From Information to the Quantum to Consciousness: How Life Has Always Been First

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Life is proposed as being more expansive in terms of reach and capability than currently understood. Aspects of life are presented suggesting it should be considered as a *distributed intelligence* that has established structures and designs in the realms of computation/information, memory/quantum mechanics, and even consciousness, before these realms were discovered by modern intelligent humans. The nature of consciousness is discussed in depth, referencing specific research including advances in *renormalization* techniques that imply consciousness exists at a fractal critical point in the brain and that consciousness is most likely fractal and holographic and exists on a space-time boundary where consciousness and memories are stored and operate external to the human mind, analogous to *cloud computing*. A "grande vista" of life conceptual framework is proposed noting life's progression of "existential leaps."

"Men argue. Nature acts."
-- Voltaire

Have scientists underestimated the omnipresence of life? Has human anthropocentrism led us to incorrect calculations of the reach and advanced capabilities of life on this planet? We know life for its variety, reach, and fecundity. Life has shown its flexibility and adaptability over eons of time. But what we often do not consider is its shared memory, most obvious in DNA, and also the fact that life has armies of "scouts," organisms that intentionally, and by random luck, end up at the limits of risk and experience, and at the frontiers of physical existence. On our planet we see form, change, growth, shocks, extinction, and survival at all costs. We see life as fundamentally resilient - over the benefit of any individual organism.

"I like mainly to be invisible, to sort of drift around unseen in the world."
--Anne Rice

Life is omnipresent, but it is also a phantom, an invisible shadow - and perhaps even a *distributed intelligence* - that moves at a pace almost too slow to imagine, a scale and variety too vast to ignore, and with a birth, origin, destiny, and age not yet fully comprehended.

In a world where scarcity inherently drives competition, we see life that "utilizes tools" like death rates, disease, photosynthesis, symbiosis, genders, parthenogenesis, and epigenetics, to optimize its gene pools. It is upon this conceptual framework that we will speculate and voyage into new frontiers.

We may consider humans as intelligent beings that evolved to survive and ultimately to rule over nature; how presumptuous. It is incredibly more likely that life has, via eons of "scouting" stumbled upon intelligence and, in environments where it is useful (demonstrably many), life uses it. Humankind is not a lord over nature but, rather, a vehicle via which life stores, tests, utilizes, and optimizes intelligence for the survival of, life.

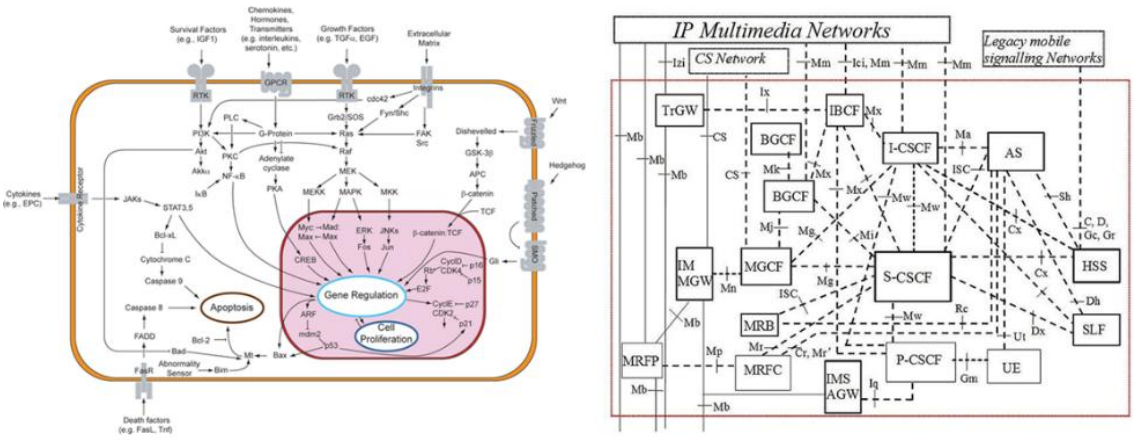
Life can be found in almost every ecosystem on this planet. It has evolved the ability to make use of the counterintuitive properties of the microscopic world. We need to look at life via more of an algorithmic and intelligent analogy. Life will "try" to make use of properties in any and every environment. With this perspective, we can then gain a better perspective on the realms of mind and consciousness. In almost every realm of complexity, we have evidence that life, versus human scientific research, has gotten there first.

There are aspects of life, often scrutinized as anthropomorphizing or *intelligent design*, that are better described as optimization. The similarity of design between cellular signaling structures and modern human telecommunications networks is an example of humans not seeking to copy nature but, regardless, ending up with a very similar structure, in the end, that life has utilized first (Figure 1).

"I moved in a direction I had never known existed… For a moment, the greed for knowledge forgot its place and demanded to be quenched… I saw a vastness that dwarfed any desert sky… Spread across the emptiness, streaming away from us with cavernous perspective in all directions and dimensions, encompassing lifetimes and hugenesses with each intricate knot of metaphysical substance, was a web. … The crawling infinity of colours, the chaos of textures that went into each strand of that eternally complex tapestry… It is complex to a degree that humbles the mind. It is a work of such beauty that my soul wept. It crawled with life."
-- China Miéville, Perdido Street Station[1]

Are there aspects of life, often labelled as anthropomorphizing or *intelligent design*, where in fact the analogy may indicate a common theme of optimization. Cellular signaling structures versus modern human telecom networks is an example of humans not seeking to copy nature, but ending up with a very similar structure in the end. Thus, are command and control paradigms emulating an actual intelligence or are these patterns - created or discovered first by life - more common than we believe? Might these be the sort of large and complex associations that an A.I. system can identify in large data sets? A tremendous new field of research is born here, where A.I. can examine patterns in the microworld like DNA, to the macroworld in environments like jungle ecosystems, and in both, over eons of time driven by evolution, to identify structures and associations not even imagined that life may have already discovered.

Figure 1. *The complexity and structure of signaling, command, and processing nodes in a living cell (left)*[2] *are remarkably similar to the far later architecture of modern human telecommunication networks (right)*[3]*. A proposed example of life discovering complex and advanced capabilities well before human intelligence.*



"DNA is like a computer program, but far, far more advanced than any software ever created."
-- Bill Gates

In so many categories of complex behaviors we see how life appears to have "gotten there first." DNA the foundation of life on our planet, is a literal computation and information processing analog. Electricity has been found to be used by life.[4] New fields investigate this phenomena including the fields of aerial electroreception and electrostatic ecology.[4] Max Levy notes in his 2024 online article in Quanta Magazine:

Invisibly to us, insects and other tiny creatures use static electricity to travel, avoid predators, collect pollen and more. New experiments explore how evolution may have influenced this phenomenon. …

> In 2013, Daniel Robert, a sensory ecologist at the University of Bristol in England, broke ground in this discipline when his lab discovered that bees can detect and discriminate among electric fields radiating from flowers. Since then, more experiments have documented that spiders, ticks, and other bugs can perform a similar trick… Studies by Víctor Ortega-Jiménez of the University of California, Berkeley revealed that a negatively charged spiderweb attracts positively charged insect prey.[4]

Animals have been shown to utilize quantum mechanics for navigation.[5] The leading theory behind the advanced navigation abilities of migratory birds is known as magnetoreception.[5] This "is the ability of animals to navigate using the inclination of the magnetic field of the Earth. A possible explanation for magnetoreception is the entangled radical pair mechanism."[5, 6, 7] The sense of smell has been associated with the act of quantum tunneling.[5] Plant life has been found to convert sunlight into energy using photosynthesis at near 100% efficiency and quantum superposition has been proposed as the mechanism used by plants.[5, 8, 9, 10, 11] Philip Ball in this 2018 article in *Physics World* references the work of Elisabet Romero of the Free University of Amsterdam:

> According to Romero, this tuning of molecular vibrations to the right frequencies for transferring energy makes the photosystem what she calls a "quantum-designed light trap." When you look at photosynthetic reaction centres for a range of organisms, she says, "there is only one design that is conserved, which suggests that nature has found a design able to perform efficient charge separation and has maintained it." In other words, she says, natural selection seems to have favoured this quantum-optimized process.[8]

With a new perspective on life's extensive capabilities and breadth of existence on our planet, we can now envision a conceptual framework describing - or matrix of the high-level phases of - the progression of life and intelligence in a quest to utilize and control major aspects of reality (Figure 2). We can separate our matrix of progression into five "existential leaps." Each leap is described by four attributes including: a) the explanatory theory underlying the leap, b) the associated mathematical concepts, c) how life appropriated the realm and the eventual associated human discovery, and d) the benefit, skill, or ability obtained from the realm's mastery. Note, per the matrix below, that quantum mechanics is not a literal predictive theory but, rather, its results are based on repeated experiments i.e., probabilities, a field which requires observations and *memory*.

Figure 2. *A conceptual framework presented as a matrix displays life's "existential leaps." We consider the possibility of the existence of a grande vista of life's progressive capabilities.*

#	Existential Leap	Explanatory Theory	Mathematical Concepts	Life's Appropriation / Human Discovery	Benefit / Skill / Ability
1	Space-Time	General Theory of Relativity	Change, Geometry	Structure, Motion, Birth/Death	Existence, Experience
2	Memory	Quantum Mechanics	Probabilities, Functions	Photosynthesis, Smell, Navigation, Brains, etc.	Stability, Copying, Compare, Learn, Optimize
3	Computation	Genetics	Algorithm, Data Storage, Information Theory, Signaling	DNA, RNA	Replication, Growth, Fecundity
4	Universe "boot code" (# 1, 2, and 3)	Simulation	Simulation, Calculus	Mind	Intelligence, Plan, Predict, Control, Communicate
5	Consciousness	Metaphysics	Fractals, Chaos, Complexity, Platonic Ideals	Holographic Memory, Subconscious, Eternal?	Consistent, Resilient, Self-Aware, Innovate, Transcend?

Based on the above conceptual framework or matrix of "existential leaps," we can propose that life, over eons of time, not only appropriated the ideas or resources of memory, computation, and signaling, but also the concept of *cloud computing* too, synonymous with resiliency and redundancy. We thus imagine a reality in our Universe with a space-time geometry of matter, energy, and forces leading to structure, change, and motion. With quantum mechanics comprised of "rules" and code synonymous with computational bits via identical particles, and observational results based on probabilities that require the key "tool" of memory. We can imagine the possibility that life appropriated these concepts, especially memory and computation, analogous to a "boot code" of the Universe, to create *minds* in physical brains.[12] Finally, we imagine life expanding via minds into the realms of fractal holographic memory on the boundary or horizon of space-time itself a la human information technology *cloud computing*. Everywhere that might life have ventured, or will venture next, is a fascinating area of speculation akin to a "grande vista" theory of life. Perhaps it is via human minds as a tool of life that some, or all, of the next existential leaps are made but, at least so far, it appears that, based on this framework, life has always gotten there first.

"Time is but memory in the making."
-- Vladimir Nabokov

The significance of memory and the lack of an exact definition of intelligence are critical topics often overlooked into today's research. Jeff Hawkins in his seminal 2005 book *On Intelligence* underscores the significance of memory:

> So how can a brain perform difficult tasks in one hundred steps that the largest parallel computer imaginable can't solve in a million or a billion steps? The answer is that the brain doesn't "compute" the answers to problems; it retrieves the answers from memory. …The entire cortex is a memory system. It isn't a computer at all.[13]

Hawkins describes his "Memory-Prediction" theory of intelligence in the brain where the human "mind (the neocortex) is constantly working to find patterns (structure) in sensory input." He notes how "identified patterns becomes memories and are: 1) stored as sequences of patterns, 2) classified or "named" in a hierarchy, 3) stored as invariant representations (fuzzy or flexible), and 4) recalled auto-associatively (fast) e.g., how when given only three musical notes, one is able to recognize an entire song."[13]

The observations of the behaviors and impact of life on this planet support the case for an expanded definition of intelligence. As Marcelo Gleiser notes in his 2025 *BigThink.com* article:

> A fresh view of intelligence - spanning living systems from bacteria to human civilization - challenges the idea that it's merely problem-solving. Traditional definitions of intelligence emphasize problem-solving ability, but a broader view suggests that intelligence is about how well a system connects, adapts, and thrives in its environment… Scientists and philosophers explored intelligence beyond the human mind, considering learning in bacteria, plants, and even ecosystems. Their conclusion: an integrated view of intelligence as distributed, relational, systemic, and deeply embedded in context: the ability of a system - be it a cell, a plant, a mind, or a civilization - to perceive, adapt, relate, and react within its context to ensure its viability, striving to remain alive and vibrant… The misguided belief that we can control natural forces through the development and application of new technologies - is a self-defeating illusion rooted in a distorted view of intelligence as efficient problem-solving.[14]

Modern research is now focusing on the idea of intelligence inherent to nature's process of evolution of life. Richard A. Watson and Eors Szathmary note in their 2016 research *How Can Evolution Learn?*:

> The theory of evolution links random variation and selection to incremental adaptation. In a different intellectual domain, learning theory links incremental adaptation (e.g., from positive and/or negative reinforcement) to intelligent behavior. Specifically, learning theory explains how incremental

> adaptation can acquire knowledge from past experience and use it to direct future behaviors toward favorable outcomes. Until recently such cognitive learning seemed irrelevant to the 'uninformed' process of evolution. In our opinion, however, new results formally linking evolutionary processes to the principles of learning might provide solutions to several evolutionary puzzles – the evolution of evolvability, the evolution of ecological organization, and evolutionary transitions in individuality. If so, the ability for evolution to learn might explain how it produces such apparently intelligent designs.[15]

Richard A. Watson and Eors Szathmary continue noting additional support for the idea of evolution as an intelligent process:

> A simple analogy between learning and evolution is common and intuitive. But recently, work demonstrating a deeper unification has been expanding rapidly. Formal equivalences have been shown between learning and evolution in several different scenarios, including: selection in asexual and sexual populations with Bayesian learning, the evolution of genotype–phenotype maps with correlation learning, evolving gene regulation networks with neural network learning, and the evolution of ecological relationships with distributed memory models. This unification suggests that evolution can learn in more sophisticated ways than previously realized and offers new theoretical approaches to tackling evolutionary puzzles such as the evolution of evolvability, the evolution of ecological organizations, and the evolution of Darwinian individuality.[15]

Consciousness vis a vis Cloud Computing

> *"Because the history of evolution is that life escapes all barriers. Life breaks free. Life expands to new territories. Painfully, perhaps even dangerously. But life finds a way."*
> *-- Michael Crichton, Jurassic Park*

Recent articles summarizing research noting the proclivity of *renormalization* techniques to solve brain self-organized criticality and *deep learning* could intimate that the challenges with finding a formal solution for quantum decoherence or even consciousness, could be chimeras if the human observed nature of reality itself are renormalizations of an infinite fractal space-time that is intractable with current techniques.

Two articles in 2014 by Jennifer Ouellette and Natalie Wolchover[16, 17] that reference renormalization and fractals in both Per Bak's famous paper on self-organized criticality[18] and Pankaj Metha and David Schwab's paper on A.I. deep learning[19], could be pointing to an even larger application of renormalization techniques in fundamental physics.

The mathematical technique called renormalization, in essence, raises analysis "up a level" to ignore infinities that prevent a quantitative solution. First, note this key passage from Oulette's article on the work of Per Bak and others uniting the concepts of self-organized criticality in the brain and renormalization:

> Through deep learning, there is also the hope of a better theoretical understanding of human cognition. Vijay Balasubramanian… noticed the conceptual similarity between renormalization and human perception. … the finding appears to support the emerging hypothesis that parts of the brain operate at a "critical point," where every neuron influences the network as a whole." In physics, renormalization is performed mathematically at the critical point of a physical system. … There may be an even deeper message in the new work… a hint that renormalization, deep learning, and biological learning fall under the umbrella of a single idea in information theory. All the techniques aim to reduce redundancy in data. Step by step, they compress information to its essence, a final representation in which no bit is correlated with any other.[16]

Also, consider this statement below from Oulette's article in the context of the collapse of the Schrödinger wave function upon a quantum system's observation or interaction with the environment:

> The brain is an incredibly complex machine. Each of its tens of billions of neurons is connected to thousands of others, and their interactions give rise to the emergent process we call "thinking." … the

> electrical activity of brain cells shift back and forth between calm periods and avalanches - just like the grains of sand in his sand pile - so that the brain is always balanced precariously right at that the critical point.[16]

Also, note these key passages on deep learning referencing fractals and renormalization from Wolchover's article on Mehta and Schwab's work:

> The new work... demonstrates that a statistical technique called *renormalization*, which allows physicists to accurately describe systems without knowing the exact state of all their component parts, also enables the artificial neural networks to categorize data as, say, "a cat" regardless of its color, size, or posture in a given video. Renormalization is a systematic way of going from a microscopic to a macroscopic picture of a physical system, latching onto the elements that affect its large-scale behavior and averaging over the rest. But a suite of sophisticated approximation schemes is required to slide up the distance scales, dilating the relevant details and blurring out irrelevant ones along the way. Mehta and Schwab's breakthrough came … when they decided to focus on a procedure called variational or "block-spin" renormalization... method involves grouping components of a system into larger and larger blocks, each an average of the components within it. The approach works well for describing fractal-like objects, which look similar at all scales, at different levels of resolution.[17]

Philosophical Implications

Notice how *renormalization*, as an approximation and methodology, is similar to Isaac Newton's use of the limit in Calculus as well as techniques created by Benoit Mandelbrot with fractal math.[20] Benoit Mandelbrot's famous paper *How long is the coast of Britain?* shows how fractal mathematical techniques are similar to the renormalization concept of "rising up a level" (e.g., an observer viewing a fractal) thus averaging out the coarse items to find higher order relationships for optimization of speed (reduction of calculation time) or to get a holistic "view," and ultimately a solution, for what seemed to be a problem hidden in infinities - as seen in the example for the approximate answer to the length of the coast line of Britain.

Thus, perhaps the similarities between the techniques used to solve fractals and renormalization intimate a deeper connection in nature. Could it be that the nature of the smallest units of space-time (let us say a theoretical Planck-length space-time "pixel", as opposed to a fundamental particle like an electron) is actually not a "square," in terms of its shape or dimension, but is, rather, a fractal shape. Would a space-time pixel that is fractal in nature possibly provide a sink-like surface area where gravity dilutes and is, thus, so comparatively "weak" compared to the other three fundamental forces in the Standard Model, as it diffuses into the "cracks" of the fractal nature of space-time? Perhaps reality itself is quantized in the sense of measurements, at a scale of a certain number of total bits or memory, follow quantum mechanics, while larger measurements or observations cross that threshold and, thus, require relativity theory to model them?

Scale Free Consciousness

Let us consider further the *scale free* or scale invariance aspects of self-organized criticality and the critical brain hypothesis.[21] At the *critical point* in the brain, the pattern of signals exists at every scale like a fractal. Self-organized criticality is defined as a property of dynamical systems where "[t]heir macroscopic behavior thus displays the spatial or temporal scale-invariance characteristic of the critical point of a phase transition, but without the need to tune control parameters to a precise value, because the system, effectively, tunes itself as it evolves towards criticality."[22] Woodrow L. Shew et al., noted in their 2009 research that "findings suggest that in the cortex, balanced excitation and inhibition establishes criticality, which maximizes the range of inputs that can be processed, and spontaneous activity and input processing are unified in the context of critical phenomena."[23] John M. Beggs, in his 2009 book *The Cortex and the Critical Point,* notes:

> One of the main consequences of being near a *critical point* is scale-free property. These are hypothesized to lead to optimal information transmission and also thought to optimize dynamic

> range, sensitivity to inputs, information storage, and computational power. Just being near the critical point will produce optimality over the scale of the brain.[24]

Now, let us make an analogy to modern Information Technology *cloud computing* where processing is done at a remote "compute" location and results transported back to a *user*. Theoretical physicist Dr. Leonard Susskind at Stanford University in his lecture on Quantum Gravity describes the Holographic Paradigm:

> A hologram is a two-dimensional mathematical representation of a three-dimensional portion of the world. … How do you take a three-dimensional thing and map it into two dimensions? Well, it's possible but it is always at the cost of the two-dimensional image looking like a random hash. … The information of what is in the hologram is in the bulk. The Holographic Principle states that the information encoding everything taking place in this three-dimensional world is encoded on the boundary of that region as a kind of quantum hologram.[25]

Some of the principles that drove the creation of cloud computing include its resiliency and redundancy. These are traits also common to life or gene pools focused on long-term survival. Thus, we might extend the analogy to brain criticality. Brains are optimized at the critical point and consciousness fades as the brain drifts away from it. Adam J. Eisen et al. note in their 2024 research in the journal *Neuron*:

> Thus, stability, and hence consciousness, needs to be understood in terms of a dynamic brain. Here, we approach the analysis of anesthetic unconsciousness through the lens of dynamic stability, a fundamental concept in dynamical systems theory and control. Essentially, dynamic stability is a measure of the robustness of a dynamical system. The system needs to be able to recover from disturbances (e.g., distractions, random fluctuations in activity) to its normal state.... We validated the model's estimates of changes in dynamic stability in systems for which the ground truth stability is known. We found that propofol-induced unconsciousness is associated with destabilized neural dynamics. ... Propofol disrupts the balance between cortical excitation and inhibition. This balance is known to be critical for maintaining the stability of cortical dynamics. Combined with our findings, this paints a picture in which propofol tampers with this balance, causing widespread cortical instabilities and thereby disrupting the brain's capacity for information processing. Overall, our analysis suggests a mechanism for anesthesia that involves destabilizing brain activity to the point where the brain loses the ability to maintain conscious awareness.[26]

At the critical point, signaling is *scale invariant* (fractal pattern going down to the smallest scale). Thus, might it be the case that life has found a "location" or mechanism for optimal information processing? Might it be the case that human consciousness does not actually lie inside our physical skulls but, rather, lies in the aforementioned quantum bulk boundary of the Holographic Paradigm? As Michael Brooks notes in a 2024 physics article in *New Scientist*, "the goings-on in space can be fully described by data held on the outer surface, or boundary, of that space, a phenomenon known as holographic duality."[27]

Is the real reason for the existence of *brain criticality* that it reaches a state of scale invariance at which point actual thought and intelligence, occurring at the bulk, is thus replicated or communicated "up the fractal ladder" to the scale of neurons in our physical world? Consider the comments from Dr Henry Markram of Blue Brain Project at the Swiss Federal Institute of Technology:

> If the changes that occur in the brain only make sense if you map them to a higher dimensional structure, then that's what you are going to have to do… Memory may be hiding in high-dimensional structures… there is a scientific possibility that what we are seeing and experiencing is a shadow projection from higher-dimensional representations… We need mathematics to climb up into those higher dimensions. Then we'll understand how those shadows emerge. Consciousness may be a shadow.[28]

The brain at its critical point, where all scales are identical fractals (i.e., synchronized), becomes synonymous with the definition of a "vertical" human data network telecommunications channel:

> When a continuous stream of fixed-length frames are sent, a synchronized receiver can in principle identify frame boundaries forever. In practice, receivers can usually maintain synchronization despite transmission errors; bit slips are much rarer than bit errors. Thus, it is acceptable to use a much smaller frame boundary marker, at the expense of a lengthier process to establish synchronization in the first place.[29]

If all particles and forces that create our reality can be encoded in a boundary, then why not consciousness as well? Colloquially this might imply that every consciousness is part of a single consciousness (the single boundary) and perhaps even add some merit to metaphysics as one's conscious *self* may already, and inherently, exist external to the physical world.

Metaphysics

We may consider life less as an "inventor" and more of an entity that commandeers, almost always, out of necessity. We can envision life with an ecosystem on planet earth that becomes increasingly large, diverse, complex, and intelligent, using whatever "tools" it can find for any competitive advantage e.g., neurons, memory, categorization and labelling, planning, learning, language, etc. Then we can imagine life seeking improvements on each of these including long-term memory, modeling, written language, and possibly even holographic and/or fractal memory as a fast, resilient, and perhaps abundant memory source.

We can speculate that it is the fractal structure that allows life to utilize yet another higher level tool or substrate. We can imagine life using fractal structures for not only optimal memory storage but, perhaps, also to access an ultimate memory or ultimate "library of libraries" akin to Carl Jung's *collective unconscious.*[30] There is an obvious analogy here between the self-similar and infinite regression of a fractal, and the recursive nature of consciousness where a mind can ask or ponder i.e., why it asks why it asks why. As Carl Jung stated in a lecture in 1936:

> My thesis then, is as follows: in addition to our immediate consciousness, which is of a thoroughly personal nature and which we believe to be the only empirical psyche (even if we tack on the personal unconscious as an appendix), there exists a second psychic system of a collective, universal, and impersonal nature which is identical in all individuals. This collective unconscious does not develop individually but is inherited. It consists of pre-existent forms, the archetypes, which can only become conscious secondarily and which give definite form to certain psychic contents.[31]

Jung also has claimed that the "unconscious has no time. There is no trouble about time in the unconscious. Part of our psyche is not in time and not in space. They are only an illusion, time and space, and so in a certain part of our psyche time does not exist at all."[32]

Note, to consciously experience and to *understand* appears to require more than just mechanical tools vis a vis neurons and a body. We can further speculate that just as A.I. gains its power from its ability to quickly and efficiently reference a massive database of historical information, perhaps the human *subconscious mind* gains the same from access to the ultimate "repository of experience" that may be stored in spacetime itself. Note that consciousness occurs in the brain, after anesthesia, only after the brain reaches the fractal critical point. We can imagine then a fractal link or "pipe" being created from our macroscopic world "all the way down" to the quantum Planck scale microscopic world.

But is there any evidence that the Universe is fractal at a fundamental microscopic scale? Modern theoretical research does support this claim.[33, 34, 35, 36] Oliver Lauscher et al. note in their 2005 paper:

> It is also shown that asymptotic safety implies that spacetime is a fractal in general, with a fractal dimension of 2 on sub-Planckian length scales. … The scale-free relation suggests that at distances below the Planck length the QEG spacetime is a special kind of fractal with a self-similar structure. … … This phenomenon is familiar from fractal geometry.[33]

Jan Ambjorn et al., note in their 2005 research how a "closer look at the quantum geometry reveals a number of highly nonclassical aspects, including a dynamical reduction of spacetime to two dimensions on short scales and a fractal structure of slices of constant time."[36]

Modern theoretical physics has also claimed that the universe is fundamentally holographic in nature with information perhaps stored on a two dimensional boundary.[37] Is this vision compatible with a fractal spacetime? Again, research appears to support a universe that is both fractal and holographic. Both holograms and fractals share the properties of self-similarity and of being able to encode information at different scales. Fractals exhibit self-similarity (their parts resemble the whole), while holograms encode information about an object's entire structure across different sizes or scales.[38] This similarity has led to the exploration of "fractal holographic principles," suggesting a possible holographic universe where information is encoded in fractal patterns.[38]

Mary Alexandria Kelly et al., in their 2013 research proposed the idea of human brains using holographic reduced representations (HRRs) or associate memory. They note:

> …a holographic associative memory is a computational memory based on the mathematics of holography. Holographic associative memory has been of interest to cognitive psychologists because: 1) associative memories are content-addressable, allowing items to be retrieved without search, in a manner similar to the fast, parallel retrieval of memories in the human mind. 2) just as human memory can store complicated and recursive relations between ideas, holographic associative memories can compactly store associations between associations. 3) holographic associative memories have what is called lossy storage, which is useful for modelling human forgetting. …The mathematics of holography has long been suggested as the principle underlying the neural basis of memory… HRRs have also been used to model how humans understand analogies and the meaning of words, how humans encode strings of characters, and to model how humans perform simple memory and problem-solving tasks.[39]

A key point of this essay is that life was not predestined to create conscious human minds. But, as the entire planet, ecosystem, gene pool, and human species evolved to the maturity and scale to permit it, and as competitive pressures drove the need for increased memory (and the need for increased intelligence), life, *scouting* and checking every corner, not only went far and wide, but also high and deep. We can speculate that "in the deep," a spark was found and then never lost. The fitness or performance advantage from an ability to comprehend and remember experiences (if not subconsciously "all" collective experience, a la Jung), thus led to the eventual success of humans over the other species on the planet.

If minds are fractal, or fractal and holographic, many open questions still remain. Has a microscopic consciousness or collective subconscious always existed? What is the exact process or protocol by which memories are stored as fractals? Can we observe, prove, or even change fractal or holographic memory storage in a brain and/or in spacetime? Can a machine be built to do the same? Does this model imply that a consciousness could exist after the death of a physical body or brain? Is there a limit to the amount of memory in spacetime? Could an increase in the amount of memory stored in a fractal spacetime be what is driving a Dark Energy expansion of the Universe? Regardless of the challenge or solution, we will likely find that life has been there first.

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