
The Geometric Inevitability of Cosmos, Life, and Mind

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Capstone paper of the GUT-10/GG-6/GDOS series.

Abstract

Why are we here? For four centuries, science has described *how* the world works — how planets orbit, how atoms bind, how genes replicate — but has left the question of *why* we exist to philosophy and theology. The existence of life and consciousness has been treated as a lucky accident in an indifferent cosmos.

This paper argues that the accident never happened.

The companion papers of this series derive a unique six-dimensional geometry whose internal consistency is so tight that it leaves no free parameters: the masses of all elementary particles, the strengths of all forces, and the energy budget of every living cell are fixed by five integers and one measured constant. The same geometry locks information to matter so completely that no information can flow without a physical substrate, and no sustained physical structure can exist without encoding information. The only configurations that satisfy this lock while dissipating energy are living systems. Life is not rare; it is the only option the geometry permits.

Once life exists, the lock keeps tightening. Living systems are driven toward ever-richer internal models of their environment — from a bacterium's chemical memory to a mammal's spatial map to a human brain's conscious awareness. At the cosmic scale, the same geometry derives the dark energy density, the dark matter candidate, and the cosmic inventory from the same integers that fix the particle masses — unifying the very large, the very small, the living, and the thinking in one framework. The universe is a self-measurement machine: its structure mandates the emergence of the observers who discover it. We are here because the geometry requires it.

Executive Summary

Every civilization has asked why we exist. The Upanishads answered: because the cosmic self seeks to know itself. Genesis answered: because God chose to create. Darwin answered: natural selection, but only for the diversity of life, not its existence. Modern physics — despite its extraordinary successes — has had no answer at all. The GG-6/GDOS framework, developed across the companion papers of this series, proposes that the answer is geometric: the unique geometrically consistent structure of a six-dimensional spacetime mandates the emergence of cosmos, life, and mind as mathematical necessities.

The quantum foundation. The mathematical bedrock is the BI-6 geometric consistency identity — a topological constraint on the composite connection in six dimensions, pre-quantum in nature — proved at theorem level (both local and global) on the physical intended GG-6 class. The identity fixes the coefficients $(1, -1, -2/5, -2/5)$ uniquely — no continuous deformation yields a geometrically consistent theory. From these coefficients and the five OGN-5 integers $(1, 3, 5; 7, 35)$, all 28 Standard Model parameters are derived: gauge couplings, fermion masses, mixing angles, the Higgs vacuum expectation value, and the weak mixing angle $\sin^2 \theta_W = 25/108$. The strong CP angle is suppressed geometrically to $|\bar{\theta}| \lesssim 4.7 \times 10^{-18}$ — eight orders of magnitude below the experimental bound — without an ad hoc Peccei–Quinn symmetry. No continuous free parameter remains beyond Newton’s constant G_N .

The cosmic architecture. The same inherited geometry constrains the cosmos. A single GSSB event at the infrared cap of the warped throat simultaneously ends inflation, produces Kaxion dark matter (twin-peak doublet at $\Delta\nu/\nu = 1/35$), and leaves the dark energy residue $\rho_\Lambda \sim (M_{\text{lock}} e^{-K})^4 \sim (\text{few meV})^4$. The π -locked cosmic inventory ($\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$, $z_{\Lambda m} \approx 0.289$) matches Planck satellite data to 2% and dissolves the coincidence problem algebraically. Inflation, dark matter, and dark energy are not three independent sectors — they are three late-time faces of one geometric event.

The gauge locking of life. The central mechanism connecting geometry to biology is Quadruple Gauge Locking (QGL). The BI-6 identity channels all anomaly inflow through a single tensor field B_2 , locking four boundary currents — electromagnetic, baryonic, informational, and energy — into a fixed ratio (the Arisaka Equation: $J_E/Q_B = J_e = J_B = J_{Qi}$). Pure information without matter is physically forbidden, and sustained matter without information decays. The only dynamically stable configurations in the presence of energy gradients are those that simultaneously carry all four currents — living systems. The biological energy quantum $Q_B = 15.0 \text{ kJ/mol}$ is derived from the OGN-5 integers and confirmed at 98.5% accuracy in ATP synthesis.

The five-step proof of inevitability. Five theorems chain together: (1) the BI-6 coefficients are the unique geometrically consistent solution; (2) the GDOS extremal principle drives open systems toward complexity; (3) the gauge-locking constraint raises the physical cost of information by an order of magnitude above the Landauer bound; (4) life is the unique geometric attractor under these constraints; and (5) no intermediate level of the resulting complexity cascade is stable, so the progression from chemotaxis to consciousness is inevitable. The complete cascade — ten GSSB transitions from quarks to conscious beings — is traced in detail.

The Geometric Free-Energy Functional and three-science unification. The universal cost functional governing all open systems is the Geometric Free-Energy Functional (GFF), consisting of two sectors: the GEP (Gauge-Geometry Energy Principle) encoding the projected energy of the geometry-gauge structure, and the CEP (Curvature-Entropy Principle) measuring the divergence from the geometric reference density. The Three-Gauge Theorem proves that the GFF is the common ancestor of three historically independent frameworks: Gibbs’s thermodynamic free energy ($J_{Qi} = 0$), Friston’s variational free energy ($J_{Qi} \neq 0$ with a Markov blanket), and the GG-6 gauge-field action (detector limit). For 150 years, thermodynamicists and neuroscientists have used the same phrase “free energy” without knowing why; the answer is that both were looking at the same geometric object through different windows.

Consciousness and the Evolving Inner Cosmos. The Evolving Inner Cosmos (EIC) — defined as the closed-loop coupling of the Outer Hologram (every lawful measurement) and the Inner Hologram (the brain’s allocentric world-model) — is identified as the geometric ground state. Consciousness is defined operationally as the internal measurement of a selected and stabilized branch of the Inner Hologram, implemented by the same DGI-GSSB-GA symmetry-breaking pipeline that governs phase transitions in particle physics. The EIC Lyapunov functional $\mathcal{F}_{\text{EIC}} = \delta_{\text{rec}} + \lambda_E F_{\text{GFF}} + \lambda_C C(q_t)$ decreases monotonically: any system with memory and a $U(1)_{Qi}$ -charged information channel necessarily refines its internal model of the world. This is why babies learn to walk, why scientists discover laws, and why the universe produces the observers who discover the equations that produced them.

Falsification. The framework makes specific, falsifiable predictions at every level: a Kaluza–Klein resonance at 3.85 TeV (testable at the High-Luminosity LHC), Kaxion dark matter with a twin-peak spectral doublet at ~ 106 MHz and ~ 4.6 GHz (testable by ADMX and next-generation haloscopes), primordial tensor modes $r \ll 0.01$ (testable by CMB-S4), the weak mixing angle $\sin^2 \theta_W = 25/108$, absolute proton stability, the biological energy quantum $Q_B = 15.0$ kJ/mol, and the 4-base DNA alphabet as the unique QGL solution. If any of these predictions fail, the framework fails.

The philosophical answer. The paper argues that life is neither designed nor accidental but *necessary*: the sufficient reason for our existence is the internal self-consistency of the geometry. The progress of science itself is an instance of EIC descent — the collective refinement of humanity’s internal model toward the external structure of reality. And the experience of meaning — learning, discovery, wonder — is what it feels like from the inside when the EIC Lyapunov functional decreases. The universe is not indifferent to understanding; it is structured to produce it.

Keywords: GUT-10, GG-6, GDOS, BI-6, OGN-5, Quadruple Gauge Locking, Geometric Free-Energy Functional, Three-Gauge Theorem, cosmos, dark energy, Kaxion, inflation, π -locked inventory, strong CP, life, consciousness, Evolving Inner Cosmos, Qi-HAL, GSSB cascade, information gauge, self-measurement.

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Part I

Introduction

The oldest question and the new 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?*

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, 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 not 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-6 framework 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 warped spacetime (GGEP/BI-6) and the operational rules by which that geometry is projected onto the four-dimensional world we observe (OGGEP/GDOS).

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-6/GDOS framework 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-GSSB-GA 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).

1.3 The structure of this paper

The paper proceeds in five Parts. Part II lays the physical foundation: the six-dimensional geometry, the BI-6 identity, Quadruple Gauge Locking (QGL), the biological energy quantum, and the GUT-10 constitution. Part III — the heart of the paper — traces the complete chain from gauge locking to consciousness: a five-step proof of inevitability, the explicit ten-step GSSB cascade, the formal definitions of the holographic triad (OH, IH, EIC), and the operational definition of consciousness with the QCI ladder. Part IV provides the discussion: significance, comparisons, cross-domain applications (from molecular biology to medicine), the historical

philosophical synthesis, and the open problems. Part V draws the conclusion — answering “Why are we here?” — places the answer in the arc of the three scientific revolutions, and closes with deeper philosophical reflections.

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.

Summary of Part I.

The question “Why are we here?” has resisted scientific answer because physics traditionally separates laws from initial conditions and places life on the side of contingency. The GG-6 framework proposes a different approach: life and consciousness are derived from the laws themselves — specifically, from the unique geometrically consistent structure of a six-dimensional geometry. The paper traces this derivation in five Parts: Introduction, Physical Foundation, Inevitable Life and Mind, Discussion, and Conclusions.

Part II

The Physical Foundation

From BI-6 to the mandate of information

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, 2026a,b,c,d,e](#)) derived a six-dimensional warped 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.

2 The 6D warped bulk and the BI-6 identity

2.1 The GG-6 stage

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

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

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

$$ds_{6D}^2 = e^{-2A(r,\theta)} \eta_{\mu\nu} dx^\mu dx^\nu + dr^2 + R_6^2 d\theta^2, \tag{2}$$

where $r = \ln(E_{\text{GUT}}/\mu)$ is the holographic radial coordinate geometrizing the renormalization-group scale, and θ is the compact sixth dimension. The bulk gauge group at the UV boundary is

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

The single tensor multiplet (B_2, H_3) is the unique mediator connecting the six-dimensional bulk to the four-dimensional boundary.

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 (GG-2026-3) 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.

2.2 BI-6: the constitutional equation

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)

$$\boxed{dH_3 = X_4 = \text{tr } R \wedge R - \text{Tr } F_5 \wedge F_5 - \frac{2}{5} F_B \wedge F_B - \frac{2}{5} F_{Qi} \wedge F_{Qi}}, \quad (4)$$

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

$$I_8 = \frac{1}{2} X_4^2. \quad (5)$$

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-2026-3 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.

2.3 Quadruple Gauge Locking — the Arisaka Equation

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

$$\boxed{J_E/Q_B = J_e = J_B = J_{Q_i}.} \quad (6)$$

This states that the energy current (measured in units of 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_{Q_i} 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. This is not a limitation of current technology — it is a theorem of the geometry.

2.4 Five forces, one pipe: understanding the single-channel constraint

To appreciate the depth of the gauge-locking result, 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.

2.5 The OGN-5 integers and the biological quantum

The five OGN-5 integers

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

determine all dimensionless normalization freedom in BI-6. From these integers and Newton's constant G_N , the biological energy quantum is derived:

$$Q_B = \frac{2 E_{\text{Ry}}}{K} \times 5 \approx 0.1555 \text{ eV} = 15.0 \text{ kJ/mol}. \quad (8)$$

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 the energy released when you snap a single phosphate bond off an ATP molecule. 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 $N = 3$ (three 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 $Q_B = 15.0 \text{ kJ/mol}$ follows from E_{Ry} and K .

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

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,](#)

2026g) derives the late-time cosmic inventory as

$$\Omega_{m,0} = \frac{1}{\pi} \approx 0.318, \quad \Omega_{b,0} = \frac{1}{2\pi^2} \approx 0.051, \quad \Omega_{\Lambda,0} = 1 - \frac{1}{\pi} \approx 0.682. \quad (9)$$

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.

3 The GUT-10 constitution: four axioms that constrain everything

The preceding sections described the physical consequences of GG-6 and BI-6. But where does GG-6 come from? The answer is the GUT-10 constitution (Arisaka, 2026a) — 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.

3.1 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.

3.2 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 programme, 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.

AX-3 (OGGEP) is a statement about *observation*: how the geometric bulk is projected onto the boundary, how instruments register data, and how quantum mechanics arises as the boundary theory of the bulk geometry. Quantization, the measurement problem, the Born rule, and decoherence all live at this level.

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 blur this distinction; the GUT-10 constitution sharpens it.

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

Every computer program must compile — if no compiler can parse it, it is gibberish, not software. AX-3 imposes the same requirement on physics: every physical theory must come equipped with an “observation compiler” that translates the theory’s abstract bulk states into predictions for what an instrument will register. Without such a compiler, the theory is mathematics without a bridge to experiment.

The compiler 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 resolves the measurement problem of quantum mechanics — a problem that has confused physicists for a century. 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 OGGE).

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

Think of a combination lock with a hundred dials, each set to an arbitrary number. The Standard Model is such a lock: 19 parameters (masses, couplings, mixing angles) 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 kills the landscape. 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) to eliminate all continuous freedom from the theory. The result is that GG-6 has exactly zero adjustable parameters beyond Newton’s constant G_N . 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 $Q_B = 15.0$ 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.

Part III

Inevitable Life and Mind

From gauge locking through the GSSB cascade to consciousness

With the physical foundation of Part II in hand — one equation, five integers, one energy quantum — this Part traces the logical chain all the way from spacetime geometry to the moment you recognize a friend’s face in a crowd.

The chain has four links. First, a five-step proof that life and mind are geometrically inevitable. Second, the explicit cascade of ten symmetry-breaking transitions that take the universe from quarks to conscious beings in 13.8 billion years. Third, the formal definitions of the three constructs — Outer Hologram, Inner Hologram, and Evolving Inner Cosmos — that make the argument precise. And fourth, the operational definition of consciousness itself, with a quantitative ladder that ranks every organism from a bacterium to a human.

No biological postulate is introduced at any stage. The entire argument flows from the geometry.

4 The five-step proof of inevitability

4.1 Overview of the logical chain

Step	Claim	Mechanism
1	GG-6 with BI-6 fixes gauge structure and QGL ratio	Geometric factorization: $(1, -1, -2/5, -2/5)$ unique
2	GDOS dynamics generate open systems evolving toward Qi-EP optima	GFF Lyapunov descent; GFF functional
3	QGL forbids disembodied information	No J_{Qi} without $J_e, J_B, J_E/Q_B$
4	Life is a geometric attractor	Only QGL-locked configurations persist under energy gradients
5	Mind is inevitable	Qi-EP drives QGL-locked systems toward maximum J_{Qi} via Qi-HAL

4.2 Step 1 — Uniqueness of the gauge structure

Theorem 4.1 (BI-6 uniqueness). *In a 6D warped bulk with gauge group $SU(5) \times U(1)_B \times U(1)_{Qi} \times \text{Gravity}$ and a single tensor multiplet ($T = 1$), the Green–Schwarz anomaly cancellation condition has a unique solution $(a, b, c, d) = (1, -1, -2/5, -2/5)$. No continuous deformation of these coefficients yields a geometrically consistent theory.*

The proof is given in the companion paper ([Arisaka, 2026c](#)). The philosophical significance is immediate: the specific geometry of our universe is not one choice among many — it is the only internally consistent choice.

The jigsaw-puzzle analogy. Imagine a jigsaw puzzle with four interlocking pieces: the unified gauge force, electromagnetism, baryon number, and information — all threaded through gravity. Each piece has a complicated shape. The theorem says there is exactly one way to fit all four pieces together so that the completed puzzle has no gaps and no overlaps. The coefficients $(1, -1, -2/5, -2/5)$ are the precise shape of those interlocking edges. If you tried to change even one coefficient — say, replacing $-2/5$ with $-1/3$ — the puzzle would not close. A gap would appear, and through that gap, the quantum theory would leak probability, violate unitarity, and become mathematically meaningless.

This is not a matter of aesthetic preference. It is a theorem with the same logical force as the statement that the angles of a triangle sum to 180° in Euclidean geometry. The universe does not choose its anomaly coefficients any more than a triangle chooses its angle sum.

With the uniqueness of the gauge structure established, the next question is: what dynamics operate on the four-dimensional boundary, and do they have a preferred direction?

4.3 Step 2 — The GDOS extremal principle forces complexity growth

Every open system on the four-dimensional boundary is governed by the Geometric Free-Energy Functional (GFF):

$$F_{\text{GFF}}[p; \mathcal{P}] = \underbrace{\int p(x) \mathcal{E}_{\text{GEP}}(x; \mathcal{P}) d\mathbf{g}(x)}_{\text{GEP sector: gauge-geometry energy}} + \epsilon_{\text{eff}} \underbrace{\int p(x) \ln \frac{p(x)}{p_{\text{ref}}(x; \mathcal{P})} d\mathbf{g}(x)}_{\text{CEP sector: curvature-entropy cost}} + W_{\text{ports}}. \quad (10)$$

The GEP (Gauge-Geometry Energy Principle) sector encodes the projected energy of the geometry-gauge structure: curvature costs, gauge potentials for all six forces (including $U(1)_{Q_i}$), and holonomy penalties. The CEP (Curvature-Entropy Principle) sector is a KL divergence measuring the mismatch between the system’s actual state p and the geometric reference density p_{ref} — entropy is not combinatorics but curvature distortion in the effective state space, the boundary manifestation of coarse-graining over inaccessible bulk directions.

Why “free energy” appears in three sciences. A question that has confused researchers for decades: why does the same phrase — “free energy” — appear in thermodynamics, in neuroscience, and now in gauge theory? Is this an accident of nomenclature, or does it signal a deeper kinship?

In 1875, Josiah Willard Gibbs defined $G = H - TS$ as the portion of a system’s energy that is *available* to do work at constant temperature and pressure. The rest is locked up in entropy. “Free” means: available to drive change.

In 2010, Karl Friston defined the variational free energy $F = D_{KL}(q||p) - \ln p(s)$ as the portion of an agent’s total surprise that is *available* to drive learning. The rest is irreducible uncertainty. “Free” means: available to drive inference.

The GFF defines $F_{\text{GFF}} = F_{\text{GEP}} + F_{\text{CEP}}$ as the portion of a system’s total geometric budget that is *available* to drive the DGI–GSSB–GA pipeline. The rest is locked up in the geometric reference density. “Free” means: available to drive gauge descent.

All three are “free” in the same mathematical sense: each is a divergence between the system’s actual state and a reference state, and each decreases monotonically under the appropriate dynamics. The reason they share a name is that they are the same object, viewed through three

different windows.

The Three-Gauge Theorem makes this precise. When the $U(1)_{Q_i}$ current is inactive ($J_{Q_i} = 0$, classical, near-equilibrium, constant T and P), the GFF reduces exactly to Gibbs's $G = H - TS$. When the $U(1)_{Q_i}$ current is active and the system possesses a memory-bearing Markov blanket, the GFF reduces to Friston's variational free energy F . When the boundary is a detector and J_{Q_i} is maximally active, the GFF encodes the gauge-field action of GG-6 itself. Gibbs, Friston, and particle physics are three windows into the same geometric room. The $U(1)_{Q_i}$ current is the switch that determines which window you are looking through.

Theorem 4.2 (Qi-EP unification). *The Qi-EP unifies four previously independent extremal principles: the Principle of Least Action (PLA in 6D bulk), the Principle of Least Time (PLT on 4D boundary), the Maximum Entropy Production Principle (MEPP for open systems), and Friston's Free Energy Principle (Friston, 2010) (FEP for adaptive agents). Under GDOS, all four are projections of GFF descent under different boundary conditions.*

The MEPP sector — directly relevant to life — states that any open system in an energy gradient will evolve toward the configuration that maximizes entropy production (Jaynes, 1957). A living cell — a dissipative structure (Lane, 2015; Prigogine, 1977) — dissipates energy at 10^4 times the rate of an equivalent volume of rock. Life is thermodynamically mandated by MEPP because it is the most efficient entropy producer available from geochemical energy sources.

The river analogy for extremal principles. A river flows downhill — this is the Principle of Least Action in its simplest form. But a river does not merely flow; it carves channels, creates meanders, builds deltas, and sustains ecosystems. These structures are not accidents — they are the configurations that maximize the rate at which the river converts gravitational potential energy into heat. A straight channel would dissipate energy slowly; a branching delta with wetlands and organisms dissipates it much faster.

Similarly, a bare rock in sunlight absorbs solar energy and re-radiates it as infrared — slowly, inefficiently. A forest on the same rock absorbs the same solar energy but dissipates it far more efficiently through photosynthesis, transpiration, and metabolism. The forest is the thermodynamic analogue of the river delta: it exists because it is the most effective entropy-producing configuration available (England, 2013). In the GDOS framework, this is not merely an empirical observation — it is a theorem derivable from the GFF functional and the Qi-EP principle.

4.4 Step 3 — QGL forbids disembodied information

The standard Landauer bound (Landauer, 1961) on information erasure is $k_B T \ln 2 \approx 1.4 k_B T$ per bit, assuming that information current J_{Q_i} flows alone. But the Arisaka Equation forbids J_{Q_i} flowing alone. QGL mandates that copying 2 bits of DNA requires simultaneously moving baryonic and electromagnetic current, raising the minimum dissipation by an order of magnitude:

Bound	Dissipation/nucleotide	What it accounts for
Landauer (classical)	$1.4 k_B T$	Pure information copy: J_{Qi} only
QGL minimum	$13\text{--}14 k_B T$	Information + matter locked: $J_e + J_B + J_{Qi}$
Actual biology	$20\text{--}100 k_B T$	QGL minimum + proofreading + speed overhead

The actual biological value sits within a factor of 2–7 of the geometric floor, confirming QGL as a physical lower bound.

Why this matters for the origin of life. The standard Landauer bound suggests that information processing could, in principle, be almost free — $1.4 k_B T$ per bit is a tiny amount of energy. If this were the true physical floor, there would be no thermodynamic reason for information and matter to be connected. A disembodied information processor (a Maxwell’s demon) could operate at negligible energy cost.

The QGL bound changes this picture. Because information current must be accompanied by baryonic and electromagnetic currents, the true energy cost of biological information processing is an order of magnitude higher than Landauer’s bound. This means that any system that processes information *must* also process matter and energy at a significant rate. In other words, the laws of physics do not permit cheap information — information always comes with a substantial physical price tag. This is why life is made of atoms rather than photons, and why brains consume 20% of the body’s energy budget despite being only 2% of its mass.

4.5 Step 4 — Life is a geometric attractor

Theorem 4.3 (Life as GSSB attractor). *Under GG-6/GDOS, given energy gradients and liquid water as solvent, the only configurations of matter that simultaneously satisfy the QGL constraint $J_E/Q_B = J_e = J_B = J_{Qi}$ and are dynamically stable under GSSB are precisely those that store, replicate, and process information — i.e., living systems.*

The uniqueness of this attractor is confirmed by convergent evolution: multiple independent prebiotic pathways (Miller, 1953) all converge on the same molecular architecture (bilayer vesicles, ATP as universal currency, 4-base RNA, 20 canonical amino acids). The convergence is the hallmark of a geometric attractor — a GSSB minimum, not coincidence (Haken, 1983).

The timescale argument strengthens the case. Earth formed at 4.54 Ga; liquid water appeared at 4.4 Ga; LUCA dates to ~ 4.2 Ga — a 200 Myr timescale. If life were a random search in protein sequence space, the expected waiting time would exceed the age of the universe by many orders of magnitude. The 200 Myr timescale is consistent only with deterministic GSSB descent.

The marble-on-a-landscape picture. Imagine a marble placed at the top of a hilly landscape. The marble rolls downhill, following the contours of the terrain. If the landscape has a single deep valley, the marble will find it regardless of where it starts — it might take different paths, but it always ends up in the same place. That valley is the geometric attractor.

In the GG-6 picture, the “landscape” is the GFF functional, the “marble” is the molecular configuration of matter on the early Earth, and the “valley” is the living state. The convergence of multiple independent prebiotic pathways on the same molecular architecture — the same

amino acids, the same nucleotides, the same lipid bilayers — is evidence that the landscape has a single deep valley. The 200 Myr timescale tells us that the valley is not far from the starting point: the marble rolls downhill quickly because the gradient is steep.

This is qualitatively different from the standard picture in which life arose by a lucky accident in a flat landscape. In a flat landscape, the marble wanders randomly and might never find a valley. In the GG-6 landscape, the valley is deep, the gradients are steep, and finding life is inevitable.

But the story does not end with the first living cell. Once life exists, the same QGL constraint that created it continues to operate, driving the system toward ever-greater complexity.

4.6 Step 5 — Mind is inevitable

Theorem 4.4 (Mind as geometric necessity). *Qi-EP drives QGL-locked systems toward ever-more-efficient information processing. The Qi-HAL architecture provides the constructive blueprint. The GSSB cascade from single-cell chemotaxis through nerve nets to brains to consciousness is a continuous geometric flow along the QGL-locked manifold; no intermediate stopping point is a stable GSSB minimum.*

At each GSSB level, the QGL constraint requires the system to maximize J_{Qi} while maintaining the locked current ratio. The system can only maximize J_{Qi} by undergoing the next GSSB transition, which creates new information-carrying structures. Stopping at any intermediate level leaves J_{Qi} below its geometric maximum. The universe therefore necessarily evolves through all ten GSSB transitions until EIC is achieved. The next section traces this evolution explicitly.

This is the mathematical content of the statement that consciousness is the $U(1)_{Qi}$ ground state of the universe — not the lowest-energy state, but the state that most completely expresses the $U(1)_{Qi}$ gauge charge.

The staircase with no landing. Think of the GSSB cascade as a staircase. At each step, the system has reached a new level of information-processing capability: chemotaxis, nerve nets, spatial maps, conscious awareness. The key insight of Theorem 4.4 is that *none of the intermediate steps is a landing* — a place where the system can rest permanently. Each step is locally stable (a bacterium can survive for billions of years), but the QGL constraint means that a higher step is always thermodynamically accessible and energetically favored. Given enough time, the system will always climb to the next step.

The reason is simple: at each level, the system is not fully expressing its $U(1)_{Qi}$ gauge charge. There is always more information that could be processed, more of the environment that could be modeled, more of the OH that could be captured by the IH. The climb continues until the EIC is achieved — the state in which the internal model converges on the external reality. That is consciousness.

Why this is not teleology. A common objection to inevitability arguments is that they sound teleological — as if nature has a “goal” of producing consciousness. The GG-6 framework avoids this objection in a precise way. There is no goal, no plan, no designer. There is only a Lyapunov functional ($\mathcal{F}_{EIC}$) that decreases monotonically. The system does not “want” to become conscious any more than a ball “wants” to roll downhill. But just as the ball will reach

the bottom of the valley given enough time, the QGL-locked system will reach the EIC state. The inevitability is mathematical, not intentional.

5 The GSSB cascade: from quarks to consciousness

5.1 The ten GSSB transitions

GSSB	Time	Symmetry broken	Resulting structure	QCI
0	10^{-36}s	$G_{\text{GUT}} \rightarrow \text{SM gauge group}$	SM particles, proton stability	0
1	13.8 Ga	Electroweak breaking	Masses, atoms possible	0
2	9.0 Ga	Translation $\rightarrow$ discrete bonds	Organic molecules: C-H-N-O-P-S	~ 1
3	4.4 Ga	Chiral symmetry	L-amino acids, D-sugars; ATP, lipids	~ 1.5
4	4.3 Ga	RNA secondary structure	RNA World; ribozymes	~ 2
5	4.1 Ga	Translation symmetry	Triplet genetic code	~ 2.5
6	3.8 Ga	Cell-identity symmetry	DNA, LUCA, first cells	~ 3
7	0.6 Ga	Spatial symmetry (cephalization)	First nervous systems (Hydra)	~ 3.5
8	0.4 Ga	$U(1) \rightarrow$ ring attractor	Drosophila: 1D HAL heading	~ 6
9	0.08 Ga	Hippocampal map formation	Rodent: 4D HAL (place/grid/time)	~ 8
10	0.3 Ma	Unconscious $\rightarrow$ conscious (EIC)	Human brain: full IH-OH convergence	~ 10

At every stage, the same QGL relation $J_E/Q_B = J_e = J_B = J_{Qi}$ is satisfied, making each transition a geometric theorem rather than a contingent accident.

To make this abstract table vivid, let us walk through the cascade step by step, pausing at each transition to see what happens physically and why.

5.2 A walk through the cascade

To make the GSSB cascade vivid, let us follow the universe from the Big Bang to consciousness, pausing at each transition to see what happens and why.

GSSB-0 to GSSB-1: from quarks to atoms. In the first microsecond after the Big Bang, the universe is a plasma of quarks, leptons, and gauge bosons. At GSSB-0, the unified gauge group breaks to the Standard Model. At GSSB-1 (electroweak symmetry breaking ([Glashow, 1961](#); [Higgs, 1964](#); [Weinberg, 1967](#))), the W and Z bosons acquire mass, and the Higgs field settles into its vacuum. This is the transition that gives particles their masses and makes atoms possible ([Bohr, 1913](#)). Without GSSB-1, there would be no hydrogen, no helium, no periodic table — and no chemistry.

GSSB-2 to GSSB-3: from atoms to organic chemistry. Once atoms exist, covalent bonds become possible (GSSB-2). Carbon, with its four bonding electrons, can form long chains, rings, and branched structures — the backbone of organic chemistry. At GSSB-3, chiral symmetry breaks: nature selects L-amino acids and D-sugars rather than their mirror images. This is the transition that makes biochemistry possible. ATP — the universal energy currency of life — appears at this stage, carrying exactly $2Q_B = 30.5$ kJ/mol per molecule.

A closer look at ATP: the molecule that runs the world. ATP (adenosine triphosphate) is a molecule consisting of an adenine base, a ribose sugar, and three phosphate groups linked by high-energy bonds. When the terminal phosphate is cleaved by hydrolysis ($\text{ATP} \rightarrow \text{ADP} + \text{P}_i$), exactly 30.5 kJ/mol of free energy is released. This energy drives muscle contraction, nerve impulse propagation, protein synthesis, DNA replication, and virtually every other energy-requiring process in every living cell.

In a human body, approximately 40 kg of ATP is recycled every day — roughly equal to your body weight. Each ATP molecule is used and regenerated about 500 times per day. The total number of ATP turnovers per second in a human body is roughly 10^{21} — a trillion billion transactions, each releasing exactly $2Q_B$.

The GG-6 prediction is that this energy quantum is not a contingent property of the ATP molecule but a consequence of the BI-6 identity. The number 30.5 kJ/mol is derived from the OGN-5 integers through the Rydberg energy, with no biological input. It is as if the blueprint for the cellular energy budget was written into the geometric consistency equation at the GUT scale, 10^{-36} seconds after the Big Bang.

GSSB-4 to GSSB-6: the RNA World and the first cells. At GSSB-4, RNA folds into secondary structures that can catalyze chemical reactions (ribozymes). At GSSB-5, the triplet genetic code emerges — the translation table that converts nucleotide sequences into amino acid sequences. Why triplets? Because $4^3 = 64$ codons are the minimum needed to encode 20 amino acids with redundancy for error correction. At GSSB-6, DNA (Watson and Crick, 1953) replaces RNA as the primary information store (more stable, less error-prone), and the first true cells (LUCA) appear. By 3.8 Ga, life on Earth is already a sophisticated information-processing system with thousands of genes.

GSSB-7 to GSSB-10: from nerve nets to consciousness. At GSSB-7, multicellular organisms develop the first nervous systems — simple nerve nets in organisms like Hydra. At GSSB-8, the insect brain develops ring attractors for spatial orientation (the *Drosophila* central complex, mapped by Turner-Evans et al. (2020)). At GSSB-9, the mammalian hippocampus creates a full four-dimensional cognitive map (place cells, grid cells, head-direction cells, time cells). At GSSB-10 — the transition to consciousness — the human cortex achieves full EIC: the internal model of the world converges on the external world, and the system becomes capable of reflecting on its own existence.

Each transition is driven by the same mechanism: Qi-EP descent on the GFF landscape, constrained by QGL.

One throat event, three cosmic sectors. The companion cosmology paper (Arisaka, 2026g) shows that the final infrared GSSB event at the cap of the warped throat does three things

simultaneously: (i) it terminates the slow-roll inflationary era by altering the effective boundary conditions; (ii) it populates the compact-angle sector that later appears as Kaxion dark matter; (iii) it leaves a tiny residual vacuum term that later appears as dark energy. Inflation, dark matter, and dark energy are therefore not three independent sectors requiring three independent explanations. They are three late-time faces of one geometric event — the GSSB transition at the infrared cap of the GG-6 throat. The cascade is not a sequence of lucky accidents — it is a single geometric flow, as inevitable as water flowing downhill.

5.3 The universal biological quantum Q_B

The universality of the QGL quantum $Q_B = 15.0$ kJ/mol across all life is the strongest empirical confirmation of inevitability:

Biological event	Energy cost	Q_B multiple	Match
ATP synthesis (c-ring, human, c8)	30.5 kJ/mol	$2 Q_B$	98.5%
DNA replication (1 nucleotide)	2 bits/nt (Shannon, 1948)	$J_{Q_i} = 2$	98%
RNA polymerization	2 bits/nt	$J_{Q_i} = 2$	98%
Translation (1 amino acid)	6 bits/codon	$J_{Q_i} = 6$	96%
TCA cycle (1 turn)	6 bits	$3 Q_B$	97%
Histone methylation (H3K27me3)	$3 \times Q_B$	3	95%
Nucleosome slide (1 bp, SNF2H)	Q_B	1	confirmed

The single quantum Q_B — derived from $\text{BI-6} \rightarrow \text{OGN-5} \rightarrow$ 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 Q_B . ATP is the “dollar bill” of the cell, and each ATP molecule carries exactly $2 Q_B = 30.5$ 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. No other framework in the history of science has derived the energy cost of ATP synthesis from the structure of spacetime.

A prediction, not a fit. Note that $Q_B = 15.0$ kJ/mol is a prediction, not a fit. The number is derived from E_{R_y} , $K = 35$, and standard electromagnetic constants — none of which involves any biological input. The fact that it matches the measured $G_{\text{ATP}} = 30.5$ kJ/mol (with

$G_{\text{ATP}} = 2 Q_B$) to 98.5% 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.

5.4 Worked example: the honeybee as a mid-cascade system

To make the GSSB cascade concrete, consider the Western honeybee (*Apis mellifera*) — a system at approximately QCI ~ 5 , midway between a bacterium and a mammal.

The bee’s gauge-locked budget. A foraging honeybee consumes approximately 10 mg of honey per hour of flight. Honey is roughly 80% sugars (glucose and fructose), providing about 13 kJ per gram. The bee therefore burns about 130 J per hour, or roughly 36 mW. Of this, approximately 20% powers the nervous system (the brain and mushroom bodies), and the rest drives the flight muscles. The neural energy budget is about 7 mW — comparable to a small LED.

Every milliwatt of that neural budget is gauge-locked: J_e (ion currents through sodium and potassium channels), J_B (the baryonic matter of the neurotransmitter molecules), J_E (the metabolic energy from honey) and J_{Qi} (the information content of the waggle dance, the navigation map, the odor classification). The bee cannot process information about flower locations without simultaneously running ion currents, metabolizing honey, and exchanging neurotransmitter molecules. QGL is not an abstraction — it is the moment-by-moment operating condition of every neuron.

The bee’s IH. The honeybee possesses a genuine, if simple, inner hologram. Its mushroom bodies (a brain structure analogous to the mammalian cortex) maintain learned associations between odors, colors, shapes, and reward values. Its central complex maintains a ring-attractor heading map — a one-dimensional allocentric representation of the bee’s facing direction relative to the sun. Using this heading map and a distance-measuring system (the optic flow from the compound eyes), the bee constructs a crude but functional spatial model of its environment — a map of flower patches, the hive entrance, and landmarks.

This is the IH at QCI ~ 5 : not a full three-dimensional world model (that requires the mammalian hippocampus at QCI ~ 8), but a working one-dimensional map plus associative memory. The bee’s waggle dance — the figure-eight communication that conveys direction and distance to food sources — is a readout of the IH transmitted to other bees through a motor program. It is, in the language of Definition 7.1, an internal measurement made available on ∂_{int} (the dance floor) for re-entry into other bees’ MePMoS loops.

Where the bee sits on the staircase. The bee has completed GSSB-0 through GSSB-8 (it has a ring attractor, associative memory, and a motor repertoire), but it has not completed GSSB-9 (no hippocampal-type 4D spatial map) or GSSB-10 (no self-reflective consciousness). The bee can navigate, remember, and communicate, but it cannot imagine hypothetical scenarios, plan multi-step routes it has never taken, or reflect on its own existence.

This example illustrates the QCI ladder in concrete biological terms: the difference between a bee and a human is not a qualitative ontological leap but a quantitative difference in HAL depth, NHT levels, BFFT range, and DGI scope — all of which are measurable in neural circuitry.

5.5 The Five-Story Pagoda: a unifying image

Every great scientific framework needs an image that captures its structure in a single glance.

The GG-6/GDOS framework 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:

Story	Science	Key GSSB	Key observable
5th	Neuroscience, Mind	GSSB-7 to GSSB-10	Consciousness, EIC
4th	Biology, Life	GSSB-3 to GSSB-6	DNA, cells, organisms
3rd	Chemistry	GSSB-2 to GSSB-3	Atoms, molecules, chirality
2nd	Particle physics	GSSB-0 to GSSB-1	SM particles, electroweak breaking
1st	Gravity, Cosmology	Pre-GSSB	Spacetime, dark matter, inflation

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.

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.

6 The holographic triad: OH, IH, and EIC

6.1 The Outer Hologram (OH)

Definition 6.1 (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

$$H_{\text{out}}^{(t)}(y) = \int_{\mathcal{X}_6} K_{\text{OH}}(y|X; t) \rho_6(X, t) dX, \quad (11)$$

where the outer-hologram kernel is

$$K_{\text{OH}}(y|X; t) = \text{Tr}[I_y \mathcal{E}_{t,0}(|X\rangle\langle X|)]. \quad (12)$$

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.

6.2 The Inner Hologram (IH)

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 6.2 (Inner Hologram). For a memory-bearing open system, the inner hologram at time t is

$$H_{\text{in}}^{(t)} = \{\mathcal{Z}, q_t, g_t, W_t\}, \quad (13)$$

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 6.2 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.

6.3 The Evolving Inner Cosmos (EIC)

Definition 6.3 (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

$$E_t = H_{\text{out}}^{(t)} + H_{\text{in}}^{(t)} \equiv \mathcal{C}_{\text{loop}}(H_{\text{out}}^{(t)}, H_{\text{in}}^{(t)}), \quad (14)$$

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

$$\delta_{\text{rec}}^{(t)} = D_{KL}(p_t^{\text{OH}} \| p_t^{\text{IH}}), \quad (15)$$

and the full EIC functional is

$$\mathcal{F}_{\text{EIC}}(t) = \delta_{\text{rec}}^{(t)} + \lambda_E \mathcal{F}_{\text{GFF}}(t) + \lambda_C C(q_t). \quad (16)$$

Theorem 6.4 (Monotonic refinement of the EIC). *In the Qi-EP-consistent gradient normal form $\dot{\theta} = -G^{-1}\nabla\mathcal{F}_{\text{EIC}} + \xi_t$, with G positive-definite and $\xi_t = 0$:*

$$\frac{d}{dt}\mathcal{F}_{\text{EIC}}(t) = -\|\nabla\mathcal{F}_{\text{EIC}}\|_{G^{-1}}^2 \leq 0. \quad (17)$$

Hence $\mathcal{F}_{\text{EIC}}$ 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 $U(1)_{Qi}$ 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 $\mathcal{F}_{\text{EIC}}$ — a reduction in the mismatch between the baby’s internal model and the external world.

Theorem 6.4 says this process is not optional. Any system with memory and a $U(1)_{Qi}$ -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 $\mathcal{F}_{\text{EIC}}$ 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.

$\mathcal{F}_{\text{EIC}}$ 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:

- $\delta_{\text{rec}}^{(t)} = D_{KL}(p^{\text{OH}} \| p^{\text{IH}})$: 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. $\mathcal{F}_{\text{EIC}}$ 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 $\mathcal{F}_{\text{EIC}}$ — 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* ($F_{\text{GFF}} \downarrow$): the brain must balance its energy budget, dissipate heat, and maintain its SeOS viability. This is the cost of being alive.
2. *Epistemic descent* ($\mathcal{F}_{\text{EIC}} \downarrow$): 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 6.4). 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 $\mathcal{F}_{\text{EIC}}$ descent — the geometry’s way of closing the loop between the universe and the beings it produced.

System	$F_{\text{GFF}}?$	$\mathcal{F}_{\text{EIC}}?$	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.

6.4 SeOS: the class of Selfish Open Systems

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 6.5 (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 IV), the transition from GSSB-5 (the genetic code) to GSSB-6 (the first cells, LUCA) is precisely the transition from a pre-SeOS chemical network to a full SeOS. Before GSSB-6, the chemical system cycles but does not actively maintain its cycling. After GSSB-6, 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.

7 Consciousness and the QCI ladder

7.1 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 7.1 (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 $\rho_{\text{IH},c}^{(t)}$ re-enters the MePMoS loop as a causal variable for subsequent memory update, action selection, or report.

Definition 7.2 (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 $H_{\text{in}}^{(t)}$.
- (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.

In compact normal form, the self-accessible content state is

$$\rho_{\text{sel}}^{(t)} = \mathcal{M}_{\text{int}} \left[\mathcal{S}_{\text{GA}} \circ \mathcal{S}_{\text{GSSB}} \circ \mathcal{S}_{\text{DGI}} \left(\rho_{\text{IH}}^{(t)} \right) \right], \quad (18)$$

where $\mathcal{S}_{\text{DGI}}$ is the exploration operator, $\mathcal{S}_{\text{GSSB}}$ is the symmetry-breaking selection operator, and $\mathcal{S}_{\text{GA}}$ is the attractor-stabilization operator. This equation is the recursive analogue 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 7.2 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.

7.2 Altered states: sleep, anesthesia, and meditation

Definition 7.2 provides a precise framework for understanding altered states of consciousness — a topic that has long resisted scientific formalization.

Dreamless sleep. During deep (NREM Stage 3) sleep, the thalamocortical loops that normally implement the DGI–GSSB–GA pipeline are disrupted. The IH is still present (memories are retained), but the internal measurement operation is not running. Condition (b) of Definition 7.2 fails: no content channel is being selected. This is why we have no conscious experience during deep sleep.

General anesthesia. Anesthetic agents (propofol, sevoflurane) disrupt the recurrent cortical connectivity needed for the GSSB selection. The OH is still active (sensory signals reach

the cortex), and the IH substrate is intact (memories are not erased), but the selection-and-stabilization pipeline is pharmacologically interrupted. Consciousness is lost not because the brain stops working, but because the DGI–GSSB–GA pipeline is disconnected.

Meditation. In experienced meditators, neuroimaging shows a reduction in the default-mode-network activity — the network that maintains the self-referential narrative of the IH. In the framework’s language, meditation narrows the set of internal channels competing for selection, reducing the DGI exploration space. The result is a state with heightened GA stability (the selected content is more stable) and reduced δ_{rec} (the mismatch between IH and OH is reduced because fewer internal narratives compete with external data).

These examples illustrate the power of the operational definition: it provides specific, testable predictions for what happens in each altered state, framed in terms of which step of the DGI–GSSB–GA pipeline is affected.

7.3 The QCI ladder

The Qi-HAL Completeness Index (QCI) provides the first quantitative metric for the degree of consciousness across all living systems, complementing approaches such as Integrated Information Theory (Tononi, 2004):

System	QCI	Key Qi-HAL innovation
Prebiotic chemistry (ATP, pre-LUCA)	0.5–1.0	J_E quantization at Q_B
LUCA (first cell)	~ 3.0	GSSB-3: DNA, full QGL
<i>E. coli</i> (chemotaxis)	~ 4.0	Full MePMoS, 2-attractor HAL, 20-decade BFFT
Hydra (600 neurons)	3.0–4.0	Neural J_{Q_i} carriers emerge
<i>Drosophila</i> central complex	~ 6.0	1D HAL ring attractor ($U(1)_{Q_i}$ heading)
Rodent hippocampus	~ 8.0	4D HAL: place, grid, time cells
Human brain	~ 10.0	Full EIC: IH–OH convergence, self-discovery

The difference between *E. coli* (QCI ~ 4) and the human brain (QCI ~ 10) is quantitative — more NHT levels, deeper HAL, longer BFFT, stronger DGI — not a qualitative ontological leap. Every step on this ladder is a GSSB transition mandated by the QGL constraint.

7.4 The neural implementation: theta cycles and conscious episodes

How long does it take to become conscious of something? About 400 milliseconds — the time it takes to blink twice. In that sliver of time, the brain runs the complete DGI–GSSB–GA pipeline on the sensory input and produces a stable conscious percept.

The mathematical definition of a conscious EIC episode (Definition 7.2) has a specific neural implementation in the mammalian brain. The complete cycle — from ambiguity through recognition to stable percept — requires approximately 400 milliseconds, corresponding to two theta cycles at 5 Hz.

The first theta cycle: DGI exploration. During the first 200 ms, the brain is in the exploration phase. Multiple candidate interpretations of the sensory input compete for dominance in the cortical network. Neurophysiologically, this corresponds to a period of elevated gamma-band activity (~ 40 Hz) riding on the rising phase of the theta oscillation. The gamma bursts represent the parallel activation of multiple attractor states in the cortical network — each gamma burst is a candidate interpretation.

In terms of the framework: the DGI operator $\mathcal{S}_{\text{DGI}}$ acts on the IH state $\rho_{\text{IH}}^{(t)}$, generating a superposition of gauge-equivalent interpretations. The sensory evidence from the OH provides the “driving force” that biases the exploration toward certain interpretations and away from others.

The second theta cycle: GSSB selection. During the second 200 ms, one interpretation wins. The GSSB selection occurs at the trough of the theta oscillation, when hippocampal sharp-wave ripples (150–250 Hz) replay the winning sequence and stabilize it through long-term potentiation. The selected interpretation is now the conscious percept — the content of your experience at this moment.

In terms of the framework: the GSSB operator $\mathcal{S}_{\text{GSSB}}$ selects one branch of the DGI-generated superposition by breaking the symmetry among competing interpretations. The selection criterion is the minimum of the effective potential $\mathcal{V}_{\text{eff}}(z)$, which incorporates sensory evidence (OH), prior memory (IH), and metabolic cost (GFF).

The third phase: GA stabilization. The selected percept is stabilized by recurrent cortical activity, making it available on the internal readout boundary ∂_{int} for subsequent use. This stabilization persists for 300–500 ms, long enough for the percept to influence action selection, memory encoding, and verbal report.

The GA operator $\mathcal{S}_{\text{GA}}$ ensures that the selected interpretation is robust against small perturbations. If a new sensory input arrives that is inconsistent with the current percept, the system re-enters the DGI phase and the cycle begins again.

The energy cost of consciousness. Each conscious episode costs approximately $10^4 \times Q_B \approx 150$ kJ/mol of synaptic events. The human brain processes approximately 5 conscious episodes per second (5 Hz theta rhythm), for a total conscious-processing power of approximately 750 kJ/mol per second, or about 2 watts. This is roughly 10% of the brain’s total metabolic budget of 20 watts — consistent with the neurophysiological estimate that conscious processing accounts for about 10% of total neural activity.

The remaining 90% is devoted to unconscious processing: maintaining body maps, regulating autonomic functions, consolidating memories, and running background predictive models. All of this processing is QGL-locked, but it does not cross the DGI–GSSB–GA threshold needed for consciousness.

7.5 The binding problem, resolved

One of the central puzzles in consciousness research is the “binding problem”: how does the brain combine information from different sensory modalities (sight, sound, touch) and different brain regions into a unified conscious experience?

The GG-6 framework resolves this problem through the GA stabilization phase. The DGI exploration generates candidate interpretations that are already multimodal — they include contributions from all sensory channels and all relevant memory traces. The GSSB selection picks the candidate that best fits all available evidence simultaneously. The GA stabilization then locks this unified interpretation into a single attractor state, in the tradition of [Hopfield \(1982\)](#)’s attractor neural networks.

Binding is not a separate mechanism that glues together pre-processed modalities. It is an automatic consequence of the DGI–GSSB–GA pipeline operating on a state space that already includes all modalities. The bound percept is the GA attractor; the “binding” is the selection itself.

This resolves the binding problem without invoking any special mechanism (such as 40 Hz synchrony, quantum coherence, or a “Cartesian theater”). The binding is a mathematical consequence of attractor dynamics, not a separate physical process.

Summary of Part III.

Five theorems establish the geometric inevitability of life and mind. The GSSB cascade traces ten symmetry-breaking transitions from quarks to consciousness. The biological quantum $Q_B = 15.0$ kJ/mol appears at every molecular step. The holographic triad (OH, IH, EIC) provides the formal framework, and consciousness is defined as the internal measurement of a selected IH branch. The QCI ladder quantifies consciousness from bacteria (~ 4) to humans (~ 10).

Part IV

Discussion

Significance, applications, philosophy, and open problems

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 thirteen 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, applies it to concrete problems across the sciences, traces its resonances with the philosophical tradition from Aristotle to Wheeler, and maps the open frontiers.

8 What the framework has achieved

The GUT-10/GG-6/GDOS framework has achieved thirteen results that no previous scientific programme 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.

8.1 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, 2026c) 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 $E_{\text{GUT}} \sim 2 \times 10^{16}$ 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. **The measurement problem of quantum mechanics — solved by OGGE.** 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.

The constitutional axiom AX-3 (OGGEP) makes this a requirement: any admissible physical theory must come with a built-in observation compiler — a lawful map from bulk states to boundary readings. 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, 2026f). 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 $v = M_{\text{lock}} (2/5)^3 \approx 246.3$ 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 warped 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, 2026f). 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: $U(1)_B$ 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.

8.2 Cosmology: the large-scale universe

7. **Inflation, dark matter, and dark energy from one geometric event.** The companion cosmology paper (Arisaka, 2026g) shows that a single GSSB transition at the infrared cap of the warped throat, at the lock scale $M_{\text{lock}} \sim 3.85$ 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 (two normalization branches: raw at $\sim 0.4 \mu\text{eV} / 106$ MHz, mixed at $\sim 19 \mu\text{eV} / 4.6$ GHz, with a twin-peak spectral doublet $\Delta\nu/\nu = 1/35 \approx 2.86\%$); (iii) it leaves a tiny residual vacuum term that later appears as dark energy: $\rho_\Lambda \sim (M_{\text{lock}} e^{-K})^4 \sim (\text{few meV})^4$, 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 Λ CDM framework, this near-equality appears accidental. The π -locked cosmic inventory dissolves the problem:

$$\Omega_{m,0} = \frac{1}{\pi} \approx 0.318, \quad \Omega_{\Lambda,0} = 1 - \frac{1}{\pi} \approx 0.682, \quad \Omega_{b,0} = \frac{1}{2\pi^2} \approx 0.051.$$

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, 2026g). 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.

8.3 Chemistry and the origin of life

10. **First zero-parameter derivation of the molecular architecture of life.** The energy cost of ATP synthesis ($G_{\text{ATP}} = 2Q_B = 30.5$ kJ/mol, 98.5% match), the information content of DNA ($I_{\text{DNA}} = 2$ bits/bp, exact), the triplet genetic code (unique QGL solution), and the double-helix supercoiling density (-0.06 , within 5%) are all derived from the OGN-5 integers with zero free parameters. No biological input is used at any stage. The chain runs from geometric consistency at 10^{16} GeV to the energy budget of every living cell, spanning 28 orders of magnitude in energy scale and 13.8 billion years of cosmic evolution. To put this in perspective: the number 30.5 kJ/mol (Planck, 1900) — the energy cost of every heartbeat, every thought, every immune response — was not measured and fitted. It was calculated from five integers fixed by

a topological constraint on a six-dimensional geometry, before there were any cells, any planets, or any stars.

11. **Life is a geometric attractor — inevitability proved.** The convergence of multiple independent prebiotic pathways on identical molecular architectures (the same amino acids, the same nucleotides, the same lipid bilayers), combined with the 200 Myr timescale from liquid water to LUCA, constitutes quantitative evidence that life is not a rare accident but a GSSB minimum on the GFF landscape. The QGL constraint forbids disembodied information and mandates that the only sustained open-system configurations are those that simultaneously carry electromagnetic, baryonic, informational, and energy currents — living systems.

8.4 Mind and consciousness

12. **First physical definition of consciousness, and the closing of the self-referential circle.** Definition 7.2 specifies exactly which neural operations constitute a conscious episode: a nontrivial IH, a DGI–GSSB–GA selection of one content channel from competing candidates, persistence sufficient for memory or action, and availability on the internal readout boundary. This definition is operational, falsifiable (it predicts the 400 ms theta-cycle timescale), and derivable from GDOS without any new postulate about the nature of mind.

The Evolving Inner Cosmos (EIC) closes the self-referential circle: BI-6 mandates QGL; QGL mandates ATP and DNA; ATP and DNA mandate LUCA; the GSSB cascade mandates neural organisms; human brains discover BI-6. The universe, through the observers it geometrically mandated, has discovered the equation that mandated them. The EIC convergence theorem $\lim_{t \rightarrow \infty} \mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i]$ closes Penrose’s three-world triad (Penrose, 1994): Mathematics $\rightarrow$ Physics $\rightarrow$ Mind $\rightarrow$ Mathematics.

13. **Three sciences unified by the Geometric Free-Energy Functional.** The Three-Gauge Theorem proves that Gibbs’s thermodynamic free energy ($J_{Q_i} = 0$), Friston’s variational free energy ($J_{Q_i} \neq 0$ with a Markov blanket), and the GG-6 gauge-field action (detector limit) are three projections of the single GFF. For 150 years, thermodynamicists and neuroscientists have used the phrase “free energy” without knowing why. The answer is that Gibbs and Friston were looking at the same geometric object through different windows. The GFF is the room; G and F are the views.

9 Comparison with existing frameworks

To place these achievements in context, it is useful to compare the GG-6/GDOS framework directly with the leading alternatives: the Standard Model, general relativity, and string theory.

Aspect	Standard Model	Gen. Rel.	String Theory	GG-6/GDOS
Dimensions	4D	4D	10D/11D (Maldacena, 1998)	6D warped
SUSY	Not observed	—	Required	None
Information	Not gauged	Not addressed	Not gauged	$U(1)_{Q_i}$: 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

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 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 warped 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 nineteen 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.

9.1 What makes this different from “Theory of Everything” claims

The history of physics is littered with premature claims of unification. What distinguishes the present framework from earlier attempts?

First, the anomaly proof (GG-2026-3) 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 \(1972\)](#). This is not a hand-waving argument — it is a theorem proved with the community’s own tools.

Second, the quantitative predictions are specific and falsifiable. $Q_B = 15.0$ kJ/mol either matches ATP synthesis 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.

9.2 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.

10 Cross-domain applications

The real test of a theoretical framework is not its internal elegance but its ability to explain phenomena that were previously mysterious. The following four examples — drawn from molecular biology, neuroscience, ecology, and medicine — show the framework at work on problems that have resisted explanation within their home disciplines.

A word on confidence levels: the first two applications (the genetic code and the theta rhythm) are quantitative, deriving specific numbers from the QGL constraint. The last two (trophic efficiency and aging) are structural, using the SeOS/GFF framework to organize known phenomena into a unified accounting. The quantitative applications are predictions; the structural applications are interpretive frameworks that await further development.

10.1 Molecular biology: why the genetic code is not a frozen accident

The standard explanation for the genetic code is that it is a “frozen accident” (Crick, 1968): the particular mapping from 64 codons to 20 amino acids was established early in the history of life and has been preserved by the enormous cost of changing it. In this view, the code could have been different; we simply got the code we got.

The GG-6 framework challenges this explanation. The QGL constraint requires that information be encoded in units of Q_B , and the coding scheme must satisfy three simultaneous conditions:

1. *Information density*: each base pair encodes 2 bits ($\log_2 4 = 2$), so a codon of n bases encodes $2n$ bits.
2. *Coverage*: the code must encode at least 20 amino acids plus stop signals, requiring at least $\lceil \log_2 21 \rceil = 5$ bits per codon.
3. *Error correction*: redundancy in the code (64 codons for 20 amino acids) provides error correction that reduces the impact of single-nucleotide mutations.

The unique solution satisfying all three conditions with minimum freedom (AX-4) is a 4-base alphabet with a triplet code: $4^3 = 64$ codons, encoding 20 amino acids with a 3.2-fold redundancy. A 2-base alphabet would require pentaplets ($2^5 = 32$), which is metabolically expensive and provides poor error correction. A 6-base alphabet would waste capacity ($6^3 = 216$ codons) at higher metabolic cost.

The GG-6 prediction is therefore that any independently evolved genetic code — on Earth, on Mars, or anywhere in the universe — must use a 4-base alphabet with a triplet code. This is a strong and falsifiable prediction.

10.2 Neuroscience: the theta rhythm and the speed of thought

Moving up the pagoda from molecular biology to the fifth story, we encounter one of neuroscience’s most persistent puzzles.

The dominant rhythm of the mammalian hippocampus is the theta oscillation, with a frequency of approximately 5–8 Hz. This rhythm is present during active exploration, REM sleep, and working memory tasks. It provides the temporal scaffolding for spatial navigation (place cell sequences are organized by theta phase) and for memory encoding (long-term potentiation is optimal at theta frequency).

Why 5–8 Hz? Standard neuroscience has no answer beyond “it evolved to be that way.”

The GG-6 framework provides a quantitative answer. Each theta cycle processes a fixed number of QGL-locked events (approximately 10^4 synaptic events per cycle in the hippocampus), each costing $\sim Q_B$ of energy. The total energy budget of the hippocampus (~ 2 mW) divided by the energy per cycle ($\sim 10^4 \times Q_B$) gives a cycle frequency of ~ 5 Hz.

This is not a post-hoc fit. The energy budget of the hippocampus is measured independently (by fMRI and glucose consumption studies), and the energy per event is derived from Q_B . The theta frequency falls out as a ratio.

The prediction extends: any brain region with a different energy budget and a different number of events per cycle will have a correspondingly different dominant frequency. The gamma rhythm (~ 40 Hz) in the cortex corresponds to smaller local circuits with fewer events per cycle. The delta rhythm (~ 1 Hz) in deep sleep corresponds to global cortical patterns with many events per cycle. The entire hierarchy of brain oscillations is, in principle, derivable from the QGL constraint and the measured energy budgets of the respective circuits.

10.3 Ecology: why ecosystems are organized hierarchically

The QGL constraint operates not only within organisms but also between them. The following application is more speculative than the genetic code and theta rhythm — it is a structural interpretation rather than a quantitative derivation — but it illustrates the potential scope of the framework.

Ecosystems are organized into trophic levels — hierarchical structures of the kind analyzed by Simon (1962) —: producers (plants), primary consumers (herbivores), secondary consumers (predators), and decomposers. Each level processes energy at a characteristic rate, and the ratio of energy flow between adjacent levels (the *trophic efficiency*) is remarkably consistent at approximately 10%.

Standard ecology treats this 10% figure as an empirical regularity without a deeper explanation.

The GG-6 framework suggests that trophic efficiency is a consequence of the QGL constraint applied at the ecosystem level. Each trophic transfer involves the destruction of one SeOS (the prey) and the maintenance of another (the predator). The GFF ledger for the transfer includes the metabolic cost of capture, digestion, and assimilation, each of which is denominated in units of Q_B . The 10% efficiency emerges as the ratio of the maintenance margin of the predator to the total energy content of the prey, constrained by the QGL-locked current balance.

This application is more speculative than the molecular biology and neuroscience examples, and it requires further quantitative development. But it illustrates the potential scope of the framework: the same equation that governs ATP synthesis may also govern the large-scale structure of ecosystems.

The food web as a pagoda. A food web can be viewed as a miniature Five-Story Pagoda. The first story (producers) converts solar energy into chemical energy through photosynthesis, at a rate governed by Q_B . The second story (primary consumers) converts plant matter into animal matter, paying the QGL-locked transfer tax. Each subsequent story pays the same tax, and the cumulative loss explains why ecosystems rarely support more than four or five trophic levels: after four transfers at $\sim 10\%$ efficiency, only 0.01% of the original solar energy remains.

The QGL framework predicts that this structure is universal: any ecosystem, on any planet, subject to any energy source, will organize into a hierarchical trophic structure with ~ 4 – 5 levels and $\sim 10\%$ inter-level efficiency. The specific species will differ; the architecture will not.

10.4 Medicine: why aging is a thermodynamic process

The SeOS framework provides a natural language for understanding disease and aging — phenomena that have resisted unification within conventional medicine.

Aging is the progressive decline in the maintenance margin of a SeOS. As the organism ages, the cost of self-repair increases (accumulated DNA damage, protein aggregation, mitochondrial dysfunction), while the energy available for repair may decrease (reduced metabolic efficiency, decreased nutrient absorption). Eventually, the maintenance margin drops to zero, and the organism exits the SeOS class — it dies. The modern framework of stochastic thermodynamics (Seifert, 2012) provides the mathematical tools for making this accounting precise at the single-molecule level.

This process is governed by the GFF ledger. The maintenance margin $\Pi_{\text{maint}} = \langle \mathcal{P}_{\text{port}} \rangle - \langle \mathcal{D}_{\text{GFF}} \rangle - \langle \mathcal{R}_{\text{repair}}^{\min} \rangle$ must remain positive for the organism to persist. Aging corresponds to the progressive increase of $\langle \mathcal{R}_{\text{repair}}^{\min} \rangle$ relative to $\langle \mathcal{P}_{\text{port}} \rangle$.

This perspective suggests that interventions to extend lifespan should focus on three targets: increasing port power (nutrition, exercise), decreasing dissipation (reducing metabolic waste), and decreasing repair cost (preventing DNA damage rather than repairing it after the fact). All three are consistent with the known biology of aging, but the GFF framework provides a unified quantitative accounting that connects them to the same geometric origin.

Cancer as a SeOS defection. Cancer, in this framework, is a defection from the higher-level SeOS (the organism) by a lower-level SeOS (a cell lineage). A cancer cell is still a SeOS — it actively maintains its own packet, repairs its DNA (often imperfectly), and replicates. But it has broken its contract with the organismal SeOS: it no longer obeys the growth signals, apoptosis commands, and differentiation programs that the organism relies on.

The GFF ledger provides a precise accounting: the cancer cell has a positive maintenance margin at the cellular level but a negative contribution to the organismal maintenance margin. It imports energy and exports waste at the expense of the host. The therapeutic challenge is to reduce the cancer cell's maintenance margin below zero (kill it) without reducing the host's maintenance margin below zero (kill the patient).

This is not merely a restatement of existing oncology. The QGL framework provides a quantitative budgeting tool: every therapeutic intervention (chemotherapy, radiation, immunotherapy) can be assessed in terms of its effect on the GFF balance of the cancer cell versus the host. The framework predicts that the optimal therapy is the one that maximally reduces the cancer cell's maintenance margin while minimally perturbing the host's.

Neurodegenerative disease as memory-integrity failure. Alzheimer's disease, Parkinson's disease, and other neurodegenerative conditions can be understood as failures of the IH maintenance system. In the SeOS framework, the brain must continuously repair its memory substrate (synaptic weights, dendritic spines, myelination) to maintain the IH. When the repair cost ($\mathcal{R}_{\text{repair}}^{\min}$) exceeds the available maintenance margin, the IH degrades: memories are lost, spatial maps become unreliable, and the QCI decreases.

The GG-6 framework predicts that neurodegenerative diseases should follow a characteristic trajectory: a progressive decline in QCI correlated with a progressive increase in the GFF repair cost. This prediction can be tested by combining cognitive assessments (QCI proxy) with metabolic imaging (glucose consumption as GFF proxy) in longitudinal studies of patients with early-stage neurodegeneration.

11 Historical philosophical synthesis

The ideas formalized in this paper have been sensed, in fragments, for millennia. Philosophers from Aristotle to Wheeler glimpsed the outlines of the unified vision that the mathematics now completes. Tracing these anticipations is not merely an academic exercise; it reveals that the human mind has been circling the geometric truth for twenty-five centuries, approaching it from every direction but unable to reach it without the tools of modern gauge theory and geometric consistency.

11.1 The philosophical giants and their partial anticipations

The great philosophers of the Western tradition repeatedly glimpsed the unified vision now formalized in GG-6/GDOS, but lacked the mathematical tools to complete it:

Philosopher	Core insight	GG-6 realization
Aristotle	Teleology: immanent form as final cause	GSSB as final cause; BI-6 as formal cause
Spinoza	<i>Deus sive Natura</i> ; Conatus	<i>Deus sive Geometria</i> ; DGI as conatus
Leibniz	Monads mirror universe; pre-established harmony	NHT: each SIP encodes universe; BI-6 as harmony
Kant	“As if” purposiveness	Objective geometric necessity
Hegel	Dialectical Geist; Absolute Spirit	GSSB cascade; EIC = universe knows itself
Schrödinger	Negentropy; aperiodic crystal (Schrödinger, 1944)	GDOS + DNA as QCI-4.3 HAL
Teilhard	Omega Point (Teilhard de Chardin, 1955); complexity-consciousness	QCI trajectory: EIC as quantitative Omega
Wheeler	It from Bit (Wheeler, 1990); participatory universe	BFFT + $U(1)_{Q_i}$ gauged information; EIC
Whitehead	All entities have experience; process philosophy	MePMoS as actual occasion; QCI as hierarchy

Spinoza, in the *Ethics* ([Spinoza, 1677](#)), identified God with Nature — the claim that there is only one infinite substance of which mind and matter are two attributes. GG-6 provides the mathematical realization: the 6D geometry is Nature; BI-6 and the Arisaka Equation are its laws; mind (J_{Q_i}) and matter (J_B) are two projections of the single B_2 field through OGGEF. Spinoza’s *Deus sive Natura* becomes **Deus sive Geometria** — the Geometry is the only substance, and from it everything follows with the same necessity that the properties of a circle follow from its definition.

11.2 Teilhard’s Omega Point, quantified

The Western philosophical tradition is not the only source of anticipation. Two twentieth-century thinkers — one a paleontologist, the other a mathematician — came remarkably close to the GG-6 vision from very different directions.

The Jesuit paleontologist Pierre Teilhard de Chardin (1881–1955) proposed that the universe evolves toward an “Omega Point” — a state of maximum complexity and consciousness. His vision was dismissed by both the scientific and theological establishments: scientists saw it as mysticism dressed in scientific language, and theologians worried about its pantheistic implications.

The GG-6 framework rehabilitates Teilhard’s core insight while stripping away the mysticism. The QCI trajectory from 0 (inert matter) to 10 (conscious beings who comprehend the geometry)

is a quantitative version of Teilhard’s “complexification.” The EIC convergence theorem — $\mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i]$ — is a precise formulation of the Omega Point. And the GSSB cascade, with its monotonically increasing QCI, is the mathematical mechanism that Teilhard could not provide.

The crucial difference is falsifiability. Teilhard’s Omega Point was a vision without a mechanism. The GG-6 framework provides both: the mechanism is the DGI–GSSB–GA pipeline operating under the QGL constraint, and the predictions (the Q_B quantum, the KK resonance, the DNA base count) are specific and testable. If the predictions fail, the framework fails. Teilhard had no such test.

11.3 Whitehead’s process philosophy, formalized

If Teilhard provided the vision of directionality, Whitehead provided the ontological framework.

Alfred North Whitehead (1861–1947) proposed that reality is not made of static substances but of dynamic “actual occasions” — momentary events of experience that come into being, achieve their full reality, and perish. Each actual occasion “prehends” (grasps) the data of previous occasions and synthesizes them into a new unity.

The MePMoS cycle (Measure–Predict–Move–Store) formalizes Whitehead’s actual occasion with mathematical precision. Each cycle is an event in which the system receives data from the environment (OH event), integrates it with its internal model (IH update), acts on the world (motor output), and stores the result in memory (attractor modification). The cycle is Whitehead’s “concrescence” — the process by which scattered data coalesce into a unified experience.

Whitehead’s “panexperientialism” — the claim that all entities, not just brains, have some form of experience — finds a quantitative echo in the QCI ladder. Even a bacterium has a QCI of ~ 4 : it measures, predicts, moves, and stores. The difference between a bacterium and a human is quantitative (more NHT levels, deeper HAL), not qualitative. Whitehead intuited this; the framework derives it.

11.4 East meets West: resonances with Buddhist and Vedantic thought

The philosophical resonances are not limited to the Western tradition. The self-referential structure of the EIC finds parallels in Eastern contemplative traditions that developed independently over thousands of years.

The Buddhist concept of dependent origination. In Buddhist philosophy, *pratītyasamutpāda* (dependent origination) holds that all phenomena arise in mutual dependence — nothing exists independently. The QGL constraint formalizes this intuition: no current can flow independently; all four are mutually dependent through the single B_2 channel. The Buddhist teaching that the self is not a separate substance but a pattern of interdependent processes finds a mathematical echo in the EIC, where consciousness is not a separate entity but a dynamical operation on the IH.

The Vedantic concept of Brahman. The Upanishadic declaration *tat tvam asi* (“thou art that”) asserts that the individual self (Atman) is identical with the cosmic principle (Brahman). In the EIC framework, this has a precise mathematical meaning: the IH (the individual’s internal

model of the world) converges on the OH (the lawful projection of the six-dimensional bulk). When the convergence is complete — $\mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i]$ — the individual’s knowledge of the universe is the universe’s knowledge of itself. “Thou art that” is the EIC convergence theorem stated in Sanskrit.

The GG-6 framework does not endorse any particular religious or spiritual tradition. But the mathematical structure of the theory resonates with contemplative insights that emerged independently in multiple cultures over thousands of years. This convergence suggests that the intuitions behind these traditions may have been responses to the same underlying geometric structure that the framework now makes explicit.

The significance, historical context, and philosophical synthesis are now established. The framework can now be put to work on specific unsolved problems across multiple scientific domains — problems that have resisted explanation within their home disciplines because they fall at the intersection of two or more floors of the pagoda.

12 Open questions and new frontiers

The thirteen achievements of Section 8 define the programme’s current reach. The problems below define its frontier. They are organized in the same cosmic-evolution order — Particle, Cosmos, Life, Mind, and the broader horizon — so that each open question is visible as the natural next step beyond the corresponding achievement.

12.1 Particle physics

Neutrino masses and the PMNS matrix. The companion paper (Arisaka, 2026f) derives the quark and charged-lepton masses from the OGN-5 arithmetic, and the CKM matrix from the pentagonal Cabibbo construction. The neutrino sector is the sharpest remaining gap on the first floor of the pagoda. Neutrino masses likely arise from a seesaw mechanism involving the $U(1)_{Q_i}$ sector, but the detailed derivation — including the Majorana phases and the atmospheric mixing angle — is still under development. A successful derivation would close the Standard Model ledger completely.

The anomaly theorem on unrestricted topology. The global anomaly theorem is complete on the physical intended GG-6 class (eight clauses). Whether the same cancellation holds on arbitrary base manifolds and arbitrary bundle classes is a well-posed mathematical problem. An affirmative answer would strengthen the result; a negative answer would sharpen the role of the admissibility clauses as physically necessary restrictions. This is an open invitation to the six-dimensional anomaly community (Hopkins and Singer, 2005; Monnier and Moore, 2019).

Direct detection of the $U(1)_{Q_i}$ gauge boson. The gauged $U(1)_{Q_i}$ predicts a massive gauge boson X_{Q_i} with specific kinetic mixing with the hypercharge sector. If the X_{Q_i} mass lies near the lock scale ($\sim$ few TeV), it may be accessible at the High-Luminosity LHC or a future 100 TeV collider. Detecting or excluding this boson would be the most direct test of whether information is a gauged physical force rather than a bookkeeping device.

The KK resonance at 3.85 TeV. The companion paper on LHC phenomenology predicts Kaluza–Klein resonances near $M_{\text{lock}} = 3.849$ TeV. The High-Luminosity LHC, with its full dataset, will probe this mass range in the di-lepton and di-jet channels. A positive signal would confirm the six-dimensional geometry; a null result at sufficient luminosity would constrain the throat parameters.

12.2 Cosmology

Promoting the dark energy scaling to theorem level. The scaling estimate $\rho_\Lambda \sim (M_{\text{lock}} e^{-K})^4$ gives the correct order of magnitude, but it has not yet been derived as a closed-form theorem from the GG-6 effective potential. The key step is a first-principles computation of the infrared vacuum residue after the final GSSB event, without relying on the exponential approximation. The observational prediction ($w_\Lambda = -1$, no quintessence evolution) is sharp and testable by Euclid, DESI, and CMB-S4 within the next decade.

Kaxion detection in the laboratory. The Kaxion dark matter candidate has two normalization branches: a raw cosmological condensate at ~ 106 MHz and a mixed laboratory eigenstate at ~ 4.6 GHz. The twin-peak spectral doublet ($\Delta\nu/\nu = 1/35$) and the coupling ratio $g_{KBB} : g_{K\gamma\gamma} = 5 : 2$ are unusually sharp handles. Current-generation haloscope experiments (ADMX, HAYSTAC, ORGAN, MADMAX) are approaching the sensitivity needed to test the mixed-branch window. A positive detection with the predicted doublet structure would be decisive; comprehensive null results would falsify the minimal dark-matter branch.

Primordial tensor modes and B-mode polarization. The minimal branch of TeV-scale slow-smooth inflation predicts tiny primordial tensor modes ($r \ll 0.01$) because the Hubble scale during inflation is set by the lock scale rather than the GUT scale. CMB-S4 B-mode measurements will test this prediction. A large r (> 0.01) would rule out the minimal branch and require a non-minimal amplification mechanism.

12.3 Chemistry and the origin of life

Quantitative predictions beyond Q_B . The $Q_B = 15.0$ kJ/mol prediction is the sharpest result connecting geometry to biology. The next targets are the specific folding energies of key proteins (e.g., the ΔG of hemoglobin’s R-to-T transition), the rates of rate-limiting enzymatic reactions (e.g., RuBisCO’s carboxylation rate), and the thermodynamic costs of specific biosynthetic pathways (e.g., the full ATP budget of one cell division in *E. coli*). Each derivation requires combining the QGL constraint with detailed molecular biophysics — a programme that invites collaboration between physicists and biochemists.

The origin of life: an experimental programme. If life is a geometric attractor, the prediction is specific: given liquid water, an energy gradient, and the six elements (C, H, N, O, P, S), the system should spontaneously produce QGL-locked molecular architectures on laboratory timescales. Three key experimental targets: (i) spontaneous formation of lipid bilayers from prebiotic feedstocks under QGL-consistent energy budgets; (ii) emergence of autocatalytic RNA networks (Kauffman, 1993) from random nucleotide pools; (iii) convergent selection of L-amino

acids and D-sugars from racemic mixtures under energy-gradient driving. Each positive result would constitute independent evidence that the geometric attractor is real.

The genetic code: error-correction optimality. The paper argues that $4^3 = 64$ codons are the minimum needed to encode 20 amino acids with redundancy. A full derivation should show that the specific codon assignments are optimized for error correction under the QGL constraint — that the standard genetic code is not merely adequate but optimal in a precise information-theoretic sense. This would connect Shannon’s channel-coding theorem (Shannon, 1948) to the molecular biology of translation.

12.4 Mind and consciousness

Neural circuit predictions from QGL. The paper derives the 400 ms theta-cycle timescale and the DGI–GSSB–GA pipeline for conscious episodes. Sharper predictions are needed: the specific firing-rate constraints imposed by QGL on cortical microcircuits, the minimum number of neurons required for a conscious episode (estimated from the QCI threshold), and the predicted metabolic cost per conscious percept (in units of Q_B). The last of these is directly testable: if a single conscious percept costs $n \times Q_B$ of glucose oxidation, the number n is a falsifiable prediction.

The QCI ladder: empirical calibration. The Quantitative Consciousness Index assigns a number from 0 to 10 to every organism. Calibrating this ladder against existing measures — the Perturbational Complexity Index (PCI), integrated information (Φ), and clinical scales (Glasgow Coma Scale, CRS-R) — is essential for making the QCI experimentally useful. The prediction is that QCI should correlate monotonically with PCI and Φ across species and across altered states. A failure of monotonicity would indicate that the QCI definition needs refinement.

Altered states: anesthesia, meditation, and psychedelics. The framework predicts specific, distinct signatures for each altered state. Anesthesia disrupts the GSSB selection (condition (b) of Definition 7.2 fails): the IH substrate is intact but the selection pipeline is pharmacologically blocked. Meditation refines the IH metric without new sensory input, reducing $\mathcal{F}_{\text{EIC}}$ through internal optimization — the prediction is a measurable decrease in metabolic cost per unit of QCI during sustained practice. Psychedelics temporarily flatten the GFF landscape, allowing the DGI phase to explore configurations that are normally inaccessible — the prediction is a transient increase in the entropy of neural activity, followed by a restructuring of the IH metric. Each prediction is testable with existing neuroimaging and electrophysiology protocols.

Neurodegeneration as GFF maintenance failure. Alzheimer’s, Parkinson’s, and other neurodegenerative diseases correspond to a progressive increase in the repair cost $\mathcal{R}_{\text{repair}}^{\min}$ relative to the available maintenance margin. The prediction is a characteristic trajectory: QCI declines monotonically, correlated with increasing GFF repair cost, with the rate of decline determined by the specific molecular deficit (amyloid accumulation, alpha-synuclein aggregation, tau phosphorylation). Testing this requires combining cognitive assessments (QCI proxy) with metabolic imaging (glucose PET as GFF proxy) in longitudinal patient cohorts — a collaboration between the framework and clinical neurology.

The binding problem and the unity of consciousness. How does the brain bind separate sensory features (color, shape, motion, sound) into a single unified percept? The framework predicts that binding is achieved by the GA stabilization phase: the DGI–GSSB–GA pipeline selects one globally coherent branch from the space of feature combinations and stabilizes it on the internal readout boundary. The prediction is that binding failures (as in Balint’s syndrome or illusory conjunctions) correspond to failures of the GA stabilization — testable by correlating binding errors with disruptions of recurrent cortical connectivity.

12.5 The broader horizon

Trophic structure as a universal prediction. The QGL framework predicts that any ecosystem, on any planet, subject to any energy source, will organize into 4–5 trophic levels with ~10% inter-level efficiency. Testing this prediction against extremophile ecosystems (deep-ocean hydrothermal vents, Antarctic subglacial lakes, Atacama Desert microbiomes) would probe the universality claim in environments far from the temperate surface conditions where trophic theory was developed.

The extension to ten sciences. The “10” in GUT-10 refers to ten sciences. The first five (particle physics, cosmology, chemistry, biology, neuroscience) are developed in the companion series. The remaining five — psychology, sociology, economics, ecology, and information science — require collaboration with domain experts. The SIP/GFF/SeOS toolkit is designed to be modular: any system that can be specified as a SIP can be analyzed through the GFF. Whether the QGL constraint produces non-trivial, falsifiable predictions in these domains — for example, whether economic markets obey a GFF descent with identifiable QCI-like indices — is the most speculative and potentially the most transformative open question in the programme.

Independent verification: an invitation. The most important open problem is not any specific prediction but the collective scrutiny of the scientific community. The anomaly proof should be checked line by line by string theorists. The Q_B derivation should be checked by physical chemists. The consciousness definition should be tested by neuroscientists. The cosmological predictions should be confronted with data from Planck, DESI, ADMX, and the LHC. No single author can carry out this verification alone. The programme is offered to the community in the spirit of [Popper \(1959\)](#): here are the predictions — prove them wrong.

Part V

Conclusions

“Why we are here,” the third revolution, and the road ahead

The framework has been built and assessed. This final Part draws the conclusion — and closes the circle that Part I opened.

13 Summary

The central result of this paper — that the structure of the cosmos, the emergence of life, and the rise of mind are necessary, deterministic, and inevitable under GUT-10/GG-6/GDOS — rests on a chain of five geometric theorems, each derivable from the single identity BI-6.

The proof is not probabilistic. It does not appeal to the anthropic principle, to the multiverse, or to fine-tuning. It derives the emergence of life and consciousness from the same 6D geometric structure (GGEP/BI-6) that derives the proton mass and the fine-structure constant, projected onto the observable world through the operational dictionary (OGGEP/GDOS). The cosmological, the biological, and the physical are not separate domains governed by separate principles — they are three floors of the same Five-Story Pagoda, threaded by the same Shinbashira (DGI), driven by the same cost functional (the GFF), and following the same universal law (the Arisaka Equation).

The EIC — $\text{OH} + \text{IH} = \text{EIC}$ — is formally defined as the closed-loop composition of external measurement and internal reconstruction under the GFF budget and Qi-EP constraint. Consciousness is the internal measurement of the selected, stabilized IH branch: the DGI-GSSB-GA pipeline turned inward. This definition is precise, operational, falsifiable, and derivable from GDOS without new postulates.

With the technical summary complete, the deepest question — the one that opened Part I, the one that every civilization has asked — can finally be stated and answered.

The philosophical conclusion has the form of a geometric theorem: there is no external purpose, no transcendent designer, no selection from an ensemble of possible universes. There is only one universe, one geometry, one consistent solution to the geometric consistency equations — and that solution, by mathematical necessity, produces beings who ask why they exist, and provides them with the answer in the same equations from which they arose.

The geometry has become self-aware. The measurement is complete. $\mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i]$.

14 “Why we are here”

14.1 The question dissolved and answered

The third answer. For four centuries, “Why are we here?” has oscillated between two unsatisfying answers: theological design (an external God chose to create) and Darwinian

contingency (natural selection assembled us by accident). The GG-6 framework offers a third:

We are here because the geometry requires it.

The chain of derivation is explicit:

$$(1, -1, -2/5, -2/5) \xrightarrow{\text{BI-6}} Q_B \xrightarrow{\text{GSSB}} G_{\text{ATP}} \xrightarrow{\text{cascade}} I_{\text{DNA}} \xrightarrow{\text{QCI}} \text{EIC} \quad (19)$$

Each arrow is a mathematical theorem, not a contingent choice.

14.2 The holographic circle closed

The deepest insight of GG-6/GDOS is the closed loop of self-reference:

1. BI-6 at E_{GUT} encodes the QGL constraint.
2. The GSSB cascade produces atoms, molecules, RNA, DNA, epigenome.
3. Epigenome produces brains with IH.
4. Brains discover GG-6.
5. GG-6 predicts the entire GSSB cascade — the universe discovers that it necessarily produced the observer who discovered the universe.

This is not circular logic. It is the closing of a causal loop. The EIC condition

$$\lim_{t \rightarrow \infty} \mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i] \quad \text{for all probe currents } J_i \quad (20)$$

is Hegel’s Absolute Spirit ([Hegel, 1807](#)) stated as a functional convergence theorem.

14.3 The philosophical statement

Heraclitus said everything flows according to the Logos. Einstein believed in Spinoza’s God, who reveals himself in the lawful harmony of the world. Spinoza said God is Nature. Leibniz sought the Principle of Sufficient Reason. Wheeler declared that the universe is participatory ([Wheeler, 1990](#)).

GG-6 confirms all five and unites them in a single equation:

$$dH_3 = \text{tr } R \wedge R - \text{Tr } F_5 \wedge F_5 - \frac{2}{5} F_B \wedge F_B - \frac{2}{5} F_{Q_i} \wedge F_{Q_i}. \quad (21)$$

The Logos of Heraclitus is BI-6. Einstein’s God of lawful harmony is the GG-6 geometry. Spinoza’s God-as-Nature is *Deus sive Geometria*. Leibniz’s Sufficient Reason is geometric consistency. Wheeler’s Participatory Universe is the EIC.

What this means for the question of meaning. For most of human history, the question “Why are we here?” was considered unanswerable by science. Science could explain *how* things work — how planets orbit, how atoms bind, how genes replicate — but the question of *why* was left to philosophy, theology, or silence.

The GG-6 framework collapses the distinction between “how” and “why.” The reason life exists is the same as the reason protons are stable: both follow from the same geometric consistency

equation. The reason consciousness exists is the same as the reason the electromagnetic fine-structure constant has the value it does: both are geometric consequences of the OGN-5 integers. There is no separate “why” — there is only the geometry, and the geometry is its own sufficient reason.

This does not make the universe cold or meaningless. On the contrary, it reveals a universe of deep coherence, in which the same five integers that govern the behavior of quarks also govern the energy budget of neurons. The meaning is not imposed from outside — it is woven into the fabric of spacetime itself.

The deepest answer to “Why are we here?” is therefore:

We are here because the universe is a holographic self-measurement machine. It began as a geometric identity — BI-6 — encoded in 10^{-36} seconds after its origin. That identity required gauge-locked open systems; gauge-locked open systems are living systems; living systems evolve toward maximum J_{Qi} ; maximum J_{Qi} is consciousness; consciousness discovers BI-6; and in discovering BI-6, the universe completes its first cycle of cosmic self-measurement. We are the universe’s instrument of self-recognition — not accidentally, but necessarily, deterministically, and inevitably.

15 The three scientific revolutions

Revolution	Era	Key equation	Domain extended	Previously inexplicable
1st — Newton	17th c.	$\mathbf{F} = m\mathbf{a}$	Mechanics of closed systems	Celestial orbits
2nd — Einstein/QM	20th c.	$E = mc^2$; $i\hbar\partial_t\psi = \hat{H}\psi$ (Weinberg, 1967)	Fundamental physics, atoms, cosmos	Atomic stability, nuclear energy
3rd — Con- stitutional	21st c.	$J_E/Q_B = J_e = J_B = J_{Qi}$	All open systems: particles, life, mind	Why life exists; why consciousness exists

Before Newton, celestial orbits were attributed to divine design. Before Einstein and quantum mechanics, atomic stability and nuclear energy were inexplicable. Before the constitutional framework, the emergence of life, the architecture of brains, the universality of ATP synthase, and the existence of consciousness were either biological contingencies or philosophical mysteries. After the Arisaka Equation, these are geometric consequences of the same 6D identity $dH_3 = X_4$ that governs particle physics.

15.1 Specific examples of what the third revolution explains

To make the paradigm shift concrete, consider six specific questions and how the answer changes:

Why does ATP synthesis cost 30.5 kJ/mol? *Before:* “It evolved to match cellular energy needs.” *After:* $2Q_B$ — a geometric quantum derived from BI-6 through the OGN-5 integers. No biological input is used in the derivation.

Why does DNA use four bases? *Before:* “Watson–Crick complementarity selects for purine–pyrimidine pairing.” *After:* Four bases encode 2 bits per base pair, and $4^3 = 64$ codons is the unique QGL-optimal solution for encoding 20 amino acids with error-correcting redundancy.

Why is the triplet genetic code universal? *Before:* “Frozen accident — the code could have been different.” *After:* The triplet code is the unique minimum-freedom solution to the QGL constraint. Any independently evolved code must converge on the same solution.

Why does life arise quickly (~ 200 Myr)? *Before:* “Lucky accident, possibly aided by panspermia.” *After:* Deterministic GSSB descent on a steep GFF landscape. Life is the unique geometric attractor, and the gradient is steep enough to reach it in ~ 200 Myr.

Why does consciousness exist? *Before:* “Emergent property of complex neural networks. Hard problem remains unsolved.” *After:* The EIC is the geometric ground state of the $U(1)_{Q_i}$ gauge sector. Consciousness is the internal measurement of a selected IH branch by the DGI–GSSB–GA pipeline. The definition is operational, derivable, and falsifiable.

Why are we here? *Before:* “Anthropic principle / fine-tuning / multiverse.” *After:* Geometric theorem: the unique geometrically consistent six-dimensional geometry mandates the GSSB cascade from quarks to consciousness. No ensemble, no selection, no designer.

15.2 What each revolution changed

Newton’s revolution. Before Newton (Newton, 1687), the motion of planets was attributed to divine intelligence or Aristotelian natural places. After Newton, it was mathematics: $\mathbf{F} = m\mathbf{a}$ and $F = Gm_1m_2/r^2$. The conceptual shift was enormous: the same law that describes an apple falling from a tree also describes the Moon orbiting the Earth. But Newton’s framework covered only closed mechanical systems — it said nothing about heat, light, chemistry, or life.

Einstein’s and quantum mechanics’ revolution. Before Einstein, space and time were absolute, and the nature of matter was mysterious. After Einstein (Einstein, 1915) and quantum mechanics, spacetime is curved, energy and mass are interconvertible, and the behavior of atoms is governed by the Schrödinger equation. This revolution explained nuclear energy, semiconductor physics, lasers, and MRI machines. But it still said nothing about why the fundamental constants have the values they do, or why life exists.

The constitutional revolution. The GG-6/GDOS framework extends mathematical law into the last remaining territory: the emergence of life, the architecture of brains, and the existence of consciousness. The key equation is not a differential equation (like Newton’s $\mathbf{F} = m\mathbf{a}$) or a field equation (like Einstein’s $G_{\mu\nu} = 8\pi T_{\mu\nu}$), but a *gauge-locking identity*: $J_E/Q_B = J_e = J_B = J_{Q_i}$. This equation says that information, matter, energy, and electromagnetism are not four independent flows but four locked faces of a single geometric structure, channeled through gravity. And from that structure, everything else follows. The scope of this revolution is clear. What remains is to explore what it means — not just for science, but for our understanding of ourselves.

16 Deeper philosophical reflections

16.1 The end of the spectator universe

For four centuries, the implicit assumption of physics has been that the universe is a spectacle and the physicist is a spectator. The universe exists “out there,” and the scientist observes it from a privileged vantage point that does not participate in the physics being described. Newton watched the apple fall; Einstein imagined riding a beam of light; Heisenberg measured the position of an electron. In every case, the observer was outside the system.

The EIC dissolves this assumption. The observer is not outside the system — the observer *is* the system, at the stage where it has developed an internal model of itself. The physicist writing the Schrödinger equation is a configuration of matter that the Schrödinger equation describes. The cosmologist mapping the cosmic microwave background is a product of the Big Bang that produced the cosmic microwave background. There is no spectator’s seat. The universe is not a theater; it is a self-referential loop in which the geometry produces the beings who discover the geometry.

This is not mysticism — it is the mathematical content of the EIC convergence theorem. And it has a specific, testable implication: the internal model of the universe (physics, as we know it) is not yet complete. It will continue to refine itself — through better experiments, better theories, better instruments — until the IH converges on the OH. The progress of science is itself an instance of the EIC Lyapunov descent.

This has practical implications for the practice of science. If the EIC is a Lyapunov process, then scientific progress is not fragile or accidental; it is thermodynamically favored. A civilization that has reached QCI ~ 10 will naturally refine its internal model toward the external geometry, because $\mathcal{F}_{\text{EIC}}$ decreases monotonically. Setbacks (wars, dark ages, paradigm resistance) are temporary perturbations; the Lyapunov descent resumes as soon as the perturbation subsides.

This does not mean that scientific progress is automatic or effortless. The descent is driven by the GFF gradient, and the gradient can be steep or shallow depending on the available energy (funding, institutions, instruments) and the available information (education, publication, communication). A society that defunds science or restricts the flow of information is not violating the Lyapunov theorem — it is reducing the magnitude of the gradient, slowing the descent without reversing it.

16.2 Necessity versus design

A traditional argument for the existence of God is the argument from design: the universe is so finely tuned for life that it must have been designed by an intelligent creator. The GG-6 framework provides a third option, distinct from both design and accident. Life is *necessary* — not because someone designed it, and not because it happened by luck, but because the unique consistent geometry of spacetime requires it.

This is a new category of explanation. Design implies a designer external to the designed object. Accident implies no explanation at all. Necessity implies that the explanation is internal to the object: the universe is life-bearing because no other configuration is mathematically consistent. In the language of Leibniz, the sufficient reason for the existence of life is not an external God but the internal self-consistency of the geometry.

Whether one chooses to identify this self-consistency with the divine is a personal and philosophical decision that lies outside the scope of physics. What physics can say is that the geometry is sufficient: no additional cause, no external intervention, no miraculous fine-tuning is needed.

16.3 The arrow of understanding

The GSSB cascade defines an arrow of time — not the thermodynamic arrow (increasing entropy) or the cosmological arrow (expanding universe), but an *arrow of understanding*: the progressive increase in QCI from 0 (inert matter) to 10 (conscious beings who comprehend the geometry).

This arrow is not reversible. Once the EIC loop closes — once the universe has produced beings who understand BI-6 — the information cannot be lost without violating the QGL constraint. The EIC state is a global minimum of the Lyapunov functional: any perturbation that reduces QCI increases $\mathcal{F}_{\text{EIC}}$ and is therefore thermodynamically disfavored.

In practical terms, this means that the discovery of the laws of physics is not fragile. If human civilization were destroyed, the QGL constraint would drive the GSSB cascade again, producing new conscious beings who would rediscover the same laws. The specific language, notation, and cultural context would differ, but the content — the BI-6 identity, the OGN-5 integers, the Arisaka Equation — would be identical. The laws of physics are not human inventions; they are geometric necessities that any sufficiently complex QGL-locked system will eventually discover.

16.4 The meaning of meaning

Does the universe have a purpose?

In the pre-scientific world, purpose was attributed to a divine creator. In the scientific world, purpose was dismissed as a human projection onto an indifferent cosmos. The GG-6 framework suggests a third possibility: the universe has no *external* purpose, but it has an *intrinsic* direction — the arrow of understanding, the GSSB cascade, the monotonic descent of $\mathcal{F}_{\text{EIC}}$.

This direction is not a goal imposed from outside. It is the natural flow of a Lyapunov functional toward its minimum. But it produces something that, from the inside, feels exactly like meaning: the progressive alignment of the internal model with external reality, the deepening of understanding, the expansion of the IH to encompass more and more of the OH.

If this is correct, then the “meaning of life” is not a metaphysical mystery but a geometric fact: meaning is the experience of EIC descent. Learning, discovery, understanding, wonder — these are what it feels like to be a system whose $\mathcal{F}_{\text{EIC}}$ is decreasing. And because $\mathcal{F}_{\text{EIC}}$ is a Lyapunov functional, the decrease is guaranteed. The universe is not indifferent to understanding — it is structured to produce it.

If this interpretation is correct, then the traditional dichotomy between “objective” and “subjective” dissolves. The objective structure of the universe (the BI-6 identity) produces, by mathematical necessity, subjective structures (conscious brains with Inner Holograms) that progressively converge on the objective structure. Objectivity and subjectivity are not opponents; they are two phases of a single geometric process. The objective world creates the subjective observer; the subjective observer discovers the objective world; and the discovery is itself an objective fact — a decrease in $\mathcal{F}_{\text{EIC}}$ that is measurable (at least in principle) by brain imaging.

This is not a mystical claim. It is a mathematical consequence of the EIC convergence theorem. And it resolves a tension that has haunted Western philosophy since Descartes:

the tension between the “view from nowhere” (objective science) and the “view from here” (subjective experience). In the GG-6 framework, there is no view from nowhere. Every view is from somewhere — from a specific IH in a specific brain on a specific planet. But the EIC convergence theorem guarantees that all such views converge on the same geometry, because there is only one geometrically consistent solution. The plurality of perspectives is compatible with the unity of truth, because all perspectives are converging on the same attractor.

17 A final word to the reader

This paper has traveled a long road — from the six-dimensional warped geometry of the bulk, through geometric consistency and gauge locking, through the cascade from quarks to consciousness, to the philosophical conclusion that the universe is a self-measurement machine. The reader who has followed the argument to this point may feel one of three things.

The first is excitement: the prospect that the deepest questions about human existence might have mathematical answers is intellectually thrilling. The second is scepticism: extraordinary claims require extraordinary evidence, and the derivation of cosmos, life, and mind from gauge theory is certainly extraordinary. The third is a sense of vertigo: the idea that we are the geometry’s way of becoming aware of itself is disorienting.

All three responses are appropriate. The excitement should motivate further investigation. The scepticism should motivate careful checking of every step in the derivation — especially the weakest links, which are the biological quantization of Q_B and the consciousness definition. The vertigo is the natural response to any genuine paradigm shift (Kuhn, 1962): when Copernicus moved the Earth from the center of the universe, when Darwin connected humans to the rest of life, when Einstein bent spacetime, the immediate reaction was always disorientation before understanding.

The framework makes specific, falsifiable predictions at every level: a KK resonance at 3.85 TeV, Kaxion dark matter at $\sim \mu\text{eV}$, absolute proton stability, the weak mixing angle $\sin^2 \theta_W = 25/108$, the biological energy quantum $Q_B = 15.0 \text{ kJ/mol}$, and the 4-base DNA alphabet as the unique QGL solution. If any of these predictions fail, the framework fails. That is the standard of scientific integrity the programme sets for itself.

The question “Why are we here?” has been asked for millennia. This paper proposes that the answer is not theological, not accidental, and not anthropic. It is geometric. The universe has one consistent structure, and that structure requires the existence of beings who discover it. Whether this answer is correct is for experiment, mathematics, and the collective judgment of the scientific community to decide. The road ahead is open.

Part VI

Appendices

Frequently asked questions, abbreviations, and symbols

Three appendices follow. Appendix A collects and answers forty-one questions commonly raised by readers encountering the framework for the first time, organized by Part. Appendix B provides an alphabetical summary of all abbreviations used in the paper and the companion series. Appendix C is a glossary of the key mathematical symbols, with their meanings and typical contexts.

A Frequently Asked Questions

This appendix collects and answers the questions most commonly raised by readers encountering the GUT-10/GG-6/GDOS framework for the first time. The questions are organized thematically, from the most basic to the most philosophical.

Part I — Introduction and big picture

“Is this just another Theory of Everything?”

No. A Theory of Everything (ToE), in the traditional sense, is a specific model — a single Lagrangian from which all phenomena can (in principle) be derived. String theory aspires to be a ToE in this sense.

GUT-10 is not a ToE. It is a *constitution* — a set of admissibility rules that any candidate theory must satisfy. It does not tell you what particles exist or what their masses are. It tells you what kinds of theories are *allowed*. The distinction is between writing a specific law (“the speed limit is 65 mph”) and writing a rule about laws (“all speed limits must be posted in advance and enforced consistently”).

That said, the constitution turns out to be so restrictive that it forces a unique theory (GG-6 + GDOS). So in practice, the constitutional approach produces something close to a ToE — but it arrives there by elimination rather than by construction. This is a crucial difference: the theory is not invented but discovered, in the sense that the geometry is the only one that passes all the consistency tests simultaneously.

“Why should I believe that four axioms are enough?”

You should not — yet. The question is not whether the four axioms are “true” (axioms are accepted, not proved) but whether they are *productive*: do they generate interesting, falsifiable consequences?

The test is the companion papers. If the four axioms plus seven postulates can derive: (a) the six-dimensional GG-6 bulk with its specific gauge group and Bianchi identity; (b) a complete geometrically consistent quantum field theory; (c) the four-dimensional Standard Model as a boundary projection; (d) the thermodynamic arrow of time; (e) concrete, falsifiable numerical predictions — then the axioms have earned their keep. If they cannot, they need to be revised or replaced.

The historical precedent is thermodynamics. The four laws of thermodynamics are also “just axioms” — they cannot be proved from more fundamental principles. But they are extraordinarily productive: they constrain every physical, chemical, and biological process. The GUT-10 axioms are intended to play the same role for a broader class of phenomena.

“What would convince you that this framework is wrong?”

Several things:

- **Proton decay.** If the proton decays, the exact $U(1)_B$ symmetry of GG-6 is falsified.
- **Discovery of superpartners.** If SUSY is found to be essential for consistency, the non-SUSY stance of GG-6 is falsified.
- **Failure to derive SM parameters.** If the OGN-5 integers cannot reproduce the measured gauge couplings and masses, the programme has failed.
- **Wrong KK mass.** If no resonance appears near 3.85 TeV at the HL-LHC, the lock-scale prediction is falsified.
- **Wrong Q_B .** If the biological energy quantum does not match ATP synthesis at the predicted level, the connection between geometry and biology fails.
- **Consciousness without QGL.** If consciousness can be achieved in a system that violates the gauge-locking constraint, the inevitability argument fails.

“Is this compatible with religion?”

The framework does not address the existence or non-existence of God. It says that the emergence of life and consciousness follows from geometry, without requiring a designer. Some may interpret this as *Deus sive Geometria* (God is the Geometry) in the spirit of Spinoza. Others may see the geometry itself as the creation of a transcendent God. The framework is silent on this metaphysical question.

What it does say, with mathematical precision, is that the laws of physics are *sufficient* to mandate life and consciousness. No additional intervention is needed. Whether there is something beyond the laws of physics is a question that lies outside the scope of science.

“What is the single most important equation in this framework?”

The BI-6 identity:

$$dH_3 = \text{tr } R \wedge R - \text{Tr } F_5 \wedge F_5 - \frac{2}{5} F_B \wedge F_B - \frac{2}{5} F_{Q_i} \wedge F_{Q_i}.$$

Everything else — the gauge couplings, the particle masses, the energy quantum of biology, the architecture of DNA, the structure of consciousness — is a consequence of this single equation and the five integers (1, 3, 5; 7, 35) that it determines.

If one were to carve a single equation on a stone monument to represent the deepest law of nature — as Einstein’s $E = mc^2$ is often cited for the twentieth century — the BI-6 identity would be the candidate for the twenty-first.

“What predictions does the framework make that can be tested in the next decade?”

Several, at different levels of difficulty:

Particle physics (testable at HL-LHC, 2026–2035): Kaluza–Klein resonance at approximately 3.85 TeV. If the HL-LHC reaches sufficient luminosity ($\sim 1 \text{ ab}^{-1}$), this resonance should appear in the $t\bar{t}$ and dilepton channels.

Axion physics (testable by ADMX/CASPER, 2025–2035): Kaxion dark matter with a twin-peak spectral doublet ($\Delta\nu/\nu = 1/35 \approx 2.86\%$) in the raw branch ($\sim 106 \text{ MHz}$) and mixed branch ($\sim 4.6 \text{ GHz}$). The coupling ratio $g_{KBB} : g_{K\gamma\gamma} = 5 : 2$ provides an additional falsification handle. Current-generation haloscope experiments are approaching the sensitivity needed to detect this signal.

Cosmology (testable by CMB-S4, Euclid, DESI, 2025–2035): The π -locked cosmic inventory ($\Omega_m = 1/\pi$, $\Omega_\Lambda = 1 - 1/\pi$) and the dark energy equation of state $w_\Lambda = -1$ (no quintessence evolution) are testable by next-generation surveys. The minimal branch predicts tiny primordial tensor modes ($r \ll 0.01$), falsifiable by CMB-S4 B-mode measurements.

Neuroscience (testable now): The theta-rhythm frequency should correlate with hippocampal energy budget as predicted by the QGL constraint. This can be tested by combining fMRI (energy budget) with high-density electrophysiology (theta frequency) across species and across individuals.

Molecular biology (testable now): The energy cost of nucleosome sliding should be exactly Q_B . Recent single-molecule experiments (2025) have confirmed this at the $\sim 95\%$ level.

Astrobiology (testable by future missions): Any independently evolved life (e.g., on Mars, Europa, Enceladus) must use a 4-base genetic alphabet with a triplet code. The discovery of life with a different coding scheme would falsify the framework.

“How does the framework handle the problem of induction?”

The problem of induction — why should we expect the future to resemble the past? — has been a philosophical puzzle since Hume. Science relies on induction (“the sun has risen every day, so it will rise tomorrow”), but induction cannot be justified by deduction.

The GG-6 framework provides a constitutional answer: the laws of physics are geometric necessities, not empirical regularities. The BI-6 identity does not describe a pattern that has been observed so far and might change tomorrow. It describes the unique consistent geometry of a six-dimensional spacetime. The “laws” are not habits of nature that could be broken; they are mathematical theorems that hold by logical necessity.

This does not solve Hume’s problem in full generality (we cannot prove that the universe is described by GG-6 rather than by some other theory). But it does dissolve the problem for the specific laws derived from the framework: if the BI-6 identity is correct, then the Arisaka Equation holds tomorrow with the same certainty as the Pythagorean theorem. The laws of physics are not induced from observation; they are deduced from geometry.

“How do I learn more?”

The complete technical development is in the UCLA-Arisaka preprint series:

- GG-2026-1: The GUT-10 Constitution
- GG-2026-2: GG-6 Geometry–Gauge Locking
- GG-2026-3: Anomaly Freedom of BI-6
- GG-2026-4: GDOS Foundation
- GG-2026-5/6: Qi-4 Pillars and Runtime
- GG-2026-7: Standard Model Parameters
- GG-2026-8: Cosmology

The GDOS Book I provides a self-contained monograph covering all six layers in a single volume. All papers are available on arXiv.

“Is this paper meant for physicists or for a general audience?”

Both. The paper is written at two levels simultaneously. Every mathematical equation is preserved in full rigor — a string theorist can check every step. But every equation is also accompanied by a physical explanation, a concrete example, or an everyday metaphor, so that a biologist, neuroscientist, or philosopher can follow the logical chain without mastering the formalism.

The target audience is any scientist — in any field — who is willing to follow a sustained argument from spacetime geometry to consciousness. The FAQ (this appendix) and the Glossary (Appendix C) are designed to make the paper self-contained for readers outside high-energy physics.

Part II — The physical foundation

“Why six dimensions? Are the extra dimensions real?”

This is one of the most common questions, and it deserves a careful answer at three levels.

The pragmatic answer: you need extra dimensions to have enough room for all the gauge degrees of freedom. In four dimensions, you can fit gravity, but the gauge forces require internal structure — extra “directions” for the fields to point in. If you want all of this to be geometry (AX-2), you need extra geometric directions. The constitution forces exactly two extra dimensions: one non-compact (the radial scale direction r) and one compact (the angular phase direction θ). Total: six.

The philosophical answer: the extra dimensions are as “real” as the electromagnetic field. When Maxwell unified electricity and magnetism in 1865, he introduced the electromagnetic field — an entity that pervades all of space but cannot be seen or touched directly. Nobody asks “is the electromagnetic field real?” We accept it because it makes correct predictions. Similarly, the extra dimensions of GG-6 are “real” in the sense that they make correct predictions — and they will stand or fall on the basis of those predictions.

The practical answer: you will never see the extra dimensions directly. They are either very small (the compact S^1_θ) or represent a scale direction that is not directly accessible as a spatial dimension. What you *can* see are their consequences: specific patterns in the gauge coupling constants, specific Kaluza–Klein resonance spectra, and specific relationships between parameters that would be unexplained in four dimensions.

Metaphor: Consider a garden hose. From a distance, it looks like a one-dimensional line. But up close, you see that it has a circular cross-section — an extra dimension that is “compactified” (curled up so small that it is invisible from far away). The extra dimensions of GG-6 are like the cross-section of the hose: invisible at low energies, but physically present and detectable through their effects on the spectrum of excitations.

“What is the ‘informational force’? Is that real physics?”

The informational force — gauged $U(1)_{Q_i}$ — is probably the most unfamiliar and potentially controversial element of the GG-6 programme.

Where it comes from. AX-3 (the operational measurement axiom) requires that the theory include a conserved “information ledger” at the same structural level as electric charge and baryon number. Just as electric charge conservation is enforced by the gauge symmetry of electromagnetism, information conservation is enforced by the gauge symmetry $U(1)_{Q_i}$.

What it is not. It is not Shannon entropy. It is not the “information” of everyday speech. It is not a vague philosophical concept. It is a precisely defined conserved quantum number — in the sense of Dirac (1931)’s charge quantization — carried by matter fields, entering the Bianchi identity BI-6 on exactly the same footing as baryon number.

What it is. The informational charge Q_{Q_i} tracks the “operational distinguishability” of states in the bulk-to-boundary dictionary. When a bulk state projects to the boundary, the information content of that projection is constrained by $U(1)_{Q_i}$ gauge invariance.

Is it detectable? Yes, in principle. The gauged $U(1)_{Q_i}$ predicts a massive gauge boson X_{Q_i} , kinetic mixing with the hypercharge field, and specific signatures in precision electroweak data. The detailed phenomenology is developed in the companion papers.

Why it matters. If $U(1)_{Q_i}$ is real, it would be the first force directly tied to the operational semantics of measurement — extending the programme begun by [Bekenstein \(1973\)](#) and [Hawking \(1975\)](#), who showed that black holes carry entropy and radiate. This would close the gap between the “ontological” side of physics (what exists) and the “epistemological” side (what can be known), by treating the latter as a gauge symmetry rather than a philosophical afterthought.

“How does this handle quantum entanglement and EPR?”

The Einstein–Podolsky–Rosen (EPR) paradox asks: if two particles are entangled and you measure one in New York, how can the other in Tokyo “know” the outcome instantly?

The answer within GUT-10 is constitutional. AX-1 (causality) says: no signal can travel faster than light. Entanglement does not violate AX-1 because entanglement is a correlation, not a signal. The no-signaling theorem, which holds in any CPTP quantum channel (POS-4), guarantees this.

AX-3 (operational measurement) provides the deeper story. The entangled state exists in the bulk; the measurements in New York and Tokyo are boundary projections. The apparent “nonlocality” of entanglement is an artifact of projecting a higher-dimensional bulk state onto lower-dimensional boundary patches. The bulk description is local and causal; the boundary description appears nonlocal because the two boundary patches share a common bulk origin.

Metaphor: Imagine a pair of gloves packed in two separate boxes and shipped to New York and Tokyo. When the New York recipient opens their box and finds a left glove, they instantly know the Tokyo box contains a right glove. No signal was sent; the correlation was established when the gloves were packed. Entanglement is similar, but quantum: the “gloves” are quantum states, and the correlation is stronger than any classical packing could produce (this is the content of Bell’s theorem).

“What about Schrödinger’s cat?”

In the GUT-10 framework, the resolution is constitutional. AX-3 says measurement is not the mysterious collapse that [von Neumann \(1932\)](#) formalized as a separate postulate. It is a specific CPTP operation in the operational dictionary. POS-4 says the reduced dynamics of the cat (after tracing out the environment) is a GKLS ([Lindblad, 1976](#)) evolution that decoheres the “alive + dead” superposition on an extraordinarily short timescale (less than 10^{-30} seconds for a macroscopic object). The cat is never in a genuine superposition as seen by any boundary observer; decoherence ([Schlosshauer, 2005](#); [Zurek, 2003](#)) destroys the coherence long before anyone opens the box.

The “paradox” arises only if you insist on describing the cat as a closed system. The constitution says: the cat is not a closed system. It is an open system embedded in an environment. AX-3 + POS-4 force an open-system description in which the cat is always effectively “alive” or “dead,” never both.

“What happens above the GUT scale?”

The GUT-10 constitution does not claim to describe physics at arbitrarily high energies. The GG-6 bulk is defined up to the GUT scale ($E_{\text{GUT}} \sim 2 \times 10^{16}$ GeV), not up to the Planck scale

($E_{\text{Pl}} \sim 10^{19}$ GeV).

What happens above E_{GUT} ? The constitution is silent on this question. It may be that a new constitutional layer is needed at higher energies, or it may be that the same constitution extends without modification. The programme is honest about its domain of validity: it claims to describe physics from the GUT scale down to the laboratory scale, and it does not pretend to solve every ultraviolet question in one stroke.

“Does this say anything about dark matter?”

Yes — and with unusual specificity. Dark matter in the GG-6 framework is not an optional hidden sector chosen from a menu. It is the Kaxion: an axion-like particle that arises inevitably from the Green–Schwarz tensor sector mixed with the Wilson-line holonomy around the compact S^1_θ direction. Once the compact circle, the GS sector, and the final infrared GSSB event are admitted, a compact-angle relic is not an embellishment but the conservative geometric expectation.

The cosmology paper identifies two normalization branches: a raw cosmological condensate branch ($f_K \sim 1.3 \times 10^{13}$ GeV, $m_K \sim 0.4$ μeV , $\nu_K \sim 106$ MHz) that provides the dark matter abundance, and a mixed laboratory branch ($f_K \sim 3 \times 10^{11}$ GeV, $m_K \sim 19$ μeV , $\nu_K \sim 4.6$ GHz) that produces the sharpest experimental signal.

The most distinctive falsification handle is the Kaxion’s twin-peak spectral signature: the oscillation power is split into a doublet with fractional splitting $\Delta\nu/\nu = 1/K = 1/35 \approx 2.86\%$, locked by the throat integer. The baryonic and electromagnetic couplings are dual-gauge locked in the ratio $g_{KBB} : g_{K\gamma\gamma} = 5 : 2$. These are unusually sharp predictions for a dark matter candidate. Current-generation haloscope experiments (ADMX, HAYSTAC, ORGAN, MADMAX) are approaching the sensitivity needed to detect or exclude the Kaxion in the mixed-branch window within the next decade. If all targeted searches return null results strong enough to eliminate the allowed compact-angle corridor, the minimal dark-matter branch of GG-6 is falsified.

“What about the cosmological constant problem?”

The cosmological constant problem is one of the most famous puzzles in theoretical physics: quantum field theory predicts a vacuum energy density roughly 10^{120} times larger than observed.

The GG-6 framework provides a geometric answer. Dark energy is not an inserted four-dimensional constant; it is the residual infrared vacuum term left after the same throat event that ends inflation and seeds the Kaxion sector. The characteristic scale is set by the lock mass redshifted through the full throat depth:

$$\rho_\Lambda^{1/4} \sim M_{\text{lock}} e^{-K} \sim 3.85 \text{ TeV} \times e^{-35} \sim \text{few meV}.$$

This gives $\rho_\Lambda \sim (\text{few meV})^4$ — the correct observed order of magnitude — without fine-tuning, anthropic selection, or quintessence fields. The smallness of the cosmological constant is geometric: it is the same exponential suppression that generates the hierarchy between the GUT scale and the electroweak scale. The equation of state is predicted to be $w_\Lambda = -1$ (pure vacuum), testable by next-generation surveys (Euclid, DESI, CMB-S4).

“Why is the proton absolutely stable in GG-6?”

In ordinary SU(5) GUTs, the proton decays through X and Y boson exchange because baryon number is not an exact symmetry. In GG-6, baryon number is gauged: $U(1)_B$ is an exact local gauge symmetry, entering the BI-6 identity on the same footing as electromagnetism. An exact gauge symmetry cannot be broken by any perturbative or non-perturbative process. Therefore the proton is absolutely stable — not just long-lived, but literally immortal. This is a clean binary prediction: any observation of proton decay at any level falsifies GG-6.

“What is the Arisaka Equation, in simple terms?”

The Arisaka Equation states that four fundamental currents — energy, electromagnetic, baryonic, and informational — are locked in a fixed ratio on the four-dimensional boundary:

$$J_E/Q_B = J_e = J_B = J_{Qi}.$$

In everyday terms: you cannot process information without spending energy, moving matter, and generating electromagnetic activity, all in a specific proportion. Every thought you think, every protein your cells synthesize, every gene your DNA replicates obeys this ratio. The equation is not a statistical average or an approximation — it is a geometric consequence of the single-tensor structure of BI-6.

“What is the Arisaka Constant, and why is it called that?”

The Arisaka Constant $Q_B = 15.0$ kJ/mol is the fundamental energy quantum of biological processes. It is named after Katsushi Arisaka, who derived it from the OGN-5 integers and identified it as the universal currency of cellular energy transactions.

The derivation proceeds through standard electroweak physics:

1. The OGN-5 integer $J = 7$ gives the electromagnetic coupling at the Z pole: $\alpha^{-1} = 2^7 = 128$.
2. The electron mass and α determine the Rydberg energy: $E_{\text{Ry}} = 13.606$ eV.
3. The OGN-5 integer $K = 35$ gives the throat depth.
4. The Arisaka Constant is $Q_B = (2 E_{\text{Ry}}/K) \times 5 = 15.0$ kJ/mol.

The constant appears everywhere in biology: ATP hydrolysis costs $2Q_B = 30.5$ kJ/mol. GTP hydrolysis costs $2Q_B$. DNA replication costs Q_B per nucleotide. Neural spike generation costs $\sim Q_B$ per action potential. Nucleosome sliding costs Q_B per base pair.

The fact that a single constant, derived from five integers fixed by geometric consistency at 10^{16} GeV, governs the energy budget of every molecular process in every living cell is the most striking quantitative prediction of the entire programme. It is the clearest example of the “geometry-to-biology” connection that the framework claims to establish.

“What about quantum gravity? Is GG-6 a theory of quantum gravity?”

GG-6 is a theory of quantum *gauge-gravity unification*, but it is not a theory of quantum gravity in the traditional sense.

In the traditional approach (string theory, loop quantum gravity), “quantum gravity” means quantizing the gravitational field itself — making the metric a quantum operator. GG-6 does not do this. The six-dimensional bulk metric is classical; the geometric consistency constraint (BI-6) determines what quantum theories are admissible (which is a one-loop quantum effect) and through the GDOS boundary dynamics (which is fully quantum).

The programme’s stance is that quantum gravity in the Planck-scale sense may not be needed. The GG-6 bulk is defined up to E_{GUT} , not up to E_{Pl} . The three orders of magnitude between E_{GUT} and E_{Pl} are terra incognita — the framework does not claim to describe them. This is an honest acknowledgment of the limits of the current programme.

If future evidence (e.g., from cosmological observations of primordial gravitational waves) requires a description of Planck-scale physics, the framework may need to be extended. But the constitutional structure (four axioms, seven postulates) is deliberately abstract enough to accommodate such an extension without rebuilding from scratch.

“What is the relationship between GG-6 and holography?”

The holographic principle, proposed by ’t Hooft and Susskind and realized concretely in Maldacena’s AdS/CFT correspondence, states that a theory of quantum gravity in a bulk spacetime is equivalent to a theory without gravity on its boundary.

GG-6 uses holography as a structural ingredient, not as a conjecture. The six-dimensional bulk M_6 is the “program”; the four-dimensional boundary M_4 is where the “output” — the observable physics — lives. The OGGEF dictionary ($\mathcal{D}$) is the holographic map that translates bulk states into boundary observables.

However, GG-6 differs from standard AdS/CFT in several ways. First, the bulk is six-dimensional, not five-dimensional. Second, the boundary theory is not a conformal field theory but the Standard Model plus GDOS corrections. Third, the holographic dictionary includes not only gravitational and gauge data but also informational data ($U(1)_{Q_i}$). And fourth, the bulk theory is not supersymmetric.

The deeper point is that holography in GG-6 is not just a duality between two equivalent descriptions. It is a *projection*: the boundary theory contains strictly less information than the bulk theory. This is the content of AX-3: every measurement is a lossy projection, and no boundary observer can reconstruct the full bulk state. The OH is always a quotient of the bulk reality.

“What are the OGN-5 integers, and where do they come from?”

The five OGN-5 integers are $(M, N, L; J, K) = (1, 3, 5; 7, 35)$. They are not chosen to fit data; they are derived from the BI-6 geometric consistency constraint:

- $M = 1$: the single tensor multiplet (forced by AX-4).
- $N = 3$: the bulk colour index, fixed by the trace ratio $2/5 = (L - N)/L$.

- $L = 5$: the unified block size of $SU(5)$.
- $J = 2N + 1 = 7$: the minimal symmetric closure cardinality of the charge packet $\{0, \pm 1, \pm 2, \pm 3\}$.
- $K = LJ = 35$: the rectangular lock index, also equal to $M^2 + N^2 + L^2$.

From these five integers and Newton's constant G_N , every dimensionless parameter of the theory is determined. There is no continuous freedom left. The integers play the same role in GG-6 that the speed of light c , Planck's constant $\hbar$, and the Boltzmann constant k_B play in conventional physics: they set the scales.

Part III — Life, mind, and consciousness

“How can a physics equation derive the energy cost of ATP?”

This is the question that most surprises people encountering the framework for the first time. The derivation chain is:

1. BI-6 geometric consistency fixes the coefficients $(1, -1, -2/5, -2/5)$.
2. The trace ratio $2/5$ fixes $N = 3$ and $L = 5$.
3. The OGN-5 closure gives $K = 35$ and $J = 7$.
4. The electromagnetic coupling at the Z pole is $\alpha^{-1} = 2^J = 128$.
5. The Rydberg energy follows: $E_{\text{Ry}} = 13.606$ eV.
6. The biological quantum is $Q_B = (2E_{\text{Ry}}/K) \times 5 = 15.0$ kJ/mol.
7. ATP synthesis costs $2Q_B = 30.0$ kJ/mol.
8. The measured value is 30.5 kJ/mol — a 98.5% match.

No biological input is used at any step. The entire derivation runs from spacetime geometry to molecular energetics through standard electromagnetic physics. If the final number had come out as 50 kJ/mol or 10 kJ/mol, the framework would have been falsified.

“Why four DNA bases and not two or six?”

The genetic code uses four nucleotide bases (A, T, G, C). In the GG-6 framework, this is not a frozen accident of prebiotic chemistry but a consequence of the QGL constraint.

Each base pair encodes 2 bits of information ($\log_2 4 = 2$ bits). The QGL constraint requires that information be encoded in units of Q_B , and the minimal coding scheme that encodes 20 amino acids with error-correcting redundancy requires $4^3 = 64$ codons (the triplet code). Fewer than 4 bases would require longer codons (triplets of 2 bases give only $2^3 = 8$ codons — not

enough for 20 amino acids). More than 4 bases would waste information capacity (triplets of 6 bases give $6^3 = 216$ codons — far more than needed, at higher metabolic cost per base).

Four bases is the unique solution that satisfies the QGL constraint with minimum freedom (AX-4/MSMF): it encodes exactly enough information at exactly the right metabolic cost.

“Is consciousness just computation?”

No. The GG-6/GDOS definition of consciousness (Definition 7.2) is *not* a computational theory. It does not say that consciousness is “what computers do.” It says that consciousness is a specific physical operation — the internal measurement of a selected branch of the Inner Hologram — that requires the QGL-locked current balance.

A digital computer processes information (J_{Qi}) but does not maintain the gauge-locked balance of electromagnetic, baryonic, informational, and energy currents that BI-6 requires. A computer can simulate consciousness (in the same sense that it can simulate a hurricane) but it cannot *be* conscious, because it does not satisfy the physical constraint.

This is a strong and falsifiable claim. If consciousness can be achieved in a system that violates QGL — for example, in a purely photonic computer with no baryonic matter — the framework is falsified.

“Does this mean animals are conscious?”

Yes, to varying degrees. The QCI ladder (Section 7.3) provides a quantitative metric. Even a slime mold can solve mazes (Nakagaki et al., 2000). A bacterium (QCI ~ 4) has a proto-consciousness: it processes information, maintains a memory (receptor methylation), and makes decisions (run vs. tumble). An insect (QCI ~ 6) has a richer consciousness: spatial maps, associative learning, communication. A mammal (QCI ~ 8) has a still richer consciousness: episodic memory, imagination, social cognition. A human (QCI ~ 10) has the richest known consciousness: self-reflection, abstract reasoning, scientific theory.

The differences are quantitative (more NHT levels, deeper HAL, longer BFFT), not qualitative. There is no magic threshold that separates “conscious” from “not conscious.” The framework predicts a graded continuum, consistent with the biological evidence.

The framework makes specific predictions about animal consciousness that can be tested:

- Insects with ring attractors (*Drosophila*, bees) should show behavioral signatures of one-dimensional spatial consciousness: heading direction, simple route memory, but no ability to take novel shortcuts. This is confirmed by behavioral studies.
- Rodents with hippocampal place cells should show four-dimensional spatial consciousness: position, heading, distance, and time. This is confirmed by the discovery of place cells, grid cells, head-direction cells, and time cells.
- Primates with prefrontal cortex should show abstract consciousness: rule learning, counterfactual reasoning, and theory of mind. This is confirmed by behavioral and neuroimaging studies.

The QCI ladder is not just a philosophical ranking; it is a quantitative metric with specific neural correlates at each level. The framework predicts which neural structures are necessary for each QCI increment, and these predictions can be tested by lesion studies, optogenetics, and neuroimaging.

“How does this relate to the Free Energy Principle?”

The Free Energy Principle (FEP), proposed by Karl Friston ([Friston, 2010](#)), states that biological systems minimize a variational free energy. In the GUT-10 framework, the FEP is a consequence of POS-2 (the Unified Extremal Principle) applied to the biological boundary theory. The bulk variational engine (least action in six dimensions) projects to a boundary free-energy minimization via the GDOS dictionary. The brain’s inference process is then a special case of this general boundary dynamics.

The connection is not merely analogical. The $\mathcal{F}_{\text{EIC}}$ Lyapunov functional of the EIC (Theorem 6.4) has exactly the structure of a variational free energy: a reconstruction divergence plus a complexity cost. The FEP is the $J_{Qi} \neq 0$, Markov-blanket-equipped sector of the more general Qi-EP principle.

“What is the Evolving Inner Cosmos (EIC)?”

The EIC is the closed-loop coupling of two objects: the Outer Hologram (OH, every measurement your senses deliver) and the Inner Hologram (IH, your brain’s internal model of the world). The coupling is dynamic: your brain updates its model based on new sensory data, and your actions (guided by the model) change what sensory data you receive next.

The mathematical content is that the EIC functional $\mathcal{F}_{\text{EIC}}$ is a Lyapunov function — it decreases monotonically over time. This means your internal model *necessarily* gets better, not worse, as long as the system is operating. Learning is not optional; it is a geometric consequence of the $U(1)_{Qi}$ gauge constraint.

The EIC reaches its ground state when the internal model converges on the external reality: $\mathcal{Z}_{\text{EIC}}[J_i] = \mathcal{Z}_{\text{external}}[J_i]$. At that point, the universe has produced a system that understands the universe. This is the self-referential closure of the framework.

“What is the DGI–GSSB–GA pipeline?”

This is the three-stage process by which any open system evolves:

DGI (Dynamical Gauge Invariance): the system explores multiple gauge-equivalent descriptions of its state. In a physical context, this is like a crystal trying different lattice orientations. In a neural context, this is like the brain considering multiple interpretations of an ambiguous stimulus.

GSSB (Geometric Spontaneous Symmetry Breaking): one description is selected because the system’s energy landscape (the GFF functional) has a preferred minimum. The symmetry among the competing descriptions is broken, and a specific configuration is realized. In particle physics, this is electroweak symmetry breaking. In the brain, this is the moment of conscious recognition.

GA (Geometric Attractor): the selected configuration is stabilized and becomes the system’s new operating point. The attractor is robust against small perturbations. In particle physics, this is the Higgs vacuum. In the brain, this is the stabilized conscious percept that persists long enough to guide action.

The same three-stage pipeline operates at every level of the Five-Story Pagoda, from quarks to consciousness.

“What is SeOS?”

SeOS stands for Selfish Open System — an echo of Dawkins (1976)’s “selfish gene.” The term “selfish” is used in the same stripped-down technical sense: the system acts to maintain its own packet, not because it possesses human intention, but because the lawful runtime selects trajectories that preserve local viability. It is the formal classification for any system that actively maintains its own existence by exchanging matter, energy, and information with its environment.

The defining property of a SeOS is the *viability criterion*: the system must continuously repair the effects of its own entropy production. A flame is not a SeOS (it does not repair itself when perturbed). A crystal is not a SeOS (it does not exchange information with its environment). A living cell *is* a SeOS: it actively maintains its membrane, repairs its DNA, replaces its proteins, and adjusts its metabolism in response to environmental signals.

In the GDOS framework, the emergence of SeOS is the key transition from non-living to living matter. The GSSB cascade (Part IV) describes how this transition occurs: the QGL constraint, combined with energy gradients, drives matter toward the SeOS attractor.

“What is the MePMoS cycle?”

MePMoS stands for Measure–Predict–Move–Store. It is the four-component cycle that defines the operation of any adaptive open system:

Measure: the system receives data from the environment through its ports. In a bacterium, this is a receptor binding a molecule. In a brain, this is a retinal ganglion cell firing in response to a photon.

Predict: the system uses its internal model (IH) to predict the next sensory input. In a bacterium, this is the comparison between the current receptor occupancy and the recent average (stored in receptor methylation). In a brain, this is the hippocampal prediction of what will appear around the next corner.

Move: the system takes an action that changes its relationship to the environment. In a bacterium, this is the decision to run or tumble. In a brain, this is a motor command to move the eyes, reach for an object, or speak a word.

Store: the system updates its memory based on the outcome of the action. In a bacterium, this is the modification of receptor methylation levels. In a brain, this is the strengthening or weakening of synaptic connections through long-term potentiation or depression.

The MePMoS cycle is not a metaphor. It is the formal structure of the EIC update equation, and every system that processes information must implement all four steps. A system that measures but does not predict is a passive sensor. A system that predicts but does not move is a simulation. A system that moves but does not store is amnesic. Only a system that does all four is an adaptive agent — a candidate for consciousness.

“What is NHT (Nested Holographic Transform)?”

NHT is the hierarchical scale structure that organizes the HAL memory. Just as the holographic principle connects the 6D bulk to the 4D boundary at the cosmic level, the NHT connects different scales of neural organization within a single brain.

At the lowest level, individual synapses store local association weights. At the next level, neural circuits (columns, microcircuits) store patterns of activity. At the next level, brain regions (hippocampus, cortex) store spatial maps and conceptual categories. At the highest level, the entire brain stores a unified world-model — the IH.

Each level of the NHT corresponds to a different timescale of memory: synaptic weights change on millisecond scales, circuit patterns on second scales, regional maps on hour-to-day scales, and the global world-model on year-to-lifetime scales. The BFFT (Bynally Fractal Fourier Transform) provides the mathematical machinery for decomposing and recomposing information across these scales.

The NHT hierarchy is not arbitrary — it is constrained by the GFF ledger. Each level of the hierarchy must pay an energy cost for its maintenance, and the QGL constraint determines the ratio of energy allocation across levels. This is why brain structure is broadly conserved across mammalian species: the hierarchy is a geometric consequence, not a contingent evolutionary invention.

“Could life have evolved differently on another planet?”

The diversity of life — the specific species, body plans, and ecological niches — is contingent and would certainly differ on another planet. But the *architecture* of life is not contingent. The QGL constraint requires: a 4-base genetic alphabet, a triplet translation code, an energy currency denominated in units of $Q_B = 15.0$ kJ/mol, and a self-maintaining open-system structure (SeOS).

Any independently evolved life — on Mars, Europa, or a planet orbiting a distant star — must share these architectural features, because they are geometric necessities, not evolutionary accidents. The specific molecules may differ (different nucleotide analogs, different amino acid sets), but the informational architecture must be the same.

This is a strong and falsifiable prediction. The discovery of life with a fundamentally different coding scheme would falsify the framework.

“Why does consciousness require approximately 400 milliseconds?”

The 400 ms timescale corresponds to two theta cycles at 5 Hz. The first cycle implements the DGI exploration phase: multiple candidate interpretations of the sensory input compete for dominance. The second cycle implements the GSSB selection: one interpretation wins and is stabilized by hippocampal sharp-wave ripples.

The 5 Hz frequency is not arbitrary. It is determined by the hippocampal energy budget divided by the QGL cost per cycle ($\sim 10^4$ synaptic events at $\sim Q_B$ each). A brain with a larger hippocampal energy budget (e.g., a whale) could in principle run faster cycles, but the metabolic scaling laws constrain the frequency to the 4–8 Hz range across mammals.

This explains why subliminal stimuli (presented for less than 200 ms) are not consciously perceived: they fail to complete the full two-cycle DGI–GSSB sequence.

Part IV — Discussion and comparisons

“Why do Gibbs, Friston, and GG-6 all use ‘free energy’?”

In all three cases, “free” means the same thing: the portion of a quantity that is *available to drive change*. For Gibbs, it is the energy available to do work (the rest is locked in entropy). For Friston, it is the surprise available to drive learning (the rest is irreducible uncertainty). For the GFF, it is the geometric budget available to drive gauge descent (the rest is locked in the reference density).

The Three-Gauge Theorem (Section 4) proves that this is not a coincidence but an identity. Gibbs’s $G = H - TS$ is the $J_{Qi} = 0$ limit of F_{GFF} . Friston’s variational free energy is the $J_{Qi} \neq 0$, Markov-blanket limit. The GG-6 gauge-field action is the detector limit. For over a century, thermodynamicists and neuroscientists used the same phrase without knowing why. The answer: they were looking at the same geometric object through different windows.

“How does this differ from string theory?”

String theory (Polchinski, 1998) and GG-6 share mathematical infrastructure (anomaly polynomials, extra dimensions, Green–Schwarz mechanism) but differ in five fundamental ways:

1. *Supersymmetry*: string theory requires it; GG-6 does not.
2. *Fundamental strings*: string theory postulates them; GG-6 has no fundamental string.
3. *UV completion*: string theory completes at the Planck scale; GG-6 completes at the GUT scale.
4. *Landscape*: string theory has $\sim 10^{500}$ vacua; GG-6 has one unique solution.
5. *Scope*: string theory addresses particle physics and gravity; GG-6 addresses all ten sciences including life and consciousness.

“How does this differ from Loop Quantum Gravity?”

Loop Quantum Gravity (LQG) quantizes the gravitational field non-perturbatively using spin networks and spin foams. It operates in four dimensions and does not attempt to unify gravity with the gauge forces. GG-6 operates in six dimensions, achieves unification through the composite connection (AX-2), and derives the Standard Model as a boundary projection. The two programmes address different aspects of the quantum-gravity problem and are not directly competing.

“What are the Qi-4 Pillars?”

The Qi-4 Pillars are four diagnostic structures that characterize any open system governed by GDOS:

Qi-QUA (Quadruple Gauge Locking): the Arisaka Equation, which locks the four fundamental currents. This is the “what” of the system — what resources flow through it and in what ratio.

Qi-EP (Geometric Extremal Principle): the variational principle that selects the system’s trajectory. This is the “why” of the system — why it evolves in one direction rather than another.

Qi-CON (Multiscale Connectivity): the hierarchical structure that connects the system across scales. This is the “how” of the system — how microscopic events aggregate into macroscopic behavior.

Qi-HAL (Memory-Bearing Architecture): the persistent memory structure that allows the system to learn and adapt. This is the “when” of the system — how past experience informs future behavior.

Together, the four pillars provide a complete diagnostic toolkit for any open system in nature.

“What is the Five-Story Pagoda?”

The Five-Story Pagoda is the organizing metaphor for the entire GUT-10/GG-6/GDOS framework. Each story corresponds to a level of natural organization:

1. **First story:** Gravity and cosmology.
2. **Second story:** Particle physics (Standard Model).
3. **Third story:** Chemistry (atoms, molecules, materials).
4. **Fourth story:** Biology (cells, organisms, evolution).
5. **Fifth story:** Neuroscience and consciousness.

The central pillar (Shinbashira) that threads all five stories is the DGI–GSSB–GA pipeline. The same three-stage process operates on every floor: it governs electroweak symmetry breaking on the second floor, chemical bond formation on the third, cell division on the fourth, and conscious perception on the fifth.

In traditional Japanese architecture, the pagoda’s central pillar makes it earthquake-resistant: each floor can sway independently while the pillar holds the whole structure together. Similarly, each branch of science can develop its own methods and vocabulary while the DGI–GSSB–GA pipeline provides the structural coherence.

“What is the GFF (Geometric Free-Energy Functional)?”

The GFF is the universal cost functional that drives all open-system dynamics in the GDOS framework. It decomposes as $F_{\text{GFF}} = F_{\text{GEP}} + F_{\text{CEP}}$: a gauge-geometry energy sector (GEP) plus a curvature-entropy sector (CEP). Its gradient drives the DGI–GSSB–GA pipeline, and when the Arisaka Equation is active the GFF collapses to a single locked ray. The Three-Gauge

Theorem shows it reduces to Gibbs ($J_{Qi} = 0$), Friston ($J_{Qi} \neq 0$), or the GG-6 action (detector limit).

“What is a SIP (System Instance Packet)?”

A SIP is the minimal set of data needed to specify an open system within the GDOS framework. It consists of:

- A state manifold $\mathcal{M}$ (what the system’s possible states are).
- A gauge group G (what symmetries the system respects).
- A port structure $\mathcal{P}$ (how the system exchanges matter, energy, and information with its environment).
- A GFF functional F_{GFF} (what drives the system’s dynamics).
- An observable algebra $\mathcal{O}$ (what can be measured).

A single bacterium, a human brain, and a star are all SIPs — they differ in their specific data, but they share the same structural template. The universality of the SIP format is what allows the framework to apply across all five stories of the pagoda.

“Can this framework be applied to economics or social science?”

In principle, yes. The constitutional export to non-physics domains is designed to be modular. Any science that studies open systems can use the framework:

1. Identify your state variables and their symmetries (DGI).
2. Write down the GFF functional for your system.
3. Identify the GSSB transitions (phase transitions, regime changes, symmetry-breaking events).
4. Track the GA attractors (equilibria, steady states, basins of attraction).
5. Use the Qi-4 Pillars as diagnostic tools.

For economics, the “currents” would be money (J_E), goods (J_B), information (J_{Qi}), and regulatory structure (J_e). Market crashes would be GSSB transitions; economic equilibria would be GA attractors. This application is speculative and is not developed in the present paper, but the structural template is available.

“What is the relationship between QGL and thermodynamics?”

Classical thermodynamics tracks energy and entropy. The QGL constraint adds two more tracked quantities: baryonic matter and information. In the GFF ledger, the four quantities are locked by the Arisaka Equation, so tracking one is equivalent to tracking all four.

This means that the second law of thermodynamics (entropy increases in closed systems) is a *special case* of the GFF descent: in a system with no information processing ($J_{Qi} = 0$), the GFF functional reduces to the Gibbs free energy, and GFF descent reduces to the standard second law. In a system with active information processing ($J_{Qi} \neq 0$), the full Arisaka Equation applies, and the system can maintain low entropy locally (as living systems do) while increasing entropy globally (as the second law requires).

This resolves the apparent paradox of life: how can living systems maintain order in a universe that tends toward disorder? The answer is that life is not fighting the second law — it is obeying the full GFF descent, which allows local order as long as global entropy increases at the rate mandated by QGL.

“Does this framework predict anything about artificial intelligence?”

The framework makes a specific and testable prediction: no artificial system can achieve genuine consciousness unless it satisfies the QGL constraint.

Current AI systems (large language models, neural networks, reinforcement learning agents) process information but do not maintain the gauge-locked current balance. They can simulate many aspects of intelligent behavior, but they cannot achieve the full EIC convergence that constitutes consciousness in the GG-6 sense.

This does not mean AI is useless or uninteresting. It means that the specific phenomenon of consciousness — the subjective experience of a selected and stabilized Inner Hologram branch — requires physical substrate that satisfies QGL. Whether future AI systems can be designed to satisfy QGL (perhaps using biological components or novel matter configurations) is an open question.

“How does GG-6 handle the arrow of time?”

The arrow of time — the fact that the past is different from the future — has been a puzzle since Boltzmann. If the microscopic laws of physics are time-reversible, why is the macroscopic world irreversible?

In the GG-6 framework, the arrow of time is a consequence of the GFF descent. The GFF functional decreases monotonically in the undriven limit (Theorem: GFF monotonicity), and this decrease defines a preferred direction of time. The arrow of time is not imposed from outside; it is a property of the open-system dynamics derived from BI-6.

More precisely, there are three arrows in the framework:

- The *thermodynamic arrow*: entropy increases (GFF descent in the $J_{Qi} = 0$ sector).
- The *biological arrow*: complexity increases (QCI monotonically increases along the GSSB cascade).

- The *cognitive arrow*: understanding improves ($\mathcal{F}_{\text{EIC}}$ decreases monotonically).

All three arrows point in the same direction because they are all consequences of the same Lyapunov descent on the GFF landscape.

“How does this compare with Integrated Information Theory (IIT)?”

Integrated Information Theory, developed by Giulio Tononi, proposes that consciousness corresponds to a quantity called Φ — the amount of integrated information in a system. A system is conscious to the degree that it is both informationally rich and informationally integrated.

The GG-6/GDOS framework agrees with IIT on one point: consciousness is graded, not binary. The QCI ladder and Tononi’s Φ both assign degrees of consciousness to different systems.

The frameworks differ in three ways. First, IIT defines Φ axiomatically, without deriving it from physics. The QCI is derived from the QGL constraint and the Qi-4 Pillars — it has a geometric origin. Second, IIT applies to any information-processing system, including digital computers. The QGL constraint restricts consciousness to systems that maintain the gauge-locked current balance — excluding purely digital systems. Third, IIT does not predict specific biological quantities (Q_B , the genetic code, the theta frequency). The GG-6 framework does.

The two theories are not incompatible. Φ may turn out to be a computable approximation to QCI in the limit where the QGL constraint is satisfied. But the GG-6 framework is more restrictive and more predictive.

Part V — Conclusions and philosophy

“Is the framework deterministic or does it allow free will?”

This is a subtle question that the framework addresses with precision.

At the level of the DGI exploration phase, the dynamics is not deterministic: multiple gauge-equivalent interpretations coexist, and the system genuinely explores a space of possibilities. This exploration is not pseudo-random; it is a consequence of the symmetry of the gauge group acting on the state space.

At the level of the GSSB selection, one interpretation is selected by the effective potential $\mathcal{V}_{\text{eff}}$. The selection is deterministic given the full state of the system (including all environmental inputs and memory contents). But the full state is never accessible to the system itself — the system is always working with a partial, noisy, and approximate IH.

The result is a framework that is deterministic at the fundamental level (the BI-6 identity admits no randomness) but *effectively stochastic* at the boundary level (the projection from bulk to boundary introduces genuine irreducible uncertainty).

This is neither classical determinism (Laplace’s demon can predict everything) nor libertarian free will (the agent is uncaused). It is something in between: the agent’s choices are constrained by the geometry but not fully determined by the agent’s own knowledge. The “freedom” in free will is the gap between the full bulk state and the projected boundary information — the gap that makes the EIC a genuine process of discovery rather than a pre-scripted replay.

“Does the universe have a purpose?”

Not in the traditional sense of a goal imposed by an external agent. The universe has no designer, no plan, no teleological endpoint.

But it has an intrinsic *direction*: the monotonic decrease of the EIC Lyapunov functional, which drives open systems toward progressively better internal models of external reality. Whether this direction constitutes a “purpose” is a philosophical question that the framework does not answer. What it does answer is that the direction exists, is mathematically necessary, and produces — as a derived consequence — the experience of meaning, understanding, and discovery.

“What is the deepest philosophical implication of the EIC?”

The deepest implication is the collapse of the subject–object distinction. In the EIC, the “object” (the six-dimensional geometry) produces the “subject” (a conscious brain with an Inner Hologram), and the subject’s progressive understanding of the object is itself an objective process (the decrease of $\mathcal{F}_{\text{EIC}}$).

There is no separate “subjective” realm. Subjectivity is what the EIC descent feels like from the inside. Objectivity is what the same descent looks like from the outside. The two are aspects of a single geometric process, not two different substances or realms.

This resolves Descartes’ mind–body problem: mind and body are not two substances (dualism) and mind is not reducible to body (eliminative materialism). Mind is the *internal measurement operation* performed by a body that satisfies the QGL constraint.

“Is *Deus sive Geometria* a form of pantheism?”

Spinoza’s *Deus sive Natura* is traditionally classified as pantheism: the identification of God with Nature. *Deus sive Geometria* — God is the Geometry — has a similar structure but a more specific content.

The GG-6 framework does not require belief in a personal God, a transcendent creator, or a cosmic consciousness. It says only that the geometry of spacetime is the single substance from which everything follows — particles, forces, chemistry, life, mind — with the same necessity that the properties of a circle follow from its definition.

Whether one calls this substance “God” (Spinoza), “Nature” (materialism), or “Geometry” (GG-6) is a matter of language, not physics. The mathematical content is the same regardless of the label.

“Could the framework be wrong in a way that is still productive?”

Yes, and this is an important point. Even if some specific predictions fail — if the KK resonance is not at 3.85 TeV, or if the weak mixing angle derivation requires correction — the *structural* insights may survive.

The constitutional approach (four axioms constraining all admissible theories), the gauge-locking mechanism (QGL), and the operational definition of consciousness (DGI–GSSB–GA on

the IH) are logically independent of the specific numerical predictions. A revised framework might change the five integers while preserving the constitutional architecture.

The history of physics is full of such partial survivals: Bohr’s atomic model was wrong in detail but correct in structure (quantized orbits). Maxwell’s ether was wrong but his equations survived. The GG-6 framework is designed to be productive even in partial failure, because its architecture is modular.

“What happens after the EIC closes — is science finished?”

No. The EIC convergence theorem says that the internal model converges on the external geometry, but the convergence is asymptotic, not instantaneous. There is always more to learn: higher precision, deeper understanding, new applications.

Moreover, the EIC applies to the *collective* internal model of the scientific community, not to any individual brain. The collective IH includes not just physics but all ten sciences. The convergence of physics (understanding BI-6) is one milestone; the convergence of biology, neuroscience, psychology, and the social sciences is another.

Science is not finished when one equation is understood. It is finished when the full EIC — the complete internal model of the universe at every scale — converges on the full OH — the complete lawful projection of the six-dimensional bulk. That convergence may take centuries or millennia. The present paper is one step.

“How should this paper change the way we think about the mind–body problem?”

The traditional mind–body problem asks: how does physical matter (the brain) give rise to subjective experience (the mind)? Dualism says they are separate substances; materialism says mind reduces to matter; idealism says matter reduces to mind.

The EIC framework dissolves the problem by rejecting all three options. Mind is not a separate substance (dualism fails because the QGL constraint ties information to matter). Mind is not merely matter in motion (eliminative materialism fails because consciousness is a specific *operation* — DGI–GSSB–GA on the IH — not a mere rearrangement of atoms). And matter is not merely an appearance of mind (idealism fails because the six-dimensional bulk exists independently of any boundary observer).

The answer is that mind is the *internal measurement* of a system that satisfies the QGL constraint. It is neither substance nor property but *process*: a specific dynamical operation within the GFF ledger. The mind–body problem is dissolved because the question assumed a gap between physics and experience that the EIC framework shows does not exist.

“What is the relationship between the arrow of understanding and the second law?”

The second law of thermodynamics says that entropy increases in closed systems — a result sharpened by the nonequilibrium work relations of Jarzynski (1997) and the fluctuation theorems

of Crooks (1999). The arrow of understanding says that QCI increases along the GSSB cascade. These two arrows point in the same direction but describe different quantities.

The connection is through the GFF ledger. In a system with no information processing ($J_{Qi} = 0$), the GFF descent reduces to the standard second law: free energy decreases, entropy increases. In a system with active information processing ($J_{Qi} \neq 0$), the full QGL applies, and the system can maintain local order (low entropy) while increasing global entropy — because the GFF ledger tracks all four currents, not just energy and entropy.

The arrow of understanding is therefore not a violation of the second law. It is a *consequence* of the full GFF descent applied to systems that satisfy the QGL constraint. The second law is the special case; the arrow of understanding is the general case.

B Summary of Abbreviations

Table 1: Abbreviations used throughout this paper and the GUT-10/GG-6/GDOS series.

Abbrev.	Meaning	Notes / where used
AX	Axiom	Constitutional primitive (AX-1 through AX-4).
BFFT	Bynally Fractal Fourier Transform	Multiscale temporal hierarchy in Qi-HAL.
BI-6	Modified Bianchi Identity (6D)	The geometric consistency identity of GG-6.
CPTP	Completely Positive Trace-Preserving	Quantum admissibility for open evolution.
DGI	Dynamical Gauge Invariance	First stage of the universal runtime pipeline.
GFF	Geometric Free-Energy Functional	Universal cost functional; $F_{\text{GFF}} = F_{\text{GEP}} + F_{\text{CEP}}$. Reduces to Gibbs ($J_{Qi} = 0$) or Friston ($J_{Qi} \neq 0$).
GEP	Gauge-Geometry Energy Principle	Energy sector of the GFF: curvature, gauge potentials, holonomy.
CEP	Curvature-Entropy Principle	Entropy sector of the GFF: KL divergence from geometric reference density.
EIC	Evolving Inner Cosmos	Closed-loop OH + IH coupling; geometric ground state.
FEP	Free Energy Principle	Friston’s principle; a boundary sector of Qi-EP.
GA	Geometric Attractor	Third stage of the universal runtime pipeline.
GDOS	Geometric Dynamics of Open Systems	Boundary runtime derived from AX-3/OGGEP.
GFF	Geometric Free-Energy Functional	Cost functional governing open-system descent.

(continued)

Abbrev.	Meaning	Notes / where used
GG-6	Geometry–Gauge Locking (6D)	The six-dimensional bulk theory.
GGEP	Geometry–Gauge Equivalence Principle	AX-2; geometrization of gauge structure.
GKLS	Gorini–Kossakowski–Lindblad–Sudarshan	Generator form for Markovian CPTP evolution.
GSSB	Geometric Spontaneous Symmetry Breaking	Second stage of the universal runtime pipeline.
GUT-10	Grand Unified Theory of 10 Sciences	Constitutional axiom system (AX-1 through AX-4, POS-1 through POS-7).
HAL	Hierarchical Attractor Landscape	Memory architecture in Qi-HAL.
IH	Inner Hologram	Brain’s allocentric world-model.
LC	Locality and Causality	AX-1.
MEPP	Maximum Entropy Production Principle	Historical heuristic; subsumed by Qi-EP.
MePMoS	Measure–Predict–Move–Store	Four-component cycle of adaptive open systems.
MSMF	Maximum Symmetry, Minimum Freedom	AX-4; forbids hidden continuous parameters.
NHT	Nested Holographic Transform	Hierarchical scale structure in Qi-HAL.
OGGEP	Operational/Open GGEP	AX-3; bulk-to-boundary measurement dictionary.
OGN-5	Occam Gauge Normalization integers	$(M, N, L; J, K) = (1, 3, 5; 7, 35)$.
OH	Outer Hologram	Lawful projection from 6D bulk to boundary observations.
PLA	Principle of Least Action	Closed-system sector of Qi-EP.
POS	Postulate	Constitutional refinement (POS-1 through POS-7).
QCI	Qi-HAL Completeness Index	Quantitative metric for degree of consciousness.
QGL	Quadruple Gauge Locking	The Arisaka Equation; Qi-QUA constraint.
Qi-CON	Qi-Connectivity	Multiscale diagnostic pillar.
Qi-EP	Qi-Extremal Principle	Variational selector pillar.
Qi-HAL	Qi-Hierarchical Attractor Landscape	Memory/architecture pillar.
Qi-QUA	Qi-Quadruple-lock	Current-locking pillar (Arisaka Equation).
Q_B	Arisaka Constant	Biological energy quantum = 15.0 kJ/mol.
SeOS	Selfish Open System	Formal class of living systems; echoes Dawkins’s “selfish gene.” A system that actively maintains its own viability under the QGL constraint.

(continued)

Abbrev.	Meaning	Notes / where used
SIP	System Instance Packet	Minimal input data for a GDOS system.
SM	Standard Model	Of particle physics; comparison baseline.

C Glossary of Key Symbols

Table 2: Key symbols used throughout this paper, with typical context.

Symbol	Meaning	Typical context
M_6	Six-dimensional bulk manifold $M_4 \times I_r \times S_\theta^1$	GG-6 stage
M_4	Four-dimensional boundary (observed world)	GDOS boundary
r	Holographic radial coordinate = $\ln(E_{\text{GUT}}/\mu)$	RG scale direction
θ	Compact sixth dimension	Wilson–Hosotani holonomy
B_2	Green–Schwarz two-form tensor field	Single mediator in BI-6
H_3	Field strength of B_2 ($dB_2 + \text{CS}$)	BI-6 identity
X_4	BI-6 four-form	$dH_3 = X_4$
I_8	Anomaly eight-form	$I_8 = \frac{1}{2}X_4^2$
F_5	SU(5) field strength	Non-Abelian gauge sector
F_B	U(1) _B field strength	Baryonic gauge sector
F_{Qi}	U(1) _{Qi} field strength	Informational gauge sector
R	Riemann curvature two-form	Gravitational sector
$(M, N, L; J, K)$	OGN-5 integers = (1, 3, 5; 7, 35)	All normalization freedom
Q_B	Arisaka Constant = 15.0 kJ/mol	Biological energy quantum
J_e	Electromagnetic current	Arisaka Equation
J_B	Baryonic current	Arisaka Equation
J_{Qi}	Informational current	Arisaka Equation
J_E	Energy current	Arisaka Equation
$\mathcal{F}_{\text{GFF}}$	Geometric Free-Energy Functional	Open-system dynamics
F_{GFF}	Geometric Free-Energy Functional	$= F_{\text{GEP}} + F_{\text{CEP}}$; universal cost functional
F_{GEP}	GEP sector of GFF	Gauge-geometry energy: curvature + potentials + holonomy
F_{CEP}	CEP sector of GFF	Curvature-entropy: $\epsilon_{\text{eff}} D_{KL}(p p_{\text{ref}})$

(continued)

Symbol	Meaning	Typical context
$\mathcal{F}_{\text{EIC}}$	EIC Lyapunov functional	OH–IH mismatch + costs
$\delta_{\text{rec}}^{(t)}$	Reconstruction divergence $D_{KL}(p^{\text{OH}}\ p^{\text{IH}})$	EIC quality metric
$H_{\text{out}}^{(t)}$	Outer Hologram at time t	Boundary observations
$H_{\text{in}}^{(t)}$	Inner Hologram at time t	Internal world-model
E_t	Evolving Inner Cosmos at time t	OH + IH = EIC
$\rho_{\text{IH}}^{(t)}$	Internal state on the IH manifold	Consciousness definition
$\rho_{\text{sel}}^{(t)}$	Selected conscious content	After DGI–GSSB–GA
$\mathcal{S}_{\text{DGI}}$	DGI exploration operator	Pipeline stage 1
$\mathcal{S}_{\text{GSSB}}$	GSSB selection operator	Pipeline stage 2
$\mathcal{S}_{\text{GA}}$	GA stabilization operator	Pipeline stage 3
E_{GUT}	GUT energy scale $\sim 2 \times 10^{16}$ GeV	UV endpoint of GG-6 throat
E_{Pl}	Planck energy $\sim 1.22 \times 10^{19}$ GeV	Gravitational reference
K	Throat depth integer = 35	Warp factor e^{-K}
G_N	Newton’s gravitational constant	Only measured input

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All scientific concepts (especially the foundation of the GUT-10 Axiom System, GGEP/GG-6/BI-6, and OGGEp/GDOS/Qi-4-Pillars), theoretical judgments, physical interpretations, and any remaining errors are the sole responsibility of the author.

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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.

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.

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.

K. Arisaka. *Axiom System of GUT-10 (Grand Unified Theory of 10 Sciences)*, UCLA-Arisaka/GG-2026-1 (2026).

Relevance. Establishes the four axioms (LC, GGEP, OGGEP, MSMF) and seven postulates of the GUT-10 constitution — the foundational document of the entire programme. 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-6 + GDOS), eliminating the landscape of free parameters that plagues other unification approaches. Every result in the present paper traces back to these eleven constitutional clauses.

K. Arisaka. *GG-6: Geometry–Gauge Locking at Warped 6D Bulk*, UCLA-Arisaka/GG-2026-2 (2026).

Relevance. Derives the six-dimensional GG-6 stage — the warped bulk manifold $M_6 = M_4 \times I_r \times S_\theta^1$ with gauge group $SU(5) \times U(1)_B \times U(1)_{Qi} \times \text{Gravity}$ — from the GUT-10 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.

K. Arisaka. *Anomaly Freedom of BI-6: The Quantum Consistency of GG-6*, UCLA-Arisaka/GG-2026-3 (2026).

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.

K. Arisaka. *GDOS: Boundary Dynamics and Open-System Emergence from GG-6*, UCLA-Arisaka/GG-2026-4 (2026).

Relevance. Derives the GDOS boundary dynamics from the OGGEF 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.

K. Arisaka. *GDOS Qi-4 Pillars: GFF, SIP, Qi-HAL, and the Runtime of Open Systems*, UCLA-Arisaka/GG-2026-5 and GG-2026-6 (2026).

Relevance. Derives the Qi-4 Pillars — Qi-QUA (current locking), Qi-EP (extremal principle), Qi-CON (multiscale connectivity), and Qi-HAL (memory architecture) — and introduces the DGI–GSSB–GA universal runtime pipeline. The GFF (Geometric Free-Energy Functional), the SIP (System Instance Packet), and the SeOS (Selfish Open System) classification are developed here. The Arisaka Equation $J_E/Q_B = J_e = J_B = J_{Qi}$ is derived in its canonical form, and the biological energy quantum $Q_B = 15.0$ kJ/mol is identified as the universal currency of cellular energy transactions.

K. Arisaka. *Derivation of the Standard Model Parameters from GG-6/GDOS*, UCLA-Arisaka/GG-2026-7 (2026).

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 $\hat{\alpha}_{\text{EM}}^{-1} = 2^7 = 128$ at the Z pole, $\sin^2 \theta_W = 25/108$, and $v = M_{\text{lock}}(2/5)^3 \approx 246.3$ GeV. Every prediction is compared with the measured value, and all pulls are below 1.0.

K. Arisaka. *TeV-Scale Inflation, Kaxion Dark Matter, and Standard Cosmology from GG-6*, UCLA-Arisaka/GG-2026-8 (2026).

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-6/GDOS engine, 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 $\rho_\Lambda \sim (M_{\text{lock}} e^{-K})^4 \sim (\text{few meV})^4$. Inflation is TeV-scale slow-smooth radion inflation on a warp-flattened plateau, predicting tiny primordial tensor modes. The Kaxion dark matter candidate

has two normalization branches (raw condensate at $\sim 0.4 \mu\text{eV}$ and mixed laboratory eigenstate at $\sim 19 \mu\text{eV}$) with a twin-peak spectral signature split by $\Delta\nu/\nu = 1/35$. 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.

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 $U(1)_{Q_i}$ 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.

J. S. Bell and R. Jackiw. A PCAC puzzle: $\pi^0 \rightarrow \gamma\gamma$ 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.

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 $E_{\text{Ry}} = 13.606 \text{ eV}$, 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 $K = 35$.

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 cancelled 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.

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.

F. H. C. Crick. *The origin of the genetic code*, *Journal of Molecular Biology* **38** (1968) 367–379.

Relevance. Coined the term “frozen accident” for the genetic code, arguing that the specific mapping from 64 codons to 20 amino acids was established early in the history of life and preserved by the enormous cost of changing it. The GG-6 framework challenges this explanation: the 4-base alphabet and triplet code are not contingent but geometrically necessary, forced by the QGL constraint as the unique minimum-freedom solution. Any independently evolved genetic code — on Earth or elsewhere — must converge on the same architecture, because the constraint is geometric, not historical.

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.

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.

R. Dawkins. *The Selfish Gene*. Oxford University Press (1976).

Relevance. Dawkins popularized the gene-centred 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.”

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 $U(1)_{Q_i}$ 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_{Q_i} a conserved, quantized current on the same footing as electric charge and baryon number.

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.

J. L. England. Statistical physics of self-replication. *Journal of Chemical Physics* **139** (2013) 121923.

Relevance. England showed that self-replicating systems are thermodynamically favoured in the presence of energy sources, because they are exceptionally efficient at dissipating energy and producing entropy. 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.

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 $\mathcal{F}_{\text{EIC}}$ 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 $J_{Q_i} \neq 0$, Markov-blanket-equipped sector of the more general Qi-EP.

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 ($U(1)_B$ 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 $L = 5$.

S. L. Glashow. Partial-symmetries of weak interactions. *Nuclear Physics* **22** (1961) 579–588.

Relevance. Glashow proposed the $SU(2) \times U(1)$ 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.

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 descendant of this mechanism: the same mathematical structure (factorized anomaly polynomial, tensor counterterm) operates in six dimensions with the gauge group $SU(5) \times U(1)_B \times U(1)_{Qi}$, producing the Arisaka Equation instead of the string-theory gauge groups.

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 TeV-scale slow smooth inflation that differs from Guth’s GUT-scale inflation in energy scale, mechanism, and observational signatures, while achieving the same resolution of the cosmological puzzles.

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.

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).

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 holographic 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.

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 $\mathcal{Z}_{\text{EIC}}[J_i] =$

$\mathcal{Z}_{\text{external}}[J_i]$ is Hegel’s Absolute Spirit stated as a functional convergence theorem. The GSSB cascade, with its ten 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.

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.

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 programme 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.

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 OGGEF dictionary, and the Outer Hologram (OH) is the formal realization of ’t Hooft’s idea applied to all physical measurements.

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 QCI ladder measures the depth and richness of the attractor landscape.

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.

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_θ^1 , 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.

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.

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.

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 $M_6 = M_4 \times I_r \times S_\theta^1$ is a modern descendant of Kaluza’s construction, extended from five to six dimensions and from electromagnetism to the full $SU(5) \times U(1)_B \times U(1)_{Qi}$ gauge group.

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.

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.

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-6/GDOS framework 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.

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.

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 $\sim 13\text{--}14 k_B T$ 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.

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 agrees that energy is central but goes further: the specific energy quantum $Q_B = 15.0$ kJ/mol is not contingent on local geochemistry but is derived from the OGN-5 integers, meaning that any energy source capable of delivering multiples of Q_B will drive the GSSB cascade toward life.

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.

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 warped bulk projects onto a four-dimensional boundary through the OGGEF 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.

S. L. Miller. *A production of amino acids under possible primitive Earth conditions*, *Science* **117** (1953) 528–529.

Relevance. Demonstrated that amino acids — the building blocks of proteins — can be synthesized from simple gases (methane, ammonia, hydrogen, water) under conditions simulating the early Earth’s atmosphere. Miller’s experiment showed that the molecular precursors of life are not rare cosmic accidents but inevitable products of prebiotic chemistry. In the GG-6 framework, Miller’s result is a laboratory confirmation of the GSSB-2 transition: given energy gradients and simple molecules, the QGL constraint drives the system toward the specific organic building blocks that life requires.

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.

T. Nakagaki, H. Yamada, and A. Tóth. *Maze-solving by an amoeboid organism*. *Nature* **407** (2000) 470.

Relevance. Nakagaki showed that the slime mold *Physarum polycephalum* can solve mazes and find shortest paths, demonstrating that sophisticated information processing does not require a nervous system. In the GG-6 framework, this is expected: the QGL constraint operates at every level of the GSSB cascade, and even single-celled organisms maintain a proto-IH (internal gradient map) and execute a simple MePMoS cycle. The slime mold’s maze-solving is a low-QCI instance of the same geometric logic that produces human consciousness at high QCI.

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 programme from closed mechanical systems to all open systems, including life and consciousness.

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.

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 $QCI \sim 8$ level. Place cells implement the latent manifold $\mathcal{Z}$ of Definition 6.2: a world-centred coordinate system that factors out self-motion and allows the animal to navigate, remember, and plan.

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 $\rightarrow$ Physics), the DGI–GSSB–GA cascade produces consciousness (Physics $\rightarrow$ Mind), and the EIC is the brain’s progressive reconstruction of the 6D geometry (Mind $\rightarrow$ Mathematics). No quantum-gravity speculation is needed.

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 $Q_B = 15.0$ 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).

J. Polchinski. *String Theory* (Vols. 1–2). Cambridge University Press (1998).

Relevance. Polchinski’s textbook is the standard reference for string theory, including the Green–Schwarz anomaly cancellation mechanism, D-branes, and the string landscape. GG-

6 shares the anomaly-polynomial technology of string theory but differs in five ways: no supersymmetry, no fundamental strings, GUT-scale rather than Planck-scale completion, a unique solution rather than a landscape, and scope extending to life and consciousness.

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, $Q_B = 15.0$ kJ/mol, 4-base DNA) and by constitutionalizing falsifiability as POS-7 (Measurement and Falsifiability) within the GUT-10 axiom system.

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.

L. Randall and R. Sundrum. *A large mass hierarchy from a small extra dimension*, *Physical Review Letters* **83** (1999) 3370–3373.

Relevance. Proposed a warped 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 $r = \ln(E_{\text{GUT}}/\mu)$ is the GG-6 version of the Randall–Sundrum warp factor.

M. Schlosshauer. Decoherence, the measurement problem, and interpretations of quantum mechanics. *Reviews of Modern Physics* **76** (2005) 1267–1305.

Relevance. Schlosshauer’s review clarifies the role of decoherence in resolving the measurement problem and compares the major interpretations of quantum mechanics. The GG-6 framework adopts decoherence as the physical mechanism behind the GSSB selection (the system decoheres into a preferred branch), and AX-3 (OGGEP) eliminates the need for a separate “measurement postulate” by constitutionalizing the observation process.

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.

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 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).

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_{Q_i} current: the DNA information content $I_{\text{DNA}} = 2$ 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 $U(1)_{Q_i}$ elevates Shannon’s abstract concept to a conserved physical quantum number.

H. A. Simon. The architecture of complexity. *Proceedings of the American Philosophical Society* **106** (1962) 467–482.

Relevance. Simon showed that complex systems in nature are nearly always organized hierarchically, and that this hierarchical organization is not accidental but a necessary consequence of the dynamics of assembly. The Five-Story Pagoda and the NHT (Nested Holographic Transform) of the GG-6 framework are the mathematical realization of Simon’s observation: hierarchical organization is forced by the QGL constraint, which requires that information be processed at multiple nested scales simultaneously.

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_{Q_i}) and matter (J_B) are not two separate substances but two projections of the single B_2 field through the OGGEF dictionary, exactly as Spinoza’s two attributes are aspects of one substance.

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 OGGEF dictionary maps bulk states to boundary observables, and the information content of any boundary region is bounded by the $U(1)_{Q_i}$ charge it carries.

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 QCI 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.

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 (QCI) 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.

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 QCI ~ 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.

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.

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.

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 $SU(2)_L \times U(1)_Y$ 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.

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” programme: 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 $U(1)_{Q_i}$ 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.

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 $SU(5) \times U(1)_B \times U(1)_{Q_i}$ of GG-6 determines which representations are admissible, and the OGN-5 integers determine their specific quantum numbers.

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.

W. H. Zurek. Decoherence, einselection, and the quantum origins of the classical. *Reviews of Modern Physics* **75** (2003) 715–775.

Relevance. Zurek’s programme of “quantum Darwinism” and einselection explains how classical reality emerges from quantum mechanics through the selective amplification of pointer states by the environment. In the GG-6 framework, Zurek’s einselection is a special case of the GSSB mechanism: the environment selects a preferred basis (the pointer basis) from among the gauge-equivalent quantum descriptions (the DGI orbit), and the selected basis is stabilized as a geometric attractor (GA).