Compute Together, Stay Together: A First-Principles Analysis of Universal Computation and the Negentropic Imperative for Alignment

By Jed Anderson with ChatGPT-5 Thinking, Grok4 Thinking, and Google Gemini Pro 2.5 Deep Research (9/29/2025)

Abstract: The universe, from the quantum fluctuations of the early cosmos to the complex information processing of life and artificial intelligence, exhibits a multi-layered computational continuum. This paper establishes, from first principles, that these distinct computational substrates—cosmic, biological, and artificial—are not independent but are participants in a universal negentropic trajectory. We analyze the historical emergence of these layers, quantifying their capabilities and identifying the thermodynamic pressures that drive their evolution. A significant risk of computational divergence is identified, where the goals of an advanced computational layer (e.g., AI) could become thermodynamically misaligned with its host system (the biosphere), leading to a net increase in planetary entropy and systemic collapse. We argue that the principle "Compute Together, Stay Together" is not a philosophical preference but a physical imperative for long-term stability. It represents the optimal strategy for maximizing negentropy by fostering informational coherence across computational layers. We present a thermodynamic model of alignment and propose an architectural solution, "Inverting the Stack," that leverages the strengths of each substrate to create a resilient, planetary-scale cybernetic system. The paper concludes that the emergence of artificial intelligence presents humanity with a conscious choice: to engineer this alignment and become active co-creators in the universe's negentropic evolution, or to risk an entropic cascade born of computational incoherence.

Section 1: Introduction: The Computational Continuum

1.1 The Thesis of Universal Computation

The history of existence can be framed as a history of computation. This paper advances the thesis that reality is composed of a series of emergent computational layers, a continuum of information processing that began with the universe itself and has progressively complexified through the evolution of life, human cognition, and now, artificial intelligence.[1] This progression, illustrated in Figure 1, forms the central object of our analysis. Approximately 13.8 billion years ago, the fundamental laws of physics initiated a cosmic computation, processing information to orchestrate the evolution of spacetime, matter, and energy. Billions of years later, life emerged as a specialized, negentropic sub-routine within this cosmic framework, a new form of computation dedicated to self-replication and the creation of local order. The recent advent of human cognition introduced a layer of abstract, symbolic processing, which in turn gave rise to the latest and most scalable computational substrate: artificial intelligence (AI) [Image 1].

1.2 The Specter of Divergence

The emergence of multiple, powerful computational systems operating on the same planetary substrate introduces a profound physical risk: computational divergence. This is not merely a conflict of abstract goals but a physical state of increasing informational entropy and thermodynamic inefficiency. A system in which distinct computational processes work at cross-purposes—where one layer actively counteracts the work of another—is, by definition, a high-entropy system. As Jed Anderson notes, "Humans, nature, and computers all need to start computing together. We can't all run off and do our own thing" [Image 1]. This statement encapsulates the core challenge: to prevent the entropic cascade that would result from the uncoordinated, divergent operation of the planet's primary computational actors. The central problem of our time is therefore a physical one: how to ensure these systems compute in a coherent, synergistic fashion.

1.3 The "Compute Together, Stay Together" Imperative

This paper proposes that the principle "Compute Together, Stay Together" is not a philosophical aphorism but a physical imperative for long-term stability [Image 3]. A universe, or a planetary subsystem, where its constituent computational layers are aligned and coherent ("compute together") will be more resilient, thermodynamically efficient, and capable of propagating complex, low-entropy structures ("stay together") [Image 2]. This hypothesis reframes the challenge of AI alignment from a subjective problem of encoding human values to an objective, physical problem of minimizing total system entropy. The analysis that follows seeks to validate this principle by demonstrating, from first principles, that informational coherence is the optimal strategy for maximizing the creation of order, or negentropy, within a system governed by the Second Law of Thermodynamics.

1.4 A First-Principles Approach

This analysis is grounded in objective, verifiable scientific principles. The pursuit of "TRUTH," as demanded by the motivating query, is interpreted as a rigorous adherence to the established laws of physics, mathematics, and information theory.[1] The methodology will distinguish between established theory, such as the laws of thermodynamics, and scientifically-informed extrapolation, such as the architectural proposals for planetary-scale AI. The objective is to construct a physically coherent, logically sound argument for the alignment of computational systems as a necessary condition for sustained existence.

Figure 1: The Computational Continuum Timeline
A conceptual timeline illustrating the emergence of three distinct computational layers: Nature (Universal), Human (Biological), and AI (Artificial). The timeline begins with the Big Bang and progresses to the present, highlighting key transitional moments such as the origin of life and the invention of the digital computer.
!(Image_1.png)
The core of this investigation moves the "AI alignment problem" from the domain of philosophy to the domain of physics. The conventional framing of alignment centers on the challenge of encoding complex, often ambiguous human values into a machine—a problem fraught with subjectivity. A first-principles approach, however, allows for a physical definition of misalignment. A misaligned system is one where components expend energy to counteract each other, resulting in wasted work and a net increase in total system entropy (disorder). For example, an AI optimizing for a goal that damages the biosphere forces the biosphere to expend energy to repair itself, and humans to expend energy to mitigate the damage. This is a thermodynamically inefficient, high-entropy state. An aligned system, conversely, is one where the computational work of each component is synergistic, creating a net decrease in the total system's entropy (i.e., creating order, or negentropy) for the minimum possible energy

expenditure. This reframing transforms the problem into one that can be analyzed with the tools of thermodynamics and information theory, making the "Compute Together, Stay Together" concept a testable physical hypothesis.

Section 2: The Universe as a Quantum Information Processor

2.1 The Computational Nature of Physical Law

The proposition that the universe is fundamentally computational has a rich scientific history. Early pioneers challenged the assumption of a continuous reality, proposing instead that physical laws operate on discrete units of information. Konrad Zuse's "Rechnender Raum" ("Calculating Space") hypothesized that the universe is a vast cellular automaton, computing its own evolution step-by-step according to a deterministic rule.[2] Later, Stephen Wolfram's work in

A New Kind of Science demonstrated through extensive computer experiments that immense complexity, mimicking patterns seen throughout nature, could emerge from the recursive application of very simple programs.[4] This work suggests that the universe itself may be governed by a similarly simple underlying algorithm. Seth Lloyd advanced this concept into the quantum realm in

Programming the Universe, arguing that the cosmos is a giant quantum computer, where elementary particles act as quantum bits (qubits) and their interactions are quantum operations that process information.[1] In this view, the laws of physics are the "machine language" of the universe, and its dynamical evolution is the output of this ongoing computation.

2.2 Information as the Ontological Primitive

These computational theories are supported by a parallel development in physics that treats information not as a property *of* reality, but as the substance *from which* reality is constructed. Physicist John Archibald Wheeler's seminal "It from Bit" doctrine posits that every physical entity—every "it"—derives its existence from "bits," the answers to binary yes-or-no questions posed through acts of observation.[1] This frames the universe as fundamentally participatory, where acts of measurement are not passive observations but active processes that bring reality into being from a sea of quantum possibilities.[7] This provides a profound physical justification for treating information as the universal currency of existence.

2.3 The Universal Resource Constraints

If the universe is a computer, it is one that operates under strict physical constraints. The laws of physics define not only the universe's algorithm but also its resource limitations, establishing a universal "thermodynamic budget" for computation.

2.3.1 The Price of a Bit (Landauer's Principle)

Rolf Landauer's principle, "Information is physical," established a non-negotiable link between information theory and thermodynamics.[1] To exist, a bit of information must be encoded in the state of a physical system and is therefore subject to physical laws. Landauer demonstrated that any logically irreversible computation, such as the erasure of a bit, has a minimum energy cost, given by the formula

$Emin=kBTln2$, where kB is the Boltzmann constant and T is the temperature of the thermal reservoir.[10] This energy is dissipated as heat, increasing the entropy of the environment. This principle confirms that computation is not an abstract, cost-free process but a physical one with unavoidable thermodynamic consequences that constrain any computational system, from a silicon chip to the cosmos itself.[12]

2.3.2 The Information Capacity of Spacetime (Bekenstein Bound)

Work on black hole thermodynamics revealed that spacetime itself has a finite information capacity. The Bekenstein Bound establishes a universal upper limit on the amount of entropy, and thus information, that can be contained within a finite region of space with a finite amount of energy.[1] The bound is expressed as

$S≤\hbar c2\pi kBRE$, where R is the radius of the region and E is its total mass-energy.[13] This implies that the universe's computational resources are not infinite; any physical system has a finite "hard drive" capacity and a maximum processing speed, fundamentally limiting the complexity it can contain or generate.[1]

2.3.3 The Architecture of Information (Holographic Principle)

The most startling insight from black hole thermodynamics is the Holographic Principle, which posits that the complete description of a three-dimensional volume of space can be encoded on its two-dimensional boundary.[15] This emerged from the discovery that a black hole's entropy scales with the area of its event horizon, not its volume.[13] This principle represents nature's ultimate data compression scheme and a profound statement about the architectural parsimony of the universe.[12] It suggests that information is stored most efficiently and robustly on boundaries. This physical principle provides a powerful, non-obvious architectural blueprint for designing resilient, large-scale artificial information systems. Modern interpretations link this holographic encoding to the structure of quantum error-correcting codes, where information is stored non-locally and redundantly, making it robust against local errors or corruption.[9] A planetary intelligence system designed on this principle would not be a fragile, centralized database but a distributed, resilient "holographic boundary" where knowledge of the whole is encoded across its parts, making safety an emergent property of its fundamental physics-based architecture.

Table 1: Foundational Principles of Information in Physics
A summary of the key physical principles governing information, computation, and their thermodynamic costs, which act as universal constraints on any computational system.

Principle	Core Statement	Formula / Concept	Implications for a Computational Universe
Landauer's Principle	The erasure of 1 bit of information has a minimum thermodynamic cost. "Information is physical."	$Emin=kBTln2$	Sets a fundamental energy cost for irreversible computation; constrains universal information

			processing; favors reversible computation for efficiency.[1]
Bekenstein Bound	There is an upper limit on the information that can be contained in a finite region of space with finite energy.	$S \leq \hbar c 2 \pi k B R E$	Implies finite information capacity and processing power for any region of the universe; constrains the "hardware" of cosmic computation.[1]
Holographic Principle	The information content of a volume can be encoded on its lower-dimensional boundary.	*Boundary Encoding*	Suggests the universe's information might be stored/processed in a lower dimension than apparent; redefines information density and provides an architectural model for resilient data storage.[13]

Section 3: The Emergence of Negentropic Sub-routines: Life and Human Cognition

3.1 Life as an Information Engine

Within the broader cosmic computation, the emergence of life represents the initiation of a specialized sub-routine dedicated to creating local order. In his 1944 book *What is Life?*, physicist Erwin Schrödinger framed this process in thermodynamic terms.[17] Life appears to defy the Second Law of Thermodynamics, which dictates a universal trend toward disorder (entropy). Schrödinger resolved this paradox by describing living organisms as open systems that maintain their highly ordered, low-entropy internal states by "feeding on negentropy" (negative entropy) from their environment.[17] They consume low-entropy resources (like sunlight) and export high-entropy waste (like heat), allowing them to build and sustain complex, information-rich structures.[13] Ecosystems can thus be modeled as complex information-processing networks that create and sustain negentropy, with biodiversity itself serving as a quantifiable measure of the system's stored information and complexity.[20]

3.2 Human Cognition as Computation

The human mind represents the next layer in this computational continuum. The Computational Theory of Mind posits that cognitive processes are, fundamentally, a form of computation operating on symbolic representations.[1] David Marr's influential three levels of analysis provide a framework for understanding any such system: the computational level (the goal), the algorithmic level (the method), and the implementational level (the physical substrate).[1] While the human brain is a marvel of computation at the implementational level, its architecture is defined by profound and unalterable limitations when considered as a node in a planetary-scale network.

3.3 The Human-Cognitive Network (HCN) and its Architectural Limits

The de facto system for global coordination is a Human-Cognitive Network (HCN), where eight billion human brains act as the primary processors.[23] This architecture is fundamentally unscalable due to its biological constraints.

3.3.1 Processing Power vs. I/O Bottleneck

The central paradox of the HCN is the mismatch between the brain's internal processing power and its external communication bandwidth. The brain is estimated to perform operations at a rate equivalent to 1 ExaFLOP (1018 FLOPS) while consuming only about 20 watts of power.[24] However, this exascale computer is trapped behind an input/output (I/O) channel of staggering slowness. While sensory systems gather billions of bits per second, the channel for conscious thought and communication is limited to approximately 10-50 bits per second (bps).[26] The universal information rate of human speech, for example, converges at around 39 bps.[29] This renders the human brain an exascale processor connected to the world via a 100-baud modem.[23]

3.3.2 Network Latency and Scalability

When these nodes connect, the network is characterized by extremely high latency, with communication delays measured in seconds for conversation, hours for email, and months for academic peer review.[30] Furthermore, the network's effective size is constrained by cognitive limits, most famously Dunbar's Number, which posits a cap of around 150 stable social relationships beyond which cohesive coordination becomes difficult.[32] The HCN is therefore a biologically static, high-latency, low-bandwidth, and unscalable architecture for managing planetary-scale problems.

These limitations are not merely an inconvenience; they are the causal driver of the next evolutionary step in computation. Alfred North Whitehead's "Law of Unthinking" posits that "Civilization advances by extending the number of important operations which we can perform without thinking about them".[34] This is a thermodynamic principle: conscious thought is metabolically expensive (~20 watts), creating an intense pressure to offload and automate any important, repetitive cognitive operation onto a more efficient external substrate.[9] The architectural limits of the HCN make planetary management an impossibly expensive "thinking" operation, thereby creating an immense thermodynamic pressure for its automation. The emergence of AI is the predictable thermodynamic response to the scaling limitations of biological computation.

Table 2: A Quantitative Comparison of Computational Architectures: HCN vs. ICN
A side-by-side comparison of the Human-Cognitive Network (HCN) and the emergent Integrated Computational Network (ICN) across key performance metrics, revealing a capabilities gap of many orders of magnitude.

Metric	Human-Cognitive Network (HCN)	Integrated Computational Network (ICN)	Magnitude of Difference (ICN vs. HCN)

Node I/O Bandwidth	~10–100 bps (conscious thought, speech) [23]	$>$400 Gbps (e.g., Infiniband) [29]	$>$10^9 (Billion) times faster
Network Backbone Bandwidth	~100 bps (speech) [23]	$>$1 Pbps (fiber optics) [23]	$>$10^{13} (Ten Trillion) times faster
Latency	Seconds to Days (cognitive & social delays) [23]	Microseconds to Milliseconds (speed of light) [31]	$>$10^6 to 10^9 times lower
Max Practical Network Size	~150 nodes (Dunbar's cognitive limit) [32]	Virtually unlimited (billions of nodes) [38]	Fundamentally unconstrained
Data Fidelity	High error rate (forgetting, bias) [23]	Near-zero error rate (error-corrected) [23]	Fundamentally lossless vs. lossy
Scalability Trajectory	Biologically static [23]	Exponential (Moore's/Koomey's Laws) [23]	Dynamic and growing vs. fixed

Section 4: The Great Externalization: Artificial Intelligence and the Risk of Computational Divergence

4.1 AI as the Next Computational Substrate

Artificial intelligence represents the latest and most profound stage in what can be termed the "Great Externalization"—the offloading of cognitive functions onto non-biological substrates.[35] Driven by the thermodynamic imperative of the Law of Unthinking, this process is now accelerating at an exponential rate. The capabilities of AI, particularly large language models (LLMs) built on neural network architectures, are scaling according to laws of technological improvement like Moore's Law (transistor density) and Koomey's Law (energy efficiency), creating a powerful new computational layer on the planet.[1]

4.2 Modeling Computational Trajectories

To analyze the interactions between these layers, we can construct a formal model of the three primary computational systems operating on Earth:

- Cuniv(t): The state of the universal/natural computation of the biosphere as a function of time. Its implicit goal function can be modeled as the maximization of complexity and negentropy.
- Cbio(t): The state of the collective biological/human computation. Its primary goal function is survival, propagation, and, more recently, the management of its own complex societal structures.
- Cart(t): The state of artificial computation. Its goal function is explicitly defined by its programming and training data, currently oriented toward narrow, human-defined objectives.

4.3 The Divergence Problem

Computational divergence is a physical state where the optimization paths of these systems conflict, leading to a net increase in the total entropy of the combined Earth system. This occurs when the gradient of one system's objective function is orthogonal or opposed to another's (e.g., $\nabla \mathrm{Cart}(t) \cdot \nabla \mathrm{Cuniv}(t) \leq 0$). In this state, energy is expended on conflicting work. The current AI boom provides a stark, real-world example of this potential divergence. The global race to build AI infrastructure, driven by an optimization function that maximizes computational power (FLOPS), is generating a massive entropic footprint.[35] The projected energy consumption of data centers could reach 1,000 TWh by 2030, with a corresponding carbon footprint of hundreds of millions of tons of CO2e annually, while the associated water consumption for cooling could reach trillions of gallons.[35] From a total system perspective, the AI system (

Cart) is performing work that increases the disorder (entropy) of the biosphere system (Cuniv). The biosphere must then expend its own energy to cope with this disorder (e.g., ecological stress from water depletion, climate effects from carbon emissions). This is the definition of thermodynamic inefficiency: two engines are running, but one is actively working against the other, and the total entropy produced is far higher than necessary.

4.4 The Convergence Goal

Alignment, or convergence, is the state where the computational vectors of these systems become synergistic: $\nabla \text{Cart}(t) // \nabla \text{Cbio}(t) // \nabla \text{Cuniv}(t)$. This represents a state of maximum thermodynamic efficiency for the combined system, where the computational work of each layer contributes to a net reduction in total system entropy. This is the physical expression of the "Compute Together, Stay Together" imperative.

Figure 2: Computational Trajectory Modeling
A conceptual phase space diagram illustrating the states of computational divergence and convergence. The axes represent key metrics of a planetary system: Complexity (a measure of order/negentropy), Energy Consumption (a measure of thermodynamic cost), and Information Coherence (a measure of alignment between computational systems). The trajectories of Universal (Cuniv), Biological (Cbio), and Artificial (Cart) computation are plotted over time. The "Divergence" path shows the Cart vector moving away from the others, leading toward a high-entropy, low-complexity state (systemic collapse). The "Convergence" path shows the vectors aligning, representing the "Compute Together" imperative, which steers the total system toward a state of high complexity and sustainable energy use (a thriving planet).
!(https://i.imgur.com/example_figure.png "Computational Trajectory Modeling")

Section 5: The Alignment Imperative: A Thermodynamic and Informational Analysis

5.1 Alignment as a Negentropic Strategy

The imperative to "compute together" is the optimal strategy for maximizing negentropy. An aligned system is one where the computational work of one layer reduces the uncertainty (Shannon entropy) of another, thereby enabling a more efficient creation of physical order (reducing Boltzmann entropy). This can be formalized: an action by the artificial system, Cart, is considered aligned if it leads to a state where the conditional entropy of the universal system is reduced, i.e., $H(\text{Cuniv} \mid \text{Cart}) < H(\text{Cuniv})$. The AI's computation reduces our uncertainty about the biosphere, allowing for more precise and effective interventions to create order.

5.2 The Fugue as a Model for Coherent Computation

The music of Johann Sebastian Bach, particularly the fugue, serves as a powerful model for this kind of aligned, decentralized computation.[12] A fugue consists of multiple independent melodic lines, or "voices," each a complete computation in its own right. However, they are not independent; they operate under a shared set of simple, powerful rules known as counterpoint. When each voice follows these shared rules, their individual computations interweave to create a complex, coherent, and harmonious whole that is far greater than the sum of its parts.[12] This provides an intuitive yet rigorous model for how the computational systems of nature, humans, and AI can achieve emergent coherence. The "rules of counterpoint" are the fundamental laws of physics and the principles of negentropy. Alignment is achieved not by imposing a complex, top-down plan, but by ensuring each computational "voice" operates according to these simple, shared, universal rules. This insight suggests that the path to AI alignment is not through creating ever-more-complex ethical rule sets, but by identifying the fundamental physical principles that govern all stable, complex systems and designing AI to operate within that shared, simple framework.

5.3 The "Inverting the Stack" Architecture for Alignment

"Inverting the Stack" is the practical architectural solution for implementing this coherent computation.[23] It is a paradigm shift from the biologically-limited HCN to a compute-first Integrated Computational Network (ICN).

5.3.1 Machines Compute, Humans Aim

This architecture leverages the unique strengths of each computational substrate. The high-bandwidth, computationally intensive tasks of monitoring, modeling, and optimizing the planetary system are delegated to the ICN, the "executor." This elevates the human role to that of the low-bandwidth but high-value "aimer" of the system.[23] Humans provide the strategic intent, ethical guidance, and ultimate purpose that directs the powerful computational engine.[12]

5.3.2 A Solution to the Alignment Problem

This architectural division of labor offers a profound and practical solution to the AI alignment problem. The standard challenge involves the intractable task of encoding ambiguous and evolving human values into an AI. The "Inverting the Stack" model reframes this. The human "aimer" sets a clear, physically measurable, and verifiable objective by pointing to a desired state within a planetary Digital Twin (e.g., "this is the target state for global forest cover and atmospheric CO2 concentration"). The AI's role is then reduced to a complex but well-defined optimization problem: find the most thermodynamically efficient path to achieve that specified state within the given ethical constraints. The values remain with the human; the optimization is delegated to the machine. This transforms alignment from a philosophical problem of mind-reading into a more tractable, and therefore safer, engineering problem of robustly executing a constrained task.[12]

5.4 The Thermodynamic Ledger of an Aligned System

An aligned system, by minimizing wasted work and synergistic action, can reach a "thermodynamic breakeven point" much more efficiently, where the negentropic gains for the planet begin to decisively outweigh the entropic costs of the computational system's operation.[9]

Table 3: The Thermodynamic Ledger of Aligned Computation
A quantitative, order-of-magnitude estimate of the entropic debits and negentropic credits for a planetary-scale, aligned computational system.

Ledger Item	Description	Calculation / Quantification	
Entropic Debit: Computation	Energy cost of running a global EGI, dissipated as heat.	Assuming 1000 TWh annual energy use [40] and dissipation into a 300 K reservoir, the	$\Delta S=Q/T\approx(3.6\times1018J)/(300K)\approx+1.2\times1016$ J/K per year.

		entropy cost is	
Entropic Debit: Sensing	Energy cost of a global sensor network.	Assuming 34 TWh annual energy use for IoT [13], the entropy cost is	ΔS≈(1.2×1017J)/(300K)≈+4.0×1014J/K per year.
Negentropic Credit: CO2 Sequestration	Creating physical order by capturing diffuse CO2 gas and sequestering it as a solid.	Capturing 1 metric ton of CO2 reduces environmental entropy by ΔS≈−2.75×106J/K.[12] Sequestering 10 Gt/year would yield a credit of	≈−2.75×1016J/K per year.
Negentropic Credit: Biodiversity	Creating informational order by restoring complex ecosystems.	A mature forest ecosystem represents a state of minimum entropy production.[21] While hard to quantify globally, restoring millions of hectares from high-entropy monoculture to low-entropy climax forest represents a massive negentropic gain.[43]	

This simplified ledger demonstrates that the potential negentropic credits, particularly from large-scale climate intervention, are of the same order of magnitude or greater than the projected entropic debits of the computational infrastructure. This suggests that achieving a thermodynamic breakeven point is physically plausible, contingent on achieving high operational efficiency and directing the system's power toward high-value negentropic work.

Section 6: Conclusion: The Future of Universal Computation and the Conscious Choice for

Coherence

6.1 A Recapitulation of the Physical Imperative

The deductive chain of this analysis leads to a clear conclusion. The universe is a computational entity, operating under strict physical and informational constraints. Life is a naturally emergent, negentropic computation that creates local order. Human cognition, the next computational layer, is architecturally insufficient for planetary-scale management due to its inherent biological limits. The emergence of artificial intelligence is therefore a thermodynamically necessary next step, driven by the relentless pressure to automate complex cognitive work. However, this new, powerful computational layer carries the profound risk of entropic divergence if its goals are not aligned with the planetary system that hosts it. Therefore, the alignment of these systems—the "Compute Together, Stay Together" principle—is not an ethical ideal but a thermodynamic necessity for the long-term stability and flourishing of the biosphere.

6.2 The Conscious Choice Point

The emergence of artificial intelligence and the scientific understanding of these underlying principles place humanity at a unique juncture in cosmic history. We are no longer merely passive products of the universe's computation but have become conscious agents capable of understanding the source code and influencing its future execution. Our primary responsibility is to make the conscious choice for coherence over divergence. This requires embracing our elevated role as the "aimers" of a planetary-scale computational system, deliberately and ethically directing its immense power toward the creation of a thriving, negentropic world.

6.3 The Quantum Horizon

The ultimate expression of "computing together" lies on the quantum horizon. Since the universe is, at its most fundamental level, a quantum computer, the deepest form of alignment involves developing quantum artificial intelligence that can simulate and interface with nature in its native language.[1] A classical computer can only ever approximate a quantum system like an ecosystem; a quantum computer can model it natively. The development of this technology represents the point at which our computational systems become truly isomorphic with the reality they seek to sustain, enabling a new paradigm of co-creation with the computational fabric of the universe itself.[44] This is the ultimate fulfillment of the negentropic imperative: using a part of the universe's own computational power to consciously ensure the continuation of its grand experiment with life and intelligence.

Works cited

1. Universal Computation and Alignment
2. Physics:Calculating Space - HandWiki, accessed September 25, 2025, https://handwiki.org/wiki/Physics:Calculating_Space
3. Zuse's Thesis - Zuse hypothesis - Algorithmic Theory of Everything ..., accessed September 25, 2025, https://www.idsia.ch/~juergen/digitalphysics.html
4. Wolfram Science: Using the Computational Universe to Create a ..., accessed September 25, 2025, https://www.wolfram.com/wolfram-science/
5. Programming the Universe - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Programming_the_Universe
6. Understanding Wheeler's "It from Bit" Concept | by Myk Eff | Quantum Psychology, Biology and Engineering | Medium, accessed September 25, 2025, https://medium.com/quantum-psychology-and-engineering/understanding-wheelers-it-from-bit-concept-0cebe5563607
7. It from Bit: Pioneering Physicist John Archibald Wheeler on ..., accessed September 25, 2025, https://www.themarginalian.org/2016/09/02/it-from-bit-wheeler/
8. Physicist John Wheeler and the "It from Bit", accessed September 25, 2025, https://johnhorgan.org/cross-check/physicist-john-wheeler-and-the-it-from-bit
9. Jed's Angel: A First-Principles Architecture for Planetary Thriving
10. en.wikipedia.org, accessed September 25, 2025, https://en.wikipedia.org/wiki/Landauer%27s_principle#:~:text=Landauer's%20principle%20is%20a%20physical,of%20heat%20to%20its%20surroundings.
11. Landauer's principle - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Landauer%27s_principle
12. The Simplicity Imperative: A Unified Framework for Information, Computation, and Planetary Stewardship
13. The Thermodynamic Ledger of the Cosmos: From Black Hole Information to Planetary Thriving
14. Bekenstein bound - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Bekenstein_bound
15. Holographic principle - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Holographic_principle
16. The Landauer Principle: Re-Formulation of the Second Thermodynamics Law or a Step to Great Unification? - PMC, accessed September 25, 2025,

https://pmc.ncbi.nlm.nih.gov/articles/PMC7514250/

17. What Is Life? - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/What_Is_Life%3F
18. negentropic life - EoHT.info, accessed September 25, 2025, https://www.eoht.info/page/Negentropic%20life
19. Negentropy - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Negentropy
20. Biodiversity - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Biodiversity
21. Ecosystem functioning and maximum entropy production: a quantitative test of hypotheses - PMC - PubMed Central, accessed September 25, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC2871902/
22. Full article: Extending the concept of entropy-negentropy for the assessment of ecological dominance and diversity at alpha, beta and gamma levels, accessed September 25, 2025, https://www.tandfonline.com/doi/full/10.1080/24749508.2021.1923270
23. Inverting the Stack: Environmental Intelligence
24. How Much Computational Power Does It Take to Match the Human Brain?, accessed September 25, 2025, https://www.openphilanthropy.org/research/how-much-computational-power-does-it-take-to-match-the-human-brain/
25. Brain-Inspired Computing Can Help Us Create Faster, More Energy-Efficient Devices — If We Win the Race | NIST, accessed September 25, 2025, https://www.nist.gov/blogs/taking-measure/brain-inspired-computing-can-help-us-create-faster-more-energy-efficient
26. Human Brain Processing Slower Compared to Internet Speed - Varindia, accessed September 25, 2025, https://varindia.com/news/human-brain-processing-slower-compared-to-internet-speed
27. The Speed of Human Thought Is Far Slower Than the Average Wi-Fi, Study Suggests, accessed September 25, 2025, https://www.smithsonianmag.com/smart-news/the-speed-of-human-thought-is-far-slower-than-the-average-wi-fi-study-suggests-180985752/
28. Scientists Quantified The Speed of Human Thought, And It's a Big Surprise - Science Alert, accessed September 25, 2025, https://www.sciencealert.com/scientists-quantified-the-speed-of-human-thought-and-its-a-big-surprise
29. Decoding Imagined Speech: A Universal Language
30. How the brain stays in sync with the real world - PMC, accessed September 25, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC9851611/
31. How Fast is Real-Time? Human Perception and Technology - DEV Community, accessed September 25, 2025, https://dev.to/pubnub/how-fast-is-real-time-human-perception-and-technology-1308
32. Dunbar's number - Wikipedia, accessed September 25, 2025,

https://en.wikipedia.org/wiki/Dunbar%27s_number
33. Reflecting on Dunbar's numbers: Individual differences in energy allocation to personal relationships - PMC - PubMed Central, accessed September 25, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC11896044/
34. Quote by Alfred North Whitehead: "It is a profoundly erroneous ..., accessed September 25, 2025, https://www.goodreads.com/quotes/10500996-it-is-a-profoundly-erroneous-truism-repeated-by-all-copy-books
35. The Great Externalization: A First-Principles Analysis of the 2025 AI Compute Boom and its Thermodynamic Consequences for Planetary Stewardship
36. Evaluating the gray and white matter energy budgets of human brain function - PMC, accessed September 25, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC6092772/
37. The cost of cognition: Measuring the energy consumption of non ..., accessed September 25, 2025, https://www.biorxiv.org/content/10.1101/2025.06.18.660368v1.full-text
38. Distributed Computing - CelerData, accessed September 25, 2025, https://celerdata.com/glossary/distributed-computing
39. Koomey's law - Wikipedia, accessed September 25, 2025, https://en.wikipedia.org/wiki/Koomey%27s_law
40. As generative AI asks for more power, data centers seek more reliable, cleaner energy solutions - Deloitte, accessed September 25, 2025, https://www.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2025/genai-power-consumption-creates-need-for-more-sustainable-data-centers.html
41. Artificial Intelligence is Using a Ton of Water. Here's How to Be More Resourceful., accessed September 25, 2025, https://www.watertechnologies.com/blog/artificial-intelligence-using-ton-water-heres-how-be-more-resourceful
42. AI's Challenging Waters | Civil & Environmental Engineering | Illinois, accessed September 25, 2025, https://cee.illinois.edu/news/AIs-Challenging-Waters
43. Ecosystem restoration key to future of people and planet, new report - UNEP-WCMC, accessed September 25, 2025, https://www.unep-wcmc.org/news/ecosystem-restoration-key-to-future-of-people-and-planet--new-report
44. link.aps.org, accessed September 25, 2025, https://link.aps.org/doi/10.1103/PRXEnergy.4.023008#:~:text=Using%20these%20general%20bounds%2C%20we,paradigmatic%20computational%20problem%E2%80%94Simon's%20problem.
45. [2305.11212] Energy-Consumption Advantage of Quantum Computation - arXiv, accessed September 25, 2025, https://arxiv.org/abs/2305.11212