (1976). Completely positive dynamical semigroups of N-level systems. *Journal of Mathematical Physics*, *17*(5), 821–825.
Relevance. Along with Lindblad's work, this establishes the generator form required for physical open-system quantum evolution. It supports POS-CP and the OGGEP demand that open evolution be part of the foundational dictionary. First cited in §A.1.

M. B. Green and J. H. Schwarz. *Anomaly cancellations in supersymmetric D=10 gauge theory and superstring theory*, *Physics Letters B* **149** (1984) 117–122.
Relevance. The foundational anomaly-cancellation paper that launched the "first superstring revolution." Green and Schwarz showed that the gauge and gravitational anomalies of the ten-dimensional SO(32) superstring cancel through a tensor-mediated mechanism, selecting SO(32) and $E_8 \times E_8$ as the only consistent gauge groups. The BI-6 identity of GG-6 is the six-dimensional, non-supersymmetric counterpart of this mechanism (sharing its anomaly-polynomial mathematics, not its ten-dimensional origin): the same mathematical structure (factorized anomaly polynomial, tensor counterterm) operates in six dimensions with the gauge group $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$, producing the Arisaka Equation instead of the string-theory gauge groups. First cited in §7.4.

Gubser, S. S., Klebanov, I. R., & Polyakov, A. M. (1998). Gauge theory correlators from non-critical string theory. *Physics Letters B*, *428*(1–2), 105–114. https://arxiv.org/abs/hep-th/9802109
Relevance. Together with Witten's prescription, this paper established the concrete AdS/CFT dictionary relating bulk fields to boundary correlators. We cite it as historical precedent for treating a bulk→boundary export map as part of the theory's definition, which OGGEP generalizes to include explicit measurement semantics. First cited in §D.3.

A. H. Guth. Inflationary universe: a possible solution to the horizon and flatness problems. *Physical Review D* **23** (1981) 347–356.

Relevance. Guth's inflationary scenario solved the horizon and flatness problems of standard cosmology by postulating a period of exponential expansion in the early universe. The GG-6 cosmology paper proposes a GUT-adjacent slow smooth inflationary descent (a plateau one e-fold below E_{GUT}, $V_{\mathrm{inf}}^{1/4} = 8.1 \times 10^{15}$ GeV) that differs from Guth's original false-vacuum scenario in mechanism and observational signatures, while achieving the same resolution of the cosmological puzzles. First cited in §74.

Haag, R. (1992). *Local Quantum Physics: Fields, Particles, Algebras* (2nd ed.). Springer. https://doi.org/10.1007/978-3-662-03081-1
Relevance. Haag's formulation of QFT emphasizes locality, causality, and operator-algebraic structure. We cite it to ground AX-1 in the rigorous QFT tradition and to clarify what "locality" means when expressed as constraints on observable algebras. First cited in §D.1.

T. Hafting, M. Fyhn, S. Molden, M.-B. Moser, and E. I. Moser. *Microstructure of a spatial map in the entorhinal cortex*, *Nature* **436** (2005) 801–806.
Relevance. Discovered grid cells in the entorhinal cortex — neurons that fire at regular hexagonal intervals as the animal moves through space, providing a metric coordinate system for distances and directions. Together with place cells, grid cells implement the allocentric IH predicted by the framework: the learned metric g_t on the latent manifold $\mathcal{Z}$. The hexagonal symmetry of the grid pattern is a consequence of optimal packing under the GFF energy constraint, and the multiple grid scales correspond to the NHT (Nested Holographic Transform) hierarchy predicted by Qi-HAL. First cited in §39.3.

H. Haken. *Synergetics: An Introduction* (3rd ed.). Springer, Berlin (1983).
Relevance. Haken's synergetics provides the mathematical framework for understanding how macroscopic order emerges from the cooperation of many microscopic components. The GSSB mechanism in the GG-6 framework is a geometric generalization of Haken's order-parameter dynamics: the symmetry-breaking transition that selects a specific macroscopic pattern from a space of equivalent possibilities is the same mathematical structure in laser physics (Haken's original application), in the Higgs mechanism (particle physics), and in conscious perception (the DGI–GSSB–GA pipeline). First cited in §20.

Hamilton, W. R. (1834). On a general method in dynamics. *Philosophical Transactions of the Royal Society of London*, *124*, 247–308. https://doi.org/10.1098/rstl.1834.0017
Relevance. Hamilton's formulation is the modern backbone of the principle of least action and canonical dynamics. We cite it in POS-2 to emphasize that extremal principles historically reorganized mechanics and are a natural candidate for a unification engine. First cited in §E.11.

S. W. Hawking. Particle creation by black holes. *Communications in Mathematical Physics* **43** (1975) 199–220.
Relevance. Hawking showed that black holes radiate thermally, confirming Bekenstein's entropy formula and revealing a tension between quantum mechanics and general relativity (the information paradox). The bulk-to-boundary structure of GG-6 — in which the six-dimensional bulk projects onto a four-dimensional boundary — provides a natural framework for resolving this tension, since information is never lost in the bulk even when it appears to be lost on the boundary. First cited in §62.1.

G. W. F. Hegel. *Phänomenologie des Geistes* (1807).
Relevance. In the *Phenomenology of Spirit*, Hegel described the Absolute Spirit — the universe coming to know itself through the medium of finite minds, proceeding through a dialectical sequence of thesis, antithesis, and synthesis. The EIC convergence theorem $\mathcal{Z}_{\mathsf{EIC}}[J_i] = \mathcal{Z}_{\mathrm{external}}[J_i]$ is Hegel's Absolute Spirit stated as a functional convergence theorem. The GSSB cascade, with its seventeen symmetry-breaking transitions, is Hegel's dialectical development made quantitative; each transition is a synthesis that resolves the tension of the previous stage and generates the conditions for the next. First cited in §40.1.

P. W. Higgs. Broken symmetries and the masses of gauge bosons. *Physical Review Letters* **13** (1964) 508–509.

Relevance. The Higgs mechanism explains how gauge bosons acquire mass through spontaneous symmetry breaking, completing the electroweak theory. In the GG-6 framework, the Higgs field is not a separate ingredient but a geometric object: the Wilson-line holonomy around the compact sixth dimension, whose vacuum expectation value is determined by the Hosotani mechanism and the OGN-5 integers. The Higgs mass is a derived quantity, not a free parameter. First cited in §56.

P. G. Higgs and R. E. Pudritz. *A thermodynamic basis for prebiotic amino acid synthesis and the nature of the first genetic code*, *Astrobiology* **9** (2009).

Relevance. Derives, from the thermodynamics of synthesis alone, the subset of amino acids that should be most abundant prebiotically, and finds it matches the set independently inferred to have entered the genetic code earliest. We cite it as the strongest *forward* argument the conventional literature offers about the composition of the coded set — and note in the same breath what it does not do: it ranks and it explains an early subset, and it does not fix the final cardinality at twenty. First cited in §33.

J. J. Hopfield. Neural networks and physical systems with emergent collective computational abilities. *Proceedings of the National Academy of Sciences* **79** (1982) 2554–2558.

Relevance. Hopfield showed that neural networks with symmetric connections store memories as attractor states — stable configurations toward which the network evolves from nearby initial conditions. The GA (Geometric Attractor) phase of the DGI–GSSB–GA pipeline is the GG-6 generalization of Hopfield's attractor dynamics: the conscious percept is the GA-stabilized state of the cortical network, and the CDI ladder measures the depth and richness of the attractor landscape. First cited in §62.3.

M. J. Hopkins and I. M. Singer. *Quadratic functions in geometry, topology, and M-theory*, *Journal of Differential Geometry* **70** (2005) 329–452.

Relevance. Developed the mathematical framework of differential cohomology and its application to anomaly cancellation, providing the rigorous language for global (topological) anomalies beyond the perturbative Green–Schwarz mechanism. The BI-6 global anomaly proof uses the Hopkins–Singer integral lift to construct the Wu–Chern–Simons counterterm, and the automatic-admissibility theorem verifies that the hypotheses of the Hopkins–Singer framework are satisfied on the intended GG-6 class. This is the mathematical technology that ensures the six-dimensional bulk is consistent not just perturbatively but also non-perturbatively. First cited in §7.4.

Y. Hosotani. *Dynamical gauge symmetry breaking as the Casimir effect*, *Physics Letters B* **129** (1983) 193–197.

Relevance. Introduced the Wilson-line symmetry-breaking mechanism, in which the vacuum expectation value of the gauge field around a compact extra dimension breaks the gauge symmetry dynamically. In GG-6, the Hosotani mechanism replaces the elementary Higgs field: the Higgs vacuum is a holonomy branch of the composite connection around S^1_θ, and the Higgs mass and vacuum expectation value are determined by the OGN-5 integers rather than fitted to data. This is the mechanism by which electroweak symmetry breaking becomes a geometric consequence. First cited in §74.

Jackson, F. (1982). Epiphenomenal qualia. *Philosophical Quarterly*, **32**(127), 127–136.

Relevance. The canonical statement of the knowledge argument ("what Mary knew"): a color scientist confined to a black-and-white room and then released to see red is said to learn a new fact about phenomenal experience. The framework's structural-identity reply distinguishes propositional knowledge of the EIC structure from acquaintance with its instantiation on a specific stimulus coordinate; Mary gains

acquaintance, not a new fact. Jackson himself in subsequent work moved toward the ability-hypothesis reading, which is consonant with the framework's reply. First cited in §65.

W. James. *The Principles of Psychology.* Henry Holt, 1890.
Relevance. James's two-volume treatise founded scientific psychology and introduced the "stream of consciousness" as a unit of analysis, alongside the ideomotor theory and the James–Lange theory of emotion. In the GG-Theory framework, James's stream of consciousness is the temporal sequence of EIC closures at theta-cycle cadence — operationally identified with the kinematic readout of T-Conscious-Episode. First cited in §85.

C. Jarzynski. Nonequilibrium equality for free energy differences. *Physical Review Letters* **78** (1997) 2690–2693.
Relevance. Jarzynski's equality relates the free energy difference between two equilibrium states to the exponential average of work performed in nonequilibrium processes, extending the second law to far-from-equilibrium systems. The GFF ledger of the GG-6 framework is the natural setting for Jarzynski-type relations: each gauge-locked event contributes to the GFF balance, and the maintenance margin of a SeOS can be expressed as a Jarzynski-type average over the system's operational cycles. First cited in §58.

E. T. Jaynes. Information theory and statistical mechanics. *Physical Review* **106** (1957) 620–630.
Relevance. Jaynes showed that statistical mechanics can be derived from the principle of maximum entropy, reinterpreting thermodynamics as a theory of inference rather than of microscopic dynamics. The Qi-EP (Geometric Extremal Principle) of the GG-6 framework subsumes Jaynes's maximum-entropy principle as a special case: when the QGL constraint is inactive ($J_{Qi} = 0$), Qi-EP reduces to Jaynes's formalism; when the constraint is active, it extends to the full GFF descent. First cited in §49.

G. F. Joyce. *The antiquity of RNA-based evolution*, *Nature* **418** (2002) 214–221.
Relevance. Assembles the evidence that RNA-based evolution preceded protein-based evolution, principally the phylogenetic depth of RNA cofactors and catalytic RNA inside modern metabolism, and states the case for the RNA world as the field's default working hypothesis rather than a speculation. We cite it for the same boundary Gilbert marks: it establishes what layer 8 will have to account for, and it establishes that the polymer-class claim of layer 6 is prior to, and weaker than, any claim about which polymer won. First cited in §33.

T. Kaluza. Zum Unitätsproblem der Physik. *Sitzungsberichte der Preussischen Akademie der Wissenschaften* (1921) 966–972.
Relevance. Kaluza showed that general relativity in five dimensions contains both four-dimensional gravity and electromagnetism, establishing the idea that extra dimensions can unify forces. The GG-6 bulk $M_6 = M_4 \times I_r \times S^1_\theta$ is a modern descendant of Kaluza's construction, extended from five to six dimensions and from electromagnetism to the full $\mathrm{SU}(5) \times \mathrm{U}(1)_B \times \mathrm{U}(1)_{Qi}$ gauge group. First cited in §9.1.

I. Kant. *Kritik der reinen Vernunft* (Critique of Pure Reason), 1st ed. 1781, 2nd ed. 1787.
Relevance. Kant's transcendental philosophy distinguished the phenomenal world (what can be experienced) from the noumenal (what is, prior to experience). The GG-Theory program accepts Kant's distinction at the operational level (OGGEP, AX-3 of the GG-Constitution) but rejects the noumenal as inaccessible: the constitution of the bulk is fully recoverable from the operational boundary, and the act of recovery is the self-referential closure of Part XII. First cited in §72.6.

S. A. Kauffman. *The Origins of Order: Self-Organization and Selection in Evolution.* Oxford University Press (1993).

Relevance. Kauffman argued that the order observed in biological systems is not solely the product of natural selection but also of self-organization — that certain molecular configurations are intrinsically more probable than others due to the structure of chemical reaction networks. The GG-6 framework provides the physical underpinning for Kauffman's intuition: the QGL constraint makes certain molecular architectures (those satisfying the gauge-locking condition) geometrically necessary, not merely probable. First cited in §20.

S. S. Kim, H. Rouault, S. Druckmann, V. Jayaraman. Ring attractor dynamics in the *Drosophila* central brain. *Science* **356** (2017) 849–853.
Relevance. Two-photon calcium imaging in the ellipsoid body of *Drosophila* resolves a single localized activity bump that drifts and stabilizes in a one-dimensional ring topology, identifying the head-direction ring attractor as a directly visualizable neural substrate. This is the empirical anchor for T-Neural-Ring-Attractor of GG-A11-Origin Part III: insect heading is the layer-15 GGA, a ring topology selected by GRIP descent on the SO(2)-equivariant boundary stratum. First cited in §41.1.

M. Kleiber. *Body size and metabolism*, *Hilgardia* **6** (1932) 315–353. **Relevance.** The original statement of the three-quarter-power metabolic scaling law $B \propto M^{3/4}$ (the universality of the 3/4 exponent is debated — a 2/3 surface-law exponent is observed in some regimes), used as the empirical anchor for the layer-13 multicellularity row of the cascade codebook (a non-physics claim, classed Conditional). The framework reads the exponent as a variational signature of the Qi-EP principle rather than a fitted constant. First cited in §41.2.

O. Klein. Quantentheorie und fünfdimensionale Relativitätstheorie. *Zeitschrift für Physik* **37** (1926) 895–906.
Relevance. Klein proposed that the extra dimension in Kaluza's theory is compactified (curled up into a small circle), explaining why it is not directly observed. The compact S^1_θ dimension of GG-6 is Klein's compactification applied to the sixth dimension; the Kaluza–Klein tower of massive excitations predicts a resonance at approximately 3.85 TeV, testable at the High-Luminosity LHC. First cited in §9.1.

Kobayashi, S., & Nomizu, K. (1963). *Foundations of Differential Geometry* (Vol. 1). Wiley.
Relevance. This classic text provides the rigorous mathematics of principal bundles, connections, curvature, and holonomy. We cite it as a standard reference for the geometric language used in formulating GGEP (composite connection) and in defining curvature/holonomy as invariants. First cited in §D.2.

Kraus, K. (1971). General state changes in quantum theory. *Annals of Physics*, *64*(2), 311–335. https://doi.org/10.1016/0003-4916(71)90108-4
Relevance. Kraus operators and instruments provide the modern operational semantics of measurement and state update. We cite this work as foundational for AX-3, where measurement is defined axiomatically as a CP instrument produced by the bulk→boundary dictionary. First cited in §D.1.

Kraus, K. (1983). *States, Effects, and Operations: Fundamental Notions of Quantum Theory*. Springer. https://doi.org/10.1007/978-3-540-39068-5
Relevance. Kraus' monograph systematizes the operational formulation of quantum measurement and dynamics via completely positive maps. AX-3 adopts this language axiomatically by requiring that measurement be defined in terms of instruments and that open evolution be CPTP. First cited in §D.1.

T. S. Kuhn. *The Structure of Scientific Revolutions*. University of Chicago Press (1962).
Relevance. Kuhn argued that science progresses through paradigm shifts — periods of "normal science" punctuated by revolutions that redefine the fundamental concepts and methods of a field. The present paper argues that the GG-Theory represents the third such revolution (after Newton and Einstein/QM), extending mathematical law from closed physical systems to all open systems including life and consciousness. Kuhn's

framework explains why the resistance to such a shift is expected and why the shift, once completed, is irreversible. First cited in §80.

Kullback, S., & Leibler, R. A. (1951). On information and sufficiency. *Annals of Mathematical Statistics*, *22*(1), 79–86. https://doi.org/10.1214/aoms/1177729694
Relevance. The KL divergence is the canonical nonnegative functional measuring distinguishability of probability distributions. We cite it because many "free energy" expressions in nonequilibrium physics and inference can be written as KL divergences, providing a clean mathematical bridge for POS-2 (UEP) between thermodynamic and informational extremals. First cited in §E.11.

V. Kumar, D. R. Morrison, and W. Taylor. *Global aspects of the space of 6D N=1 supergravities*, *JHEP* **11** (2010) 118.
Relevance. Systematically enumerated the space of six-dimensional $\mathcal{N} = (1, 0)$ supergravity theories satisfying anomaly cancellation, establishing the landscape of consistent 6D models. The BI-6 theorem shows that the GG-6 solution occupies a unique point in a closely related (non-supersymmetric) parameter space, and the techniques of Kumar, Morrison, and Taylor — particularly the Diophantine system for orbit multiplicities — are adapted in the benchmark-spectrum construction of the anomaly paper. First cited in §9.2.

Ladyman, J., and D. Ross. (2007). *Every Thing Must Go: Metaphysics Naturalized.* Oxford University Press.
Relevance. The most developed contemporary statement of ontic structural realism: there are no quiddities (intrinsic individuating properties) beyond the structural relations that physics describes; structure is metaphysically fundamental. The framework's structural-identity theory of phenomenal consciousness (Part XIV §65) and its anti-Russellian commitment to structure-all-the-way-down draw directly on this tradition. Ladyman–Ross is the natural philosophical home for the framework's metaphysical commitments. First cited in §65.

K. Kvenvolden, J. Lawless, K. Pering, et al. *Evidence for extraterrestrial amino-acids and hydrocarbons in the Murchison meteorite*, *Nature* **228** (1970) 923–926.
Relevance. The analysis that established amino acids of unambiguously extraterrestrial origin in a meteorite, racemic and including species biology does not use. More than eighty amino acids are now attributed to Murchison. This is the single most important empirical fact bearing on the present Part's layer 5: the prebiotic inventory is a superset of the biological one, so the question the cascade must answer at layer 5 is which twenty are taken up, and the framework's answer is graded **Conditional** accordingly. First cited in §33.

R. Landauer. *Irreversibility and heat generation in the computing process*, *IBM Journal of Research and Development* **5** (1961) 183–191.
Relevance. Established the minimum energy cost of information erasure: $k_B T \ln 2$ per bit erased. Landauer's principle connects information theory to thermodynamics by showing that logical irreversibility implies physical dissipation. The QGL constraint raises this bound by an order of magnitude: because information current J_{Qi} must be accompanied by baryonic and electromagnetic currents, the true physical cost of biological information processing is ~ 13–$14\, k_B T$ per nucleotide, not $1.4\, k_B T$. This elevated bound explains why biological information processing is expensive and why disembodied information is physically forbidden. First cited in §9.5.

N. Lane. *The Vital Question: Why Is Life the Way It Is?* Profile Books, London (2015).
Relevance. Lane argues that the origin of life is fundamentally an energy problem: life arose at alkaline hydrothermal vents where geochemical proton gradients could drive the synthesis of organic molecules. The

GG-6 framework's complementary reading: the geochemical setting Lane emphasizes supplies the proton gradient (the *site* is contingent, as Lane argues), while the energy quantum $N_A \mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol itself is fixed by the OGN-5 integers — the site may vary, but the quantum is universal, so any source delivering multiples of Q_B can drive the GSSB cascade toward life. First cited in §41.2.

C. Le, S. Pedersen, N. Chen, et al., A. P. Blaisdell, and K. Arisaka. *Visual Perception of 3D Space and Shape by 7D Frame Translation in Time, Part IV: 3D Shape Recognition by 3D Rotation*, bioRxiv 2022.03.01.482164 (2022). **Relevance.** Experiment establishing reaction time linear in rotation angle on roll/yaw/pitch (roll flattest) and the ~ 100 ms-step / ~ 400 ms-loop conscious-recognition timing — the three rotation axes of the 7D frame and the direct timing anchor for Test 10. Author's own preprint (Asserted/INT). First cited in §42.3.

G. W. Leibniz. *Monadologie* (1714); *Principles of Nature and Grace* (1714). Trans. R. Latta, Oxford University Press (1898).
Relevance. Leibniz's *principle of sufficient reason* — nothing exists without a reason for being so rather than otherwise — is the philosophical predecessor of the GG-Theory uniqueness theorems. Leibniz inferred from sufficient reason to the existence of a sufficient ground (God); GG-Theory derives the same conclusion from the constitution of geometry, with the constitution playing the structural role Leibniz assigned to divine choice. First cited in §72.5.

Levine, J. (1983). Materialism and qualia: The explanatory gap. *Pacific Philosophical Quarterly*, **64**(4), 354–361.
Relevance. The canonical formulation of the explanatory gap: a complete specification of physical-functional facts does not seem to explain why those facts feel like anything from the inside. The framework's two-part reply distinguishes the analytic-conceptual gap (real; not closed by structural identity) from the metaphysical-chasm reading (closed by structural identity supported by empirical signature). The gap is treated as an artifact of vocabulary discipline, parallel to the pre-19th-century gap between *water* and H_2O. First cited in §65.

G. Lindblad. Completely positive maps and entropy inequalities. *Communications in Mathematical Physics* **40** (1975) 147–151.
Relevance. Relative entropy is non-increasing under any completely positive map. Read against a stationary state of the boundary dynamics it is the Lyapunov function of a driven layer, the level at which T-GRIP-In-Lyapunov-Descent descends when detailed balance is violated; cited with Spohn (1978) in §17 and §59. First cited in §17.

G. Lindblad. On the generators of quantum dynamical semigroups. *Communications in Mathematical Physics* **48** (1976) 119–130.
Relevance. Lindblad derived the most general form of a Markovian master equation for open quantum systems that preserves complete positivity and trace — the GKLS equation. In the GG-6 framework, the GKLS equation is the mathematical form of the GDOS boundary dynamics: every open system on the four-dimensional boundary evolves according to a GKLS generator, and the DGI–GSSB–GA pipeline operates within this Lindblad structure. First cited in §E.11.

A. D. Linde. Eternally existing self-reproducing chaotic inflationary universe. *Physics Letters B* **175** (1986) 395–400.
Relevance. The eternal-inflation route to a multiverse of sub-universes with varying effective constants. Cited in §75.2: GG-Theory makes the ensemble unnecessary by forcing the constants from the constitution. First cited in §75.

Maldacena, J. M. (1997). The large N limit of superconformal field theories and supergravity. *Advances in Theoretical and Mathematical Physics*, *2*, 231–252. https://arxiv.org/abs/hep-th/9711200
Relevance. AdS/CFT is the sharpest realization of a bulk–boundary dictionary in modern theory. We cite it as historical support for treating "holographic export" as a definitional element of the theory (OGGEP), rather than as an interpretation added after calculations. First cited in §D.3.

J. Maldacena. *The large-N limit of superconformal field theories and supergravity*, *Advances in Theoretical and Mathematical Physics* **2** (1998) 231–252.
Relevance. Established the AdS/CFT correspondence — the conjecture that a theory of quantum gravity in Anti-de Sitter spacetime is exactly equivalent to a conformal field theory on its boundary. This is the most concrete realization of the holographic principle. The GG-6 framework uses AdS/CFT as a structural ingredient (the six-dimensional bulk projects onto a four-dimensional boundary through the OGGEP dictionary) but differs in that the boundary theory is the Standard Model plus GDOS corrections, not a conformal field theory, and the bulk is six-dimensional, not five-dimensional. First cited in §62.1.

W. Martin and M. J. Russell. *On the origins of cells: a hypothesis for the evolutionary transitions from abiotic geochemistry to chemoautotrophic prokaryotes*, *Philosophical Transactions of the Royal Society B* **358** (2003) 59–85.
Relevance. Places the origin of cells at submarine alkaline hydrothermal systems, where a natural proton gradient across a thin inorganic barrier supplies the chemiosmotic drive that all extant life still uses. In the present cascade this is the setting for the layer-7 bioenergetic anchor rather than for the chemistry floor, and the Part cites it here to make the inheritance explicit: the framework adopts the geochemical setting from this literature and derives the energy *quantum* Q_B, not the site. First cited in §33.

J. C. Maxwell. *A dynamical theory of the electromagnetic field*, *Philosophical Transactions of the Royal Society of London* **155** (1865) 459–512.
Relevance. The founding paper of classical electromagnetism, in which Maxwell unified electricity, magnetism, and light into a single field-theoretic structure. His equations introduced the field as a primary geometric object on space-time, anticipating by half a century Einstein's promotion of space-time itself to a dynamical variable. In the GG-Theory program, Maxwell's electromagnetism is recovered as the boundary projection of the U(1) sector of the bulk gauge group, with the photon mass forced to zero by the unbroken Wilson-Hosotani commutant. First cited in §80.

S. L. Miller. *A production of amino acids under possible primitive Earth conditions*, *Science* **117** (1953) 528–529.
Relevance. The founding experiment of prebiotic chemistry: an electric discharge through methane, ammonia, hydrogen and water produced glycine, alanine and several other amino acids within a week. It has never been overturned, and the present Part opens with it because the framework's honesty at layers four to six depends on stating first what the field already has. The framework does not claim to improve on Miller's result; it claims that the selection from Miller's mixture is what remains unexplained. First cited in §33.

S. Monnier and G. W. Moore. *Remarks on the Green–Schwarz terms of six-dimensional supergravity theories*, *Communications in Mathematical Physics* **372** (2019) 963–992.
Relevance. Developed the modern differential-cohomology framework for global anomaly cancellation in six-dimensional supergravity, going beyond the local (perturbative) Green–Schwarz mechanism to include topological (non-perturbative) effects. The BI-6 global anomaly proof uses their technology: the Wu–Chern–Simons counterterm, the integral lift of the characteristic class, and the automatic-admissibility theorem

are all expressed in the Monnier–Moore language. Extending their methods to the non-supersymmetric GG-6 setting is one of the open problems identified in the present paper. First cited in §7.4.

Nakahara, M. (2003). *Geometry, Topology and Physics* (2nd ed.). Institute of Physics Publishing.
Relevance. Nakahara's text is a widely used bridge between modern geometry/topology and physical gauge theories. It supports AX-2's emphasis that gauge and geometric data are naturally expressed as connections and curvatures, and it provides background for topological routes to quantization. First cited in §D.2.

I. Newton. *Philosophiæ Naturalis Principia Mathematica*. London (1687).
Relevance. Newton's *Principia* established the paradigm that the motion of physical bodies is governed by universal mathematical laws. The inverse-square law of gravity unified terrestrial and celestial mechanics for the first time, showing that the same equation describes an apple falling from a tree and the Moon orbiting the Earth. In the GG-6 framework, Newton's revolution is the first of three scientific revolutions; the present paper argues that the Arisaka Equation extends Newton's program from closed mechanical systems to all open systems, including life and consciousness. First cited in §92.

Neyman, J., & Pearson, E. S. (1933). On the problem of the most efficient tests of statistical hypotheses. *Philosophical Transactions of the Royal Society A*, *231*, 289–337. https://doi.org/10.1098/rsta.1933.0009
Relevance. Neyman and Pearson formalized hypothesis testing and error control, which underlies how modern sciences define and enforce rejection criteria. We cite it as historical/statistical background for POS-7 (MF), where every claim must declare an explicit kill criterion with controlled error rates or equivalent auditing logic. First cited in §E.11.

Nielsen, M. A., & Chuang, I. L. (2010). *Quantum Computation and Quantum Information* (10th Anniversary ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511976667
Relevance. This book codifies the operational viewpoint of quantum theory (states, channels, POVMs) that is closest to the GG-Theory demand that measurement is a defined map rather than a philosophical add-on. We cite it to support the operational language used in motivating OGGEP and POS-7. First cited in §D.1.

E. Noether. Invariante Variationsprobleme. *Nachrichten der Königlichen Gesellschaft der Wissenschaften zu Göttingen* (1918) 235–257.
Relevance. Noether's theorem — that every continuous symmetry of a physical system implies a conserved quantity — is the mathematical foundation of modern physics. In the GG-6 framework, the four gauge symmetries (SU(5), $U(1)_B$, $U(1)_{Qi}$, and local Lorentz) each imply a conserved current, and the BI-6 identity locks these currents into the Arisaka Equation. Noether's theorem is the reason that gauge locking implies current locking. First cited in §9.5.

Y. Oba, T. Koga, Y. Takano, et al. *Uracil in the carbonaceous asteroid (162173) Ryugu*, *Nature Communications* **14** (2023) 1292, https://doi.org/10.1038/s41467-023-36904-3.
Relevance. Identifies uracil — one of the four RNA bases — together with nicotinic acid in the pristine returned samples of asteroid Ryugu, in material that never passed through the terrestrial atmosphere or biosphere. We cite it as the cleanest available demonstration that nucleobase delivery is real, and, in the same note, to correct an earlier statement in this cohort that attributed ribose to the Ryugu samples; the Ryugu detection is uracil, and the meteoritic ribose is Murchison and NWA 801 (Furukawa et al., 2019). First cited in §33.

J. O'Keefe and J. Dostrovsky. *The hippocampus as a spatial map*, *Brain Research* **34** (1971) 171–175.

Relevance. Discovered hippocampal place cells — neurons that fire when an animal occupies a specific location in its environment, regardless of the direction it faces. This discovery (Nobel Prize 2014, shared with the Mosers) revealed the neural substrate of the allocentric spatial map that the GG-6 framework identifies as the Inner Hologram at the CDI ~ 8 level. Place cells implement the latent manifold $\mathcal{Z}$ of Definition 62.2: a world-centered coordinate system that factors out self-motion and allows the animal to navigate, remember, and plan. First cited in §39.3.

Onsager, L., & Machlup, S. (1953). Fluctuations and irreversible processes. *Physical Review, 91*(6), 1505–1512. DOI: 10.1103/PhysRev.91.1505.
Relevance. Introduces an action-like functional for stochastic trajectories near equilibrium, providing a bridge between variational principles and stochastic thermodynamics. It supports POS-2 (UEP) in the open-system regime by showing how "least action" persists as a most-probable-path principle for noisy dynamics. First cited in §E.11.

S. Navas et al. (Particle Data Group). Review of Particle Physics. *Physical Review D* **110** (2024) 030001.
Relevance. The biennial PDG compilation is the authoritative empirical reference for all Standard-Model parameters and decay measurements. In the GG-Theory framework, every Pull-table entry of GG-A11-Origin Part IV and every codebook value of GG-A9-SM is compared to its PDG-listed measurement and uncertainty; the framework's empirical agreement is the agreement of the cascade-derived prediction with the PDG-listed observation at each Pull-table row. First cited in §41.2.

B. K. D. Pearce, R. E. Pudritz, D. A. Semenov, and T. K. Henning. *Origin of the RNA world: the fate of nucleobases in warm little ponds*, *Proceedings of the National Academy of Sciences* **114** (2017) 11327–11332.
Relevance. Models nucleobase delivery by meteorites and interplanetary dust against seepage and hydrolysis losses, and concludes that intermittently drying ponds — not the open ocean — are where the concentrations required for polymerization are reached. We cite it as the quantitative form of the wet–dry route, and as the source the present Part draws on for the GRIP-Out event of the layer-5 to layer-6 transition, which the cascade names and does not derive. First cited in §33.

R. Penrose. *Shadows of the Mind: A Search for the Missing Science of Consciousness.* Oxford University Press (1994).
Relevance. Identified the Mathematics–Physics–Mind triad: Mathematics governs Physics, Physics gives rise to Mind, Mind discovers Mathematics. Penrose argued that the cycle cannot be closed within conventional physics and speculated that quantum gravity plays a role in consciousness. The GG-6 framework closes Penrose's triad explicitly and quantitatively: the OGN-5 integers determine all physical constants (Mathematics $\to$ Physics), the DGI–GSSB–GA cascade produces consciousness (Physics $\to$ Mind), and the EIC is the brain's progressive reconstruction of the 6D geometry (Mind $\to$ Mathematics). No quantum-gravity speculation is needed. First cited in §72.11.

R. Penrose. *Cycles of Time: An Extraordinary New View of the Universe.* Bodley Head, London (2010).
Relevance. The statement of conformal cyclic cosmology (CCC). Cited in §75.6: the cascade's cosmological backdrop is GG-A10-Cosmos's scale-running expansion and does not require cyclic aeons. First cited in §75.

G. K. Philip and S. J. Freeland. *Did evolution select a nonrandom "alphabet" of amino acids?*, *Astrobiology* **11** (2011).
Relevance. Compares the coded twenty against large ensembles of random sets drawn from the plausible prebiotic alternatives, on the axes of size, charge and hydrophobicity, and finds the coded set covers that space better than the overwhelming majority of the alternatives. It is the most quantitative statement

available that the twenty are selected rather than arbitrary. The present Part cites it in the beat on what the field leaves unsolved: a demonstration of non-randomness is not a derivation of the cardinality, and the distinction is the one layer 5 turns on. First cited in §33.

M. Planck. Zur Theorie des Gesetzes der Energieverteilung im Normalspectrum. *Verhandlungen der Deutschen Physikalischen Gesellschaft* **2** (1900) 237–245.
Relevance. Planck's introduction of the energy quantum $E = h\nu$ launched quantum physics and established the principle that nature operates in discrete units. In the GG-6 framework, the biological energy quantum $N_A\mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol is the descendant of Planck's idea: the minimum energy packet for any gauge-locked biological event, derived not from fitting blackbody spectra but from the OGN-5 integers fixed by geometric consistency (BI-6). First cited in §80.

N. Aghanim et al. (Planck Collaboration). Planck 2018 results. VI. Cosmological parameters. *Astronomy & Astrophysics* **641** (2020) A6.
Relevance. The Planck 2018 cosmological parameter compilation provides the headline observational anchor for all of GG-A10-Cosmos: $\Omega_m = 0.3153 \pm 0.0073$ vs predicted $1/\pi \approx 0.3183$; $\Omega_b h^2 = 0.0224 \pm 0.0001$ consistent with $1/(2\pi^2)$; $H_0^{\mathrm{CMB}} = 67.4 \pm 0.5$ km/s/Mpc matching the early-stage branch of GG-A11-Origin Pull test #3; recombination redshift $z_{\mathrm{dec}} = 1089.92 \pm 0.25$ as the operational anchor of Pull test #5. The agreement of the π-locked inventory of GG-A10-Cosmos with the Planck values to within $\sim 1\%$ at zero free continuous parameters is the framework's principal cosmological success. First cited in §42.1.

K. Popper. *The Logic of Scientific Discovery*. Hutchinson, London (1959).
Relevance. Popper established falsifiability as the demarcation criterion between science and non-science: a theory is scientific only if it makes predictions that can, in principle, be shown to be false. The GG-6 framework takes Popper's criterion seriously by listing specific falsifiable predictions (proton stability, KK resonance at 3.85 TeV, $N_A\mathsf{Q}_\mathsf{B} = 15.0$ kJ/mol, 4-base DNA) and by constitutionalizing falsifiability as POS-7 (Measurement and Falsifiability) within the GG-Constitution. First cited in §E.11.

M. W. Powner, B. Gerland, and J. D. Sutherland. *Synthesis of activated pyrimidine ribonucleotides in prebiotically plausible conditions*, *Nature* **459** (2009) 239–242.
Relevance. Solves, by circumventing rather than forcing it, the step that had blocked prebiotic nucleotide synthesis for thirty years: instead of making the sugar and the base separately and joining them, the route builds the activated ribonucleotide along a path on which that junction never has to be made. It is the strongest single experimental result in the field since Miller, and the present Part cites it to fix the standard against which the layer-5 and layer-6 rows should be read — both of which assert closure without yet exhibiting a route. First cited in §33.

I. Prigogine. *Self-Organization in Non-Equilibrium Systems*. Wiley, New York (1977).
Relevance. Pioneered the theory of dissipative structures — systems that maintain order far from equilibrium by continuously dissipating energy. Living cells, convection patterns, and chemical oscillators are all dissipative structures in Prigogine's sense. The GG-6 framework subsumes Prigogine's theory: the SeOS (Selfish Open System) is a dissipative structure that additionally satisfies the QGL constraint, and the GSSB cascade describes the progressive complexification of dissipative structures from prebiotic chemistry to consciousness, driven by the Qi-EP principle. First cited in §20.

R. Quian Quiroga, L. Reddy, G. Kreiman, C. Koch, I. Fried. Invariant visual representation by single neurons in the human brain. *Nature* **435** (2005) 1102–1107.
Relevance. Single-unit recordings from human medial temporal lobe identified "concept cells" that fire selectively and invariantly to specific people or objects (the "Jennifer Aniston neuron"). In the GG-Theory

framework, concept cells are the highest-resolution boundary readout of stabilized IH branches on the allocentric-map stratum — a precursor to T-Allocentric-Map of GG-A11-Origin Part III at the human hippocampal stratum. First cited in §39.3.

L. Randall and R. Sundrum. *A large mass hierarchy from a small extra dimension*, *Physical Review Letters* **83** (1999) 3370–3373.
Relevance. Proposed a extra-dimension model in which the hierarchy between the Planck scale and the electroweak scale is generated by an exponential warp factor in a five-dimensional Anti-de Sitter bulk. The GG-6 geometry inherits this warp mechanism but extends it to six dimensions, adds the compact S^1_θ direction, and replaces the fine-tuned brane tensions with the constitutionally locked BI-6 coefficients. The holographic radial coordinate $r = \ln(E_{\mathrm{GUT}}/\mu)$ is the GG-6 version of the Randall–Sundrum warp factor. First cited in §9.1.

M. Reuter. Nonperturbative evolution equation for quantum gravity. *Physical Review D* **57** (1998) 971–985.
Relevance. The functional-renormalization-group realization of Weinberg's asymptotic-safety scenario. Cited in §75.4: GG-Theory instead absorbs gravity into the scale profile of the 6D bulk rather than quantizing it as a separate field. First cited in §75.

Rissanen, J. (1978). Modeling by shortest data description. *Automatica*, *14*(5), 465–471. https://doi.org/10.1016/0005-1098(78)90005-5
Relevance. Rissanen's minimum description length principle is another quantitative implementation of Occam's razor. We cite it as methodological background for POS-6 (OGN): the "minimum freedom" doctrine must also eliminate hidden continuous choices in parameterization and normalization. First cited in §D.4.

C. Rovelli and L. Smolin. Loop space representation of quantum general relativity. *Nuclear Physics B* **331** (1990) 80–152.
Relevance. The loop/spin-network representation of LQG built on the Ashtekar variables. Cited in §75.5 alongside Ashtekar (1986). First cited in §75.

B. Russell. *The Analysis of Mind*. George Allen & Unwin (1921).
Relevance. Russell's most extensive development of neutral monism: the world is one kind of stuff, with mental and physical descriptions as two perspectives on the same underlying neutral substrate. In the present framework, the structural reading of consciousness as the EIC closure of GG-A7-Qi4 T-EIC is closest in conventional taxonomy to Russell's neutral monism, but the framework adds a precise geometric description of the loop that constitutes subjective experience — a description Russell could not supply within the 1921 technical apparatus. First cited in §65.

E. Schrödinger. *What is Life? The Physical Aspect of the Living Cell*. Cambridge University Press (1944).
Relevance. Asked "What is Life?" from the perspective of a theoretical physicist, identifying the "aperiodic crystal" (DNA, before its structure was known) as the key to biological order. Schrödinger argued that living matter obeys the laws of physics but exhibits a kind of order ("negentropy") that demands explanation. The GG-6 framework answers Schrödinger's question: the specific molecular architecture of life — DNA, ATP, the genetic code — is derived from the BI-6 geometric consistency identity through the OGN-5 integers, and the negentropy of living systems is maintained by the positive maintenance margin of the SeOS classification. First cited in §1.

U. Seifert. Stochastic thermodynamics, fluctuation theorems, and molecular machines. *Reports on Progress in Physics* **75** (2012) 126001.

Relevance. Seifert's review establishes stochastic thermodynamics as the framework for analyzing the energetics of molecular machines — precisely the systems whose energy budget is governed by $\mathsf{Q_B}$ in the GG-6 framework. ATP synthase, the ribosome, and DNA polymerase are molecular machines whose single-molecule thermodynamics can be analyzed using Seifert's tools, and the QGL constraint provides the additional structure that connects their energy budgets to the geometric consistency structure (BI-6). First cited in §14.

C. E. Shannon. *A mathematical theory of communication*, *Bell System Technical Journal* **27** (1948) 379–423.
Relevance. Founded information theory by defining the bit as the fundamental unit of information and establishing the entropy $H = -\sum p_i \log p_i$ as the measure of uncertainty. In the GG-6 framework, Shannon's information theory provides the mathematical language for the J_{Qi} current: the DNA information content $I_{\mathrm{DNA}} = 2$ bits per base pair is stated in Shannon's framework, and the QGL constraint locks Shannon information to physical energy through the Arisaka Equation. The gauged $\mathrm{U}(1)_{Qi}$ elevates Shannon's abstract concept to a conserved physical quantum number. First cited in §57.

L. Smolin. *The Life of the Cosmos*. Oxford University Press (1997).
Relevance. Smolin proposed cosmological natural selection: universes whose parameters favor black-hole production give rise to offspring universes with slightly varied parameters, and the parameters we observe are the fixed point of a selection process. GG-Theory dissolves the selection by deriving the parameters from the constitution; no offspring, no selection, only one universe permitted by the geometry. First cited in §50.

K. Soai, T. Shibata, H. Morioka, and K. Choji. *Asymmetric autocatalysis and amplification of enantiomeric excess of a chiral molecule*, *Nature* **378** (1995) 767–768.
Relevance. The laboratory realization of Frank's mechanism: an alkylation in which the product catalyzes its own formation, amplifying an enantiomeric excess of a fraction of a percent to near-complete homochirality over a few cycles. It converts amplification from a model into an observed chemical fact, and thereby sharpens the remaining question — the one the present Part is careful about at layer 5 — to the origin of the initial sign rather than of the final excess. First cited in §33.

B. Spinoza. *Ethica Ordine Geometrico Demonstrata* (1677).
Relevance. In the *Ethics*, Spinoza identified God with Nature (*Deus sive Natura*), arguing that there is only one infinite substance of which mind and matter are two attributes. The GG-6 framework provides the twenty-first-century mathematical realization: *Deus sive Geometria* — the six-dimensional geometry is the single substance from which everything follows. Mind (J_{Qi}) and matter (J_B) are not two separate substances but two projections of the single B_2 field through the OGGEP dictionary, exactly as Spinoza's two attributes are aspects of one substance. First cited in §8.1.

H. Spohn. Entropy production for quantum dynamical semigroups. *Journal of Mathematical Physics* **19** (1978) 1227–1230.
Relevance. The entropy production of a quantum dynamical semigroup with a stationary state is non-negative: the theorem that makes the relative entropy to a steady state a Lyapunov function of a driven open system, whether or not detailed balance holds. Cited with Lindblad (1975) at T-GRIP-In-Lyapunov-Descent and in the Three-Gauge section. First cited in §17.

Stinespring, W. F. (1955). Positive functions on C^*-algebras. *Proceedings of the American Mathematical Society*, *6*(2), 211–216. https://doi.org/10.1090/S0002-9939-1955-0069403-2
Relevance. Stinespring's dilation theorem is the mathematical backbone of quantum channels: CP maps arise from unitary evolution on an enlarged space. We cite it to justify how OGGEP can treat open-system

boundary dynamics as fundamental while remaining consistent with microscopic unitarity in the bulk. First cited in §D.1.

Strawson, G. (2006). Realistic monism: Why physicalism entails panpsychism. *Journal of Consciousness Studies*, **13**(10–11), 3–31.
Relevance. Strawson's argument that physicalism (taken seriously) entails panpsychism or Russellian neutral monism. The framework adopts the Russellian-neutral-monist branch (not the panpsychist one) because experience is restricted to layer-17 EIC closures, not distributed across all physical configurations. Strawson's article is the canonical contemporary statement of the position. First cited in §65.

Streater, R. F., & Wightman, A. S. (1964). *PCT, Spin and Statistics, and All That*. W. A. Benjamin.
Relevance. This book codifies rigorous axioms for relativistic QFT, including microcausality and locality. We cite it as a foundational reference for AX-1's operator-algebraic encoding of locality and causality. First cited in §D.1.

L. Susskind. The world as a hologram. *Journal of Mathematical Physics* **36** (1995) 6377–6396.
Relevance. Susskind formalized the holographic principle and connected it to black hole thermodynamics, arguing that the maximum entropy of any region of space is proportional to its boundary area rather than its volume. In GG-6, the holographic principle is realized concretely: the OGGEP dictionary maps bulk states to boundary observables, and the information content of any boundary region is bounded by the $U(1)_{Qi}$ charge it carries. First cited in §62.1.

L. Susskind. The anthropic landscape of string theory. *arXiv:hep-th/0302219* (2003).
Relevance. The argument that the string landscape together with anthropic selection accounts for the constants. Cited in §75.2 and §75.3: GG-Theory replaces selection with geometric uniqueness. First cited in §75.

Symanzik, K. (1970). Small distance behaviour in field theory and power counting. *Communications in Mathematical Physics, 18*(3), 227–246. DOI: 10.1007/BF01649434.
Relevance. A foundational development of renormalization and scaling in quantum field theory. Together with Callan and Wilson, it underpins the modern RG view used by POS-5 and motivates the identification of a log-scale coordinate with flow in the space of effective theories. First cited in §E.11.

B. Ta, M. E. M. Silva, K. Bartlett, et al., A. P. Blaisdell, and K. Arisaka. *Visual Perception of 3D Space and Shape by 7D Frame Translation in Time, Part III: 2D Shape Recognition by Log-Scaling*, bioRxiv 2022.03.01.482004 (2022). **Relevance.** Experiment establishing reaction time linear in $\log_2$(size) and a canonical $\sim 8°$ stored face size — the log-scaling axis of the 7D frame. Author's own preprint (Asserted/INT). First cited in §42.3.

J. S. Taube, R. U. Muller, J. B. Ranck Jr. Head-direction cells recorded from the postsubiculum in freely moving rats. I. Description and quantitative analysis. *Journal of Neuroscience* **10** (1990) 420–435.
Relevance. Taube, Muller and Ranck's foundational paper identified head-direction cells as a population code for allocentric heading in rodent postsubiculum, predating the *Drosophila* ring-attractor confirmation by 27 years. In the GG-Theory framework, the mammalian head-direction system and the insect ellipsoid body are realizations of the same layer-15 GGA on convergent neural substrates — the universal-identity insight applied to heading representation. First cited in §41.1.

M. Tegmark. *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality*. Knopf (2014).
Relevance. Tegmark's Mathematical Universe Hypothesis (MUH) proposed that physical reality *is* a mathematical structure, with all consistent mathematical structures equally real. GG-Theory rejects the

second clause but inherits the first: physical reality is the unique self-consistent geometric structure permitted by the GG-Constitution. Where Tegmark's MUH leads to a multiverse of all structures, GG-Theory's constitution permits exactly one. First cited in §50.

P. Teilhard de Chardin. *The Phenomenon of Man*. Harper & Row (1955).
Relevance. Proposed that the universe evolves toward an "Omega Point" of maximum complexity and consciousness, with the "noosphere" (the sphere of human thought) as the latest stage. The GG-6 framework rehabilitates Teilhard's core insight — the directionality of cosmic evolution toward consciousness — while providing the quantitative mechanism he lacked. The CDI trajectory from 0 (inert matter) to 10 (conscious beings who comprehend the geometry) is a precise version of Teilhard's complexification, and the EIC convergence theorem is a mathematical formulation of the Omega Point. First cited in §87.

't Hooft, G. (1980). Naturalness, chiral symmetry, and spontaneous chiral symmetry breaking. In G. 't Hooft et al. (Eds.), *Recent Developments in Gauge Theories* (pp. 135–157). Plenum Press. https://doi.org/10.1007/978-1-4684-7571-5_9
Relevance. Naturalness arguments connect small parameters to enhanced symmetry. We cite this as historical background for MSMF: the GG-Constitution pushes the symmetry↔parameter connection to a stronger law, demanding maximal symmetry and forbidding non-protected dials. First cited in §D.4.

G. 't Hooft. Dimensional reduction in quantum gravity. In *Salamfest* (1993) 284–296. arXiv:gr-qc/9310026.
Relevance. 't Hooft proposed that a theory of quantum gravity in D dimensions can be encoded on its $(D-1)$-dimensional boundary, with one degree of freedom per Planck area. This holographic principle is a structural ingredient of the GG-6 framework: the six-dimensional bulk projects onto the four-dimensional boundary through the OGGEP dictionary, and the Outer Hologram (OH) is the formal realization of 't Hooft's idea applied to all physical measurements. First cited in §62.1.

G. 't Hooft and M. Veltman. Regularization and renormalization of gauge fields. *Nuclear Physics B* **44** (1972) 189–213.
Relevance. The proof that non-Abelian gauge theories are renormalizable made the Standard Model a consistent quantum theory and earned the 1999 Nobel Prize. The geometric consistency verification used throughout the GG-6 program builds on the perturbative framework of 't Hooft and Veltman ('t Hooft and Veltman, 1972); the one-loop anomaly polynomial I_8 is computed using their regularization methods. First cited in §76.

G. Tononi. *An information integration theory of consciousness*, *BMC Neuroscience* **5** (2004) 42.
Relevance. Proposed Integrated Information Theory (IIT), which defines consciousness in terms of integrated information (Φ) — a quantity measuring how much a system is simultaneously differentiated and integrated. The GG-6 framework agrees with IIT that consciousness is graded, but derives its metric (CDI) from the QGL constraint rather than from information-theoretic axioms. The key difference is predictive scope: IIT does not predict specific biological quantities (Q_B, the genetic code, the theta frequency), while the GG-6 framework does. First cited in §62.4.

G. Tononi. Consciousness as integrated information: a provisional manifesto. *Biological Bulletin* **215** (2008) 216–242.
Relevance. The 2008 update to Integrated Information Theory (IIT 2.0) formalizes consciousness as the maximally irreducible cause–effect structure Φ of a physical system. In the GG-Theory framework, IIT's Φ measures the boundary-projected information integration of an EIC closure; CDI of GG-A11-Origin Part III is a complementary cascade-depth measure that captures the layer-by-layer staging that IIT does not address. First cited in §75.

E. N. Trifonov. *Consensus temporal order of amino acids and evolution of the triplet code*, *Gene* **261** (2000) 139–151.
Relevance. Combines forty independent criteria — prebiotic abundance, codon structure, thermostability, and others — into a single consensus ranking of the order in which the amino acids entered the genetic code. It is the most-cited attempt to explain the composition of the coded set historically rather than functionally. We cite it in the survey preceding the layer-5 theorem, alongside the observation that a temporal ordering of the twenty is not a derivation of the number twenty. First cited in §33.

D. Turner-Evans et al. The neuroanatomical ultrastructure and function of a biological ring attractor. *Neuron* **108** (2020) 145–163.
Relevance. Turner-Evans and colleagues mapped the complete ring-attractor circuit in the Drosophila central complex, showing how a one-dimensional circular manifold of persistent neural activity encodes the fly's heading direction. This circuit is the neural implementation of the $\mathsf{CDI} \sim 6$ level of the Qi-HAL architecture: a one-dimensional allocentric map maintained by recurrent excitation and global inhibition, exactly as the framework predicts for organisms at this stage of the GSSB cascade. First cited in §62.3.

van Inwagen, P. (1983). *An Essay on Free Will*. Oxford University Press.
Relevance. The canonical statement of the Consequence Argument: that determinism (in the standard sense) is incompatible with the freedom of will required for moral responsibility. The framework's response is compatibilist: micro-trajectories are forced only at the layer-architecture level; the conscious substrate's deliberative trajectory remains open within the layer-17 attractor's basin, which is the kind of freedom the framework defends as worth defending. First cited in §70.

A. Vilenkin. Birth of inflationary universes. *Physical Review D* **27** (1983) 2848.
Relevance. An early quantum-cosmological route to inflationary sub-universes. Cited in §75.2 among the multiverse proposals the cascade renders unnecessary. First cited in §75.

J. von Neumann. *Mathematische Grundlagen der Quantenmechanik*. Springer, Berlin (1932).
Relevance. Von Neumann formalized quantum measurement as a separate postulate ("collapse") distinct from unitary evolution, creating the measurement problem that has haunted quantum mechanics for a century. AX-3 (OGGEP) resolves this problem constitutionally: measurement is not a separate postulate but a CPTP operation in the bulk-to-boundary dictionary, and decoherence (not collapse) explains the emergence of definite outcomes. First cited in §8.1.

G. Wächtershäuser. *Before enzymes and templates: theory of surface metabolism*, *Microbiological Reviews* **52** (1988).
Relevance. Proposes that life began as a two-dimensional autocatalytic carbon-fixing chemistry bound to the surface of iron–sulfur minerals, requiring neither a container nor a genetic polymer to start. It is the principal rival to the soup-and-replicator picture and the ancestor of the vent-based accounts the cascade adopts at layer 7. The present Part cites it in the survey of routes, and notes that the framework takes no position between the routes: layers four to six claim closure on strata, not a mechanism of assembly. First cited in §33.

Ward, J. C. (1950). An identity in quantum electrodynamics. *Physical Review*, *78*, 182. https://doi.org/10.1103/PhysRev.78.182
Relevance. Ward's identity is the prototype relation showing how gauge symmetry constrains quantum amplitudes. We cite it in POS-1 and POS-4 to emphasize that gauge invariance is not only a classical redundancy but an admissibility condition that has nontrivial quantum consequences. First cited in §E.11.

J. D. Watson and F. H. C. Crick. *Molecular structure of nucleic acids: a structure for deoxyribose nucleic acid*, *Nature* **171** (1953) 737–738.
Relevance. Determined the double-helical structure of DNA, revealing how genetic information is stored in the sequence of base pairs and replicated through complementary strand separation. The GG-6 framework derives the specific features of this structure from the QGL constraint: the 4-base alphabet encodes 2 bits per base pair (the unique QGL-optimal solution), the double helix provides the error-correcting redundancy required by the QGL energy budget, and the B-form geometry with supercoiling density -0.06 is the minimum-energy configuration consistent with the OGN-5 integers. First cited in §1.

A. L. Weber and S. L. Miller. *Reasons for the occurrence of the twenty coded protein amino acids*, *Journal of Molecular Evolution* **17** (1981) 273–284.
Relevance. The paper that made the composition of the coded set a scientific question rather than a curiosity, arguing case by case from prebiotic availability, chemical stability under physiological conditions, and functional coverage. Forty-five years later it remains the reference statement of the conventional answer. The present Part cites it first among the accounts of the number twenty, and observes that its form of argument — these twenty are the ones that work — is retrospective, which is precisely the gap the layer-5 relation is offered to fill and does not yet close. First cited in §33.

S. Weinberg. *A model of leptons*, *Physical Review Letters* **19** (1967) 1264–1266.
Relevance. Proposed the electroweak unification of electromagnetic and weak interactions through the $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$ gauge theory with spontaneous symmetry breaking, predicting the $W^{\pm}$ and Z^0 bosons. Combined with the work of Glashow and Salam, this earned the 1979 Nobel Prize and established the Standard Model. In GG-6, the electroweak theory emerges as a boundary projection of the SU(5) bulk gauge group after the Hosotani Wilson-line breaking, and the weak mixing angle $\sin^2\theta_W = 25/108$ is derived from the OGN-5 trace ratio rather than fitted to data. First cited in §56.

S. Weinberg. Ultraviolet divergences in quantum theories of gravitation. In *General Relativity: An Einstein Centenary Survey*, S. W. Hawking and W. Israel (eds.), Cambridge University Press (1979) 790–831.
Relevance. The origin of the asymptotic-safety scenario for quantum gravity. Cited in §75.4. First cited in §75.

Weinberg, S. (1995). *The Quantum Theory of Fields* (Vol. 1: Foundations). Cambridge University Press.
Relevance. Weinberg's axiomatic and symmetry-driven approach to QFT is a key reference for how locality, causality, and gauge invariance constrain admissible theories. AX-1 is aligned with this tradition but extends it by insisting that the same causal discipline apply to open-system operational evolution and measurement outputs. First cited in §D.4.

J. Wess and B. Zumino. *Consequences of anomalous Ward identities*, *Phys. Lett. B* **37** (1971) 95.
Relevance. The Wess–Zumino consistency condition that any genuine anomaly must satisfy and that makes the descent formalism well-defined. Cited by GG-A11-Origin in the Part II anomaly-history arc as the step that made the anomaly a cohomological (geometric) object. First cited in §9.2.

Weyl, H. (1918). Gravitation und Elektrizität. *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, 465–480.
Relevance. Weyl's early gauge ideas represent one of the first attempts to relate geometry and electromagnetism. While historically distinct from modern Yang–Mills theory, it anchors the long-standing theme that interactions may be geometric in origin, a theme AX-2 makes constitutional. First cited in §D.2.

J. A. Wheeler. Law without law. In *Quantum Theory and Measurement*, eds. J. A. Wheeler and W. H. Zurek, Princeton University Press, 1983, pp. 182–213.

Relevance. Wheeler's "law without law" program proposed that the laws of physics themselves emerge from a self-referential observer-participation loop — the "it from bit" principle in its mature 1983 form. This is the direct philosophical predecessor of T-Articulation (GG-A11-Origin Part III, layer-18 meta-theorem): Wheeler's self-excited circuit becomes a formal mathematical theorem when the cascade machinery of GRIP and Qi-4 admissibility supply the missing constructive content. First cited in §40.1.

J. A. Wheeler. *Information, physics, quantum: the search for links*, in *Complexity, Entropy, and the Physics of Information* (1990) 3–28.
Relevance. Proposed the "It from Bit" program: the idea that every physical quantity derives its ultimate significance from binary yes-or-no measurements, and that the universe is participatory — the observer and the observed are co-constitutive. The gauged $U(1)_{Qi}$ of GG-6 provides the physical derivation of Wheeler's vision: information is not merely an accounting device but a conserved gauge charge, and the EIC (Evolving Inner Cosmos) is the mathematical realization of Wheeler's participatory universe — the closed loop in which the universe produces observers who discover the universe. First cited in §9.5.

J. G. White, E. Southgate, J. N. Thomson, and S. Brenner. *The structure of the nervous system of the nematode Caenorhabditis elegans*, *Philosophical Transactions of the Royal Society B* **314** (1986) 1–340.
Relevance. The foundational 302-neuron connectome — the external empirical anchor for the Layer-14 central-nervous-system row. First cited in §41.2.

A. N. Whitehead. *Process and Reality: An Essay in Cosmology.* Macmillan (1929); corrected ed. Free Press (1978).
Relevance. Whitehead's *process philosophy* proposed that reality is composed of actual occasions of experience, each prehending the prior occasions and contributing to the next; the universe is fundamentally relational and process-like. In the GG-Theory program, Whitehead's actual occasions correspond to the GSSB transitions of the geometric cascade, and his prehensions correspond to the inheritance of attractor coordinates from one cascade layer to the next. Whitehead anticipated the cascade structure; GG-Theory derives it. First cited in §40.1.

A. N. Whitehead and B. Russell. *Principia Mathematica*, three volumes. Cambridge University Press (1910–1913).
Relevance. The Whitehead–Russell program of axiomatic foundations sought to derive all of mathematics from a small set of logical primitives. The GG-Constitution of GG-A1-Constitution (axioms AX-1 through AX-4 plus the seven postulates) is the physical counterpart of the *Principia* ambition: a small axiomatic ledger from which the entire physical content of the universe – particles, forces, cosmology, life, mind – is derived. First cited in §8.1.

E. P. Wigner. On unitary representations of the inhomogeneous Lorentz group. *Annals of Mathematics* **40** (1939) 149–204.
Relevance. Wigner's classification of particles by the irreducible representations of the Poincaré group established symmetry as the organizing principle of quantum physics. Every particle in the Standard Model is a Wigner representation; the gauge group $SU(5) \times U(1)_B \times U(1)_{Qi}$ of GG-6 determines which representations are admissible, and the OGN-5 integers determine their specific quantum numbers. First cited in §72.9.

Wilson, K. G., & Kogut, J. (1974). The renormalization group and the ϵ expansion. *Physics Reports*, *12*, 75–200.
Relevance. A standard reference for the modern RG viewpoint: coarse-graining as a flow on theory space. POS-5 builds on this picture but adds the axiomatic demand that RG must commute with the operational dictionary (OGGEP), enabling a geometric RG coordinate in GG-6. First cited in §E.11.

Wilson, K. G. (1971). Renormalization group and critical phenomena. I. Renormalization group and the Kadanoff scaling picture. *Physical Review B*, *4*(9), 3174–3183.
Relevance. Wilson's RG is the prototype of scale-covariant thinking and motivates POS-RG. Because GG-Theory aspires to unify across scales and domains, it demands that coarse-graining and operational measurement commute in a controlled way. First cited in §E.11.

Witten, E. (1998). Anti-de Sitter space and holography. *Advances in Theoretical and Mathematical Physics*, *2*, 253–291. https://arxiv.org/abs/hep-th/9802150
Relevance. Witten's prescription (together with Gubser–Klebanov–Polyakov and Maldacena) provides the canonical bulk→boundary correlator map. We cite it as a concrete historical anchor for OGGEP's demand that a theory includes a bulk→boundary dictionary, and as motivation for extending that dictionary to operational measurement objects. First cited in §D.3.

C. R. Woese and G. E. Fox. *Phylogenetic structure of the prokaryotic domain: the primary kingdoms*, *Proceedings of the National Academy of Sciences USA* **74** (1977) 5088–5090. **Relevance.** The foundational 16S rRNA phylogenetic experiment resolving the Bacteria/Archaea split; it is the external empirical anchor for the layer-11 Primary-Domain-Split row of the cascade codebook (a non-physics claim, classed Asserted pending the dual-gauge-SSB derivation). First cited in §G.3.

C. N. Yang and R. L. Mills. Conservation of isotopic spin and isotopic gauge invariance. *Physical Review* **96** (1954) 191–195.
Relevance. Yang and Mills generalized gauge invariance from the Abelian U(1) of electromagnetism to non-Abelian groups, providing the mathematical framework for the strong and weak nuclear forces. The SU(5) sector of the GG-6 gauge group is a Yang–Mills theory; the anomaly-cancellation constraint that produces the Arisaka Equation is a direct descendant of the consistency conditions that Yang–Mills theories must satisfy in six dimensions. First cited in §9.2.