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The Beauty Deep Within: A Study on Some of the Similarities between the Microcosm and the Macrocosm

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Abstract*:* The present article seeks to study three striking similarities between the microcosmic world of the living systems and the grand, cosmic landscape. The opening section deals with the strange structural and morphological similarities between the peculiar architecture of the neuronal network and the gigantic cosmic web with its several interconnecting filaments of clustered galaxies. The second part of the study shall look at the similarities between the fine-tuned nature of the biological world and the fundamental laws that govern the cosmos to see whether there is really a coincidence between life's requirements and the universe's choices of parameter values. This part of the study will also try to see if the prerequisite conditions for the existence of complex life in our universe are a result of the special values of the parameters themselves or there is something else at play. The various fundamental constants that underlie our most trusted theories appear fine-tuned in the sense that if even a very tiny variation is traduced in them, life as we know it, most probably will never emerge in such a qualitatively different universe. The final section of the study will try to look at the mechanism of natural selection that is often hypothesized to be operating in both microcosm and macrocosm. Here, parallels between the black hole-generated baby universes where random variations in the fundamental physical constants are introduced, and the Darwinian method of incremental accumulation of variations through mutation and natural selection will be explored.

Keywords: Fine Tuning, neuronal network, cosmic web, black holes, DNA, gene, probability, string theory, cosmological natural selection, organized complexity, mutation and natural selection, the Darwinian paradigm, Intelligent Design.

Similarities between the Neural Network and the Cosmic Web:

The opening section of the study shall endeavor to study the strange and fascinating similarities to be found between two of the most complex systems in the entire, known cosmos – which are the neuronal network in the human brain and the network of galaxies in the physical universe. Astrophysicist Franco Vazza of the University of Bologna and neurosurgeon Alberto Feletti of the University of Verona have undertaken a detailed study of these similarities between two complex systems. It is the power of complexity and self-organization which seem to build up the similarities between two systems despite these two systems differing from one another by as much as 27 orders of magnitude. The human brain possesses some 86 billion neurons and the observance universe has some 200-400 billion stars. However, the cosmic web possesses as many as 100 billion galaxies. It is with the help of several interconnecting filaments of clustered galaxies and gases that the giant cosmic web is formed which is spread across the cosmos and separated by voids. Hercules–Corona Borealis Great Wall is known as the largest galaxy filament we know of with a length of

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approximately 10 billion light years and containing as many as several billion galaxies. While the Keenan, Barger, and Cowie (KBC) void with a dimeter of 2 billion light years is currently deemed to be the largest known void within a tiny segment of which resides our Milky Way galaxy and the solar system. However, once we start zooming out far enough the homogenous distribution of galaxies ends and we can suddenly see the chunks of galaxies scattered all across the universe randomly and this sudden vanishing of homogenous distribution of structures is dubbed by cosmologists as the End of Greatness. The human brain is a highly complex, multiscale structure where neurons seem to cluster into circuits and interconnected areas and it is this peculiar architecture of neuronal network which “allows the linking between different areas, all devoted to process specific spatiotemporal activities over their neurons, forming the physical and biological basis of cognition” (Vazza&Feletti, “The Quantitative Comparison between the Neuronal Network and the Cosmic Web”). Now, the task of dissecting the complex map of neuronal connections or the Connectome is a major challenge to neuroscience. Now mapping the entire neural connection in the brain is a highly complicated matter and even in the brain of a mouse there are as many as 70 million neurons. Biologist Sydney Brenner and his peers at the MRC Laboratory of Molecular Biology in Cambridge, UK, have mapped the neural circuitry of a *Caenorhabditis elegans.*Mapping neural circuitry of a very tiny, the one-millimeter-long worm, *Caenorhabditis elegans* in all its details with all the synaptic connections and fine branches took thirty years. It was in 1986 that the first full map of an animal’s entire synaptic connections or the first full animal ‘connectome’ was compiled. But, *Caenorhabditis elegans* has only some 400 neurons while the human brain possesses 86 billion of them. Now, mapping the mouse’s neural connections is an exponentially difficult task since a mouse has as many as 70 million neurons and the total size of the dataset can exceed one exabyte. An exabyte is equal to 1 gigabyte; the entire human genome can be encoded in a file size of up to 1.5 gigabytes. Jeff Lichtman, a neuroscientist at Harvard University in Cambridge, Massachusetts, is attempting to map the entire neural circuitry of a mouse. Scientists are still in pursuit of some organizingprinciple or a solid theoretical framework for transforming the raw brain data into fundamental knowledge and understanding. Today, despite there being a huge wealth of neuroanatomical and neurophysiological information available to most of us, we are very far from understanding mental processes which require us to understand the nonlinearities, hidden variables, and underlying mechanisms all of which continue to add to new levels of complexity. Human brain is both highly integrated and composite and any attempt from us to understand the brain in all its complexity will be fragmented and force us to construct different explanations for different aspects. Churchland and Abbott opine: “Global understanding, when it comes, will likely take the form of highly diverse panels loosely stitched together into a patchwork quilt” (“Conceptual and Technical Advances Define a Key Moment for Theoretical Neuroscience”). The 20th Century neuroscientist Karl Lashley warned us about the temptation of using machine-based metaphor for explaining the functionality of human brains. Lashley wrote, “Descartes was impressed by the hydraulic figures in the royal gardens, and developed a hydraulic theory of the action of the brain…We have since had telephone theories, electrical field theories and now theories based on computing machines and automatic rudders. I suggest we are more likely to find out about

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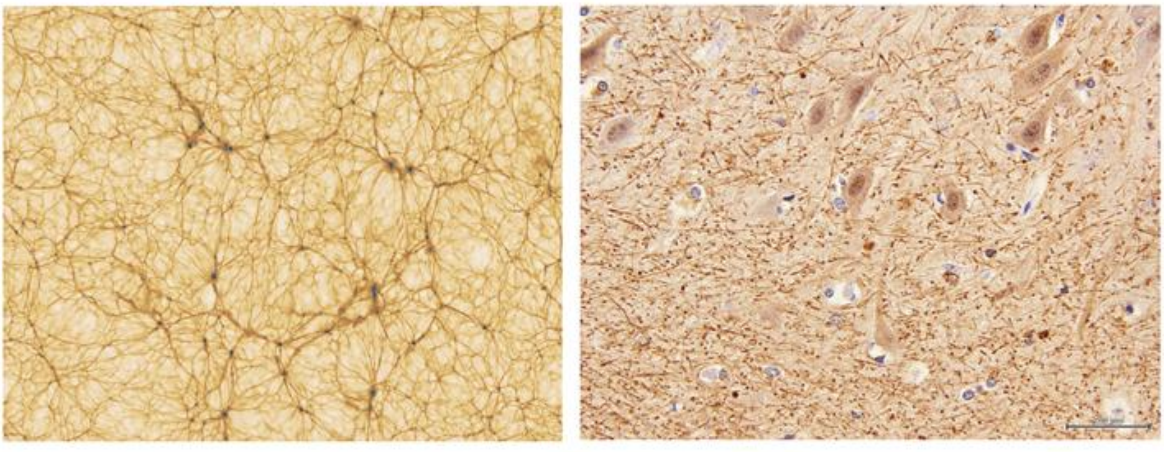
how the brain works by studying the brain itself, and the phenomena of behaviour, than by indulging in far-fetched physical analogies" ("Why Your Brain Is Not a Computer"). Hungarian neuroscientist GyörgyBuzsáki in his book *The Brain from Inside Out*, explains that brain should not be seen as a passive receptacle of information, rather it is a highly dynamic and complex organ which always searches for the best possible option among a vast projected assortment of alternative possibilities. It cannot be represented by bits of information, rather it is a constructor of novel information. American scientist Gary Marcus opines: "Computers are, in a nutshell, systematic architectures that take inputs, encode and manipulate information, and transform their inputs into outputs. Brains are, so far as we can tell, exactly that. The real question isn't whether the brain is an information processor, per se, but rather how do brains store and encode information, and what operations do they perform over that information, once it is encoded."

Now, interestingly, the study conducted by Vazza&Feletti have captured a strange structural and morphological similarity between the neuronal network and the network-like structure of web of galaxies. The study describes: "Although the relevant physical interactions in the above two systems are completely different, their observation through microscopic and telescopic techniques have captured a tantalizing similar morphology, to the point that it has often been noted that the cosmic web and the web of neurons look alike" (Vazza&Feletti, "The Quantitative Comparison"). Both these structures possess nodes which in case of cosmic web are galaxies whereas in case of neuronal network in the brain, they are the neurons themselves and both ultimately are connected by filamentous structures. In their 2017 article in *Nautilus*, Vazza&Feletti wrote":

"Galaxies can group into enormous structures (called clusters, superclusters, and filaments) that stretch for hundreds of millions of light-years. The boundary between these structures and neighboring stretches of empty space called cosmic voids can be extremely complex.Gravity accelerates matter at these boundaries to speeds of thousands of kilometers per second, creating shock waves and turbulence in intergalactic gases.We have predicted that the void-filament boundary is one of the most complex volumes of the universe, as measured by the number of bits of information it takes to describe it.This got us to thinking: Is it more complex than the brain?"("The Strange Similarity of Neuron and Galaxy Networks").



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Simulation of matter distribution in the cosmic web (left) and neuronal bodies in the cerebellum (right)

A picture showing a human neuron and a simulated galaxy cluster (Mark Miller/Virgo Consortium/Visual Complexity).

There is a common scale radius which is just a fraction of the length of the filaments in both the neurons in the human brain and the simulated galaxy clusters in the web, and of the total mass-energy content of each of those systems,the information and energy flow is only 25%.Another point to note is that while the brain is around 73% water (H.H. Mitchell, *Journal of Biological Chemistry* 158),the observable patch of ouruniverse is around 72 % dark energy. Both water and dark energy along with dark matter play an indirect role in molding the architecture of these systems, namely brain and galactic filaments respectively.

Now, Vazza and Feletti have also done a quantitative comparison between these two complex systems. They compared the slices of the cerebellum of the brain and the simulated images of the cosmic web and looked for similarities in the matter density fluctuations in these two systems. They obtained slices of the human cerebellum and cortex at differentmagnifications, and compared them to simulations of the cosmic web. To their amazement, they found that "…the relative distribution of fluctuations in the two systems was amazingly similar - although on much different scales" ("Study Maps the Odd Structural Similarities between the Human Brain and the Universe").

Fine-Tuned or Not?

The values of the fundamental constants of nature needed for a life-permitting universe to exist are found in an extremely narrow range, and sometimes it appears that something very intelligent has conspired before the universe came into being to give rise to the range of parameters which later helped life to flourish in a tiny corner of the Universe. Among such parameters or constants that are important in the universe are the masses and charges of electrons and protons, four-dimensional nature of our space-time, the Higgs vacuum expectation value which is fine-tuned to some 10^{-17}, the constraint placed on the fine structure constant by triple alpha process to 10^{-5}, the value of gravitational constant, value of cosmological constant being fine-tuned to 10^{-120}, fine tuning of entropy in the universe etc. to name a few. Paralleling this kind of fine tuning in the cosmic landscape there is also a fine

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tuning in the biological world. As Duane Gish (1976) stated, “The time required for a single catalytically active protein molecule to arise by pure chance would be billions of times the assumed age of the earth.”If we assume that each of the amino acid sequences in a protein must definitely be filled by the one specific amino acid most suitable for that sequence, then a simple calculation for20 different amino acids available for each sequencegives us the probability of randomly deriving a string of 200 amino acids in the perfect order is $1/20^{200}$. There is a huge difference between the strength of gravitational interaction and electromagnetic interaction, and this can be illustrated through the example of a proton-sized micro black hole which would have a mass of some 10^{38} protons, which is of the order of the gravitational coupling constant pegged at a value of 5.9×10^{-39}. To properly address the nature and origin of fine tuning of constants, we need to explore the physics of matter at the Planck scale where the Planck length can be thought of as the size of a black hole whose Compton wavelength matches its Schwarzschild radius. For delving into the physics at Planck scale, we need a theory of Quantum Gravity. A whole host of eminent physicists have wondered at the fine-tuned nature of our creation: Carter (1974), Carr& Rees (1979), Barrow & Tipler (1986), Ellis (1993), Weinberg (1994), Wheeler (1996), Rees (1999), Harrison (2003), Penrose (2004), Susskind (2005), Tegmark et al. (2006), Vilenkin (2006), Davies (2006), Dawkins (2006), Guth (2007), Smolin (2007), Linde (2008), Polkinghorne & Beale (2009), Hawking &Mlodinow (2010), Greene (2011), and Page (2011) are some such physicists. Various physicists have also wondered on the extremely improbable and highly fine-tuned nature of life itself. The fact that life needs a carefully maintained delicate coincidences between life-friendly ingredients and our cosmos’ choice of parameters speaks a lot for the interrelationship between the microcosm and macrocosm. Frank Wilczek remarks,“life appears to depend upon delicate coincidences that we have not been able to explain. The broad outlines of that situation have been apparent for many decades. When less was known, it seemed reasonable to hope that better understanding of symmetry and dynamics would clear things up. Now that hope seems much less reasonable. The happy coincidences between life’s requirements and nature’s choices of parameter values might be just a series of flukes, but one could be forgiven for beginning to suspect that something deeper is at work” (“Enlightenment, Knowledge, Ignorance, Temptation” in *Universe or Multiverse?* 45). Rees states, “Any universe hospitable to life – what we might call a biophilic universe – has to be ‘adjusted’ in a particular way. The prerequisites for any life of the kind we know about — long-lived stable stars, stable atoms such as carbon, oxygen and silicon, able to combine into complex molecules, etc. — are sensitive to the physical laws and to the size, expansion rate and contents of the universe. Indeed, even for the most open-minded science fiction writer, ‘life’ or ‘intelligence’ requires the emergence of some generic complex structures: it can’t exist in a homogeneous universe, not in a universe containing only a few dozen particles. Many recipes would lead to stillborn universes with no atoms, no chemistry, and no planets; or to universes too short-lived or too empty to allow anything to evolve beyond sterile uniformity” (“Cosmology and the multiverse” in *Universe or Multiverse?* 57-58). Alan Guth, an ardent proponent of inflationary theory of multiverse, states, “in the multiverse, life will evolve only in very rare regions where the local laws of physics just happen to have the properties needed for life, giving a simple explanation for why the observed universe appears

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to have just the right properties for the evolution of life. The incredibly small value of the cosmological constant is a telling example of a feature that seems to be needed for life, but for which an explanation from fundamental physics is painfully lacking" ("Eternal Inflation and Its Implications," 10). Lee Smolin also writes, "Our universe is much more complex than most universes with the same laws but different values of the parameters of those laws. In particular, it has a complex astrophysics, including galaxies and long lived stars, and a complex chemistry, including carbon chemistry. These necessary conditions for life are present in our universe as a consequence of the complexity which is made possible by the special values of the parameters" (qtd. in *The Oxford Handbook of the History of Modern Cosmology*). Leonard Susskind states, "The Laws of Physics … are almost always deadly. In a sense the laws of nature are like East Coast weather: tremendously variable, almost always awful, but on rare occasions, perfectly lovely. … Our own universe is an extraordinary place that appears to be fantastically well designed for our own existence. This specialness is not something that we can attribute to lucky accidents, which is far too unlikely. The apparent coincidences cry out for an explanation" (*The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*, 343). Stephen Hawking writes, "Most of the fundamental constants in our theories appear fine-tuned in the sense that if they were altered by only modest amounts, the universe would be qualitatively different, and in many casesunsuitable for the development of life. … The emergence of the complex structures capable of supporting intelligent observers seems to be very fragile. The laws of nature form a system that is extremely fine-tuned, and very little in physical law can be altered without destroying the possibility of the development of life as we know it" ("Stephen Hawking on God, Science and the Origins of the Universe," *WSJ*, The Wall Street Journal). Andre Linde, the proponent of the 'chaotic inflationary' theory, remarks, "the existence of an amazingly strong correlation between our own properties and the values of many parameters of our world, such as the masses and charges of electron and proton, the value of the gravitational constant, the amplitude of spontaneous symmetry breaking in the electroweak theory, the value of the vacuum energy, and the dimensionality of our world, is an experimental fact requiring an explanation. A combination of the theory of inflationary multiverse and string theory landscape provides a unique framework where this explanation can be found" (qtd. in *Inflationary Cosmology*, 46 & also in *Post-Planck Cosmology*, 296). Now, inflationary theory has lots of variants among which chaotic inflation is only one which produces multiverse of pocket universes. The phenomenon of chaotic inflation is based on the idea of Coleman-de Luccia tunneling which is then extrapolated to unknown regimes and they have the problem of Boltzmann brains to explain and are not always the best explanation for fine tuning. Moreover, the inflationary theory itself has the concept of fine tuning embedded in it where it has to start at the right way and include the right perturbations in it to produce the distribution of matter and light and also include fluctuations. Also, in the inflationary models, we find the properties of the scalar field are themselves need to be fine-tuned. Similarly, as Philip Goff states our improbable existence cannot be taken as any evidence for a multiverse: "The hope is that [the multiverse] allows us to give a "monkeys on typewriters" explanation of the fine-tuning. If you have enough monkeys randomly jabbing away on typewriters, it becomes not so improbable that one will happen to write a bit of English. By analogy, if there are enough

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universes, with enough variation in the numbers in their physics, then it becomes statistically likely that one will happen to have the right numbers for life" ("Our Improbable Existence Is No Evidence for a Multiverse"). Goff then goes on to cite the gambler's fallacy and states that invoking multiverse instead of universe does not in anyway explain away our fine-tuned nature of existence:Consider the following analogy. You wake up with amnesia, with no clue as to how you got where you are. In front of you is a monkey bashing away on a typewriter, writing perfect English. This clearly requires explanation. You might think: "Maybe I'm dreaming…maybe this is a trained monkey…maybe it's a robot." What you would not think is "There must be lots of other monkeys around here, mostly writing nonsense." You wouldn't think this because what needs explaining is why *this* monkey—the only one you've actually observed—is writing English, and postulating other monkeys doesn't explain what *this* monkey is doing….

Given how unlikely it is that an ordinary monkey would come up with "I love how yellow bananas are" just by randomly bashing away, you might suspect some kind of trick. What you would not conclude, however, is that there must be many other monkeys typing rubbish. Again, what you need explaining is why *Joey* [i.e., *this* monkey] is typing English, and the postulation of other monkeys doesn't explain this. By analogy, what we need explaining is why the only universe we've ever observed is fine-tuned, and the postulation of other universes doesn't account for this ("Our Improbable Existence"). Goff also points out the flaw in reasoning which seeks to connect the idea of fine-tuning to the multiverse: "The reason some scientists take seriously the possibility of a multiverse in which the constants vary in different universes is that it seems to explain the fine-tuning. But on closer examination, the inference from fine-tuning to the multiverse proves to be instance of flawed reasoning. So, what should we make of the fine-tuning? Perhaps there is some other way of explaining it. Or perhaps we just got lucky" ("Our Improbable Existence").

In our Universe, we find the gravitational force can be weaker by about 10^{40} than the strong nuclear force; if it were only 10^{30} times weaker, typical stars would last for not more than some few millions of years and not billions of years which is what needed for making a planet habitable for life. (*A Fortunate Universe: Life in a Finely Tuned Cosmos*, 109). A deuterium can become unstable only if the strength of the strong nuclear force is decreased by about 8 percent. A proton cannot fuse with a neutron, and as such the nuclear fusion reaction fails to proceed. Also, if the strong nuclear force increases by some 12 percent a proton can join with another proton and form a diproton (*A Fortunate Universe: Life in a Finely Tuned Cosmos*, 111). Also, the property called the Hoyle Resonance itself is a case of fine tuning where thecarbon nucleus possesses a quantum property called a resonance. The strength of strong nuclear force also determines the rate of production of carbon and oxygen in stars. If the strong nuclear force is increased by as little as 0.4%, we get stars which would produce ample carbon but no oxygen. In the absence of oxygen, there will be no water even though carbon will be there and if we go in the opposite direction which is by increasing the strong force by only 0.4%, we find all the carbon getting transformed into oxygen and the universe becoming full of water but hardly any carbon (*A Fortunate Universe: Life in a Finely Tuned Cosmos*118-119). Also, speaking of entropy production, our universe is in a

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low entropy state and if we take the example of a slightly lumpier universe which is expanding nonetheless, we shall find that most of the matter in such a universe could have been transformed into black holes and "black holes are the ultimate entropy machines" (*A Fortunate Universe* 122). Such a universe would have very little gravitational energy available to it to power life. In such a universe the only foreseeable outcome would be black holes decaying into low-energy, Hawking radiation after the passage of some trillions of years. Now, the chance of we finding ourselves in a low-entropy, life-friendly galactic neighborhood in a universe full of black holes is tremendously low which as Penrose calculates is 1 in 10^10^123. Also, equally fine-tuned is the value of density fluctuations in which is 1 in 10^5 the value is known as Q. If one decreases Q by a factor of 10 or 1 in 10^6, we find no matter would be able to clump to form meaningful structures since the diffuse and hot matter would repulse gravitational attraction which causes collapse and fragmentation of gas-clouds into stars. If we increase the value of Q to larger and larger values, we shall find a universe where only black holes would form and no stars or galaxies would ever exist for considerable period of time.

Table 1: Fundamental and derived physical and cosmological parameters

Quantity	Symbol	Value in our universe
Speed of light	c	299792458 m s^{-1}
Gravitational constant	G	6.673×10^{-11} m^3 kg^{-1} s^{-2}
(Reduced) Planck constant	$\hbar$	$1.05457148 \times 10^{-34}$ m^2 kg s^{-2}
Planck mass-energy	$m_{Pl} = \sqrt{\hbar c/G}$	1.2209×10^{22} MeV
Mass of electron; proton; neutron	m_e; m_p; m_n	0.511; 938.3; 939.6 MeV
Mass of up; down; strange quark	m_u; m_d; m_s	(Approx.) 2.4; 4.8; 104 MeV
Ratio of electron to proton mass	β	$(1836.15)^{-1}$
Gravitational coupling constant	$\alpha_G = m_p^2/m_{Pl}^2$	5.9×10^{-39}
Hypercharge coupling constant	α_1	1/98.4
Weak coupling constant	α_2	1/29.6
Strong force coupling constant	$\alpha_s = \alpha_3$	0.1187
Fine-structure constant	$\alpha = \alpha_1\alpha_2/(\alpha_1 + \alpha_2)$	1/127.9 (1/137 at low energy)
Higgs vacuum expectation value	v	246.2 GeV
QCD scale	Λ_{QCD}	≈ 200 MeV
Yukawa couplings	$\Gamma_i = \sqrt{2}m_i/v$	Listed in Tegmark et al. (2006)
Hubble constant	H	71 km s^{-1} Mpc^{-1} (today)
Cosmological constant (energy density)	$\Lambda(\rho_\Lambda)$	$\rho_\Lambda = (2.3 \times 10^{-3}$ eV$)^{-4}$
Amplitude of primordial fluctuations	Q	2×10^{-5}
Total matter mass per photon	ξ	≈ 4 eV
Baryonic mass per photon	ξ_{baryon}	≈ 0.61 eV

Based on Barns' 2012 papertitled "The Fine-Tuning of the Universe for Intelligent Life" and Tegmark et al.'s 2006 paper titled "Dimensionless constants, cosmology, and other dark matters."

Now, this kind of extremely fine-tuned nature of existence is also visible in the biological world. We know that to derive a fully functional protein, we need a properly folded chain of left-handed amino acid sequences which are joined by peptide bonds and "the probability of

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getting a properly folded chain of one-handed amino acids, joined by peptide bonds, is one chance in 10^74+45+45, or one in 10^164" (Meyer, p. 212).Even the simplest form of life has at least some 250 to 400 proteins and each protein is built of as many as three to four hundred amino acids and 20 different amino acids create all kinds of lifeforms. So, the first task would be to randomly arrange 150 amino acids into one functional protein and that too would be constrainedtowards selecting only left-handed amino acids. Now, amidst the combination of right and left-handed amino acids, the probability of getting only left-handed ones is around $(½)^{150}$ or 1 chance in 10^{45}. So, here we see the famous *chirality problem* where any form of right-handed amino acid would ruin the protein.

Then among those left-handed amino acids the probability of getting 149 peptide bonds becomes also extremely low which is somewhere near $(½)^{149}$, or 1 chance in 10^{45}("Building a Protein by Chance." *Str.org*, 2015). This is normally termed as the *bonding problem*. Now, the final obstacle is the *sequence problem* or the problem of specificity. The 20 different amino acids must be arranged in highly specific order to give rise to one functional protein. So, out of as few as 150 amino acids, we can have a total of as many as 10^{195} possible ways to create a protein which contains only 150 amino acids. Following a slightly different method of calculation, we can find that we need to construct as many as 10^164 chains of amino acids which are 150 units long to actually find the properly folded, functional protein molecule. Also, the probability of finding the functional sequence of the universal protein named RecA among vast range of evolutionary samplingsis somewhat 1 in 10^{250} and this estimate of chance takes into account such various factors as length of the genome, mutation rates, total number of diverse lifeforms etc., to name a few. However, in the four billion years of history of life in Earth, there could not have been more than 10^{42} sequences which makes the probability of finding a fully functional protein from amidst a vast range of possibilities almost nil. So, conducting as many as 10^250 trials which include all forms of mutations, deletions, insertions, in as few as 10^43 opportunities seem next to impossible.If we consider a strand of DNA in the smallest free-living organism known we get a strand which is about 1.5 million nucleotides long, where each nucleotide can mutate in at least three separate ways, we find that the probability of getting a single-point mutation in this bacterium is $3^{1.5M}$. The figure can also be written as 10^{715000} which is mind boggling in its immensity. David Begun in 2006, comments on the improbability for a piece of DNA to evolve into a properly functioning gene: "… it takes a whole set of unlikely conditions for a piece of random DNA to evolve into a gene. First, some of the DNA must act as a promoter, telling the cell to make RNA copies of the rest. Next, these copies must have a sequence that can be edited into a viable messenger RNA blueprint for the protein-making factories. What's more, this messenger RNA must encode a relatively long protein – the average length is 900 base pairs – which is unlikely because on average a random stretch of DNA will have a 'stop' codon every 20 base pairs. Finally, of course, the new protein must do something useful. The obstacle seems insurmountable" (qtd. in *How Evolution Explains Everything About Life*).

Now, life does not just build upon only one functional RecA sequence but in fact needs as many as few tens of thousands of proteins.In various other studies, we can see how even a relatively small protein which is a mere 100 amino acids long can assume some 10^100

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different configurations. An article in *MIT Technology Review* titled “Physicists Discover Quantum Law of Protein Folding” writes: Proteins are long chains of amino acids that become biologically active only when they fold into specific, highly complex shapes. The puzzle is how proteins do this so quickly when they have so many possible configurations to choose from. To put this in perspective, a relatively small protein of only 100 amino acids can take some 10^100 different configurations. If it tried these shapes at the rate of 100 billion a second, it would take longer than the age of the universe to find the correct one. Just how these molecules do the job in nanoseconds, nobody knows…Today, Luo and Lo say these curves can be easily explained if the process of folding is a quantum affair. By conventional thinking, a chain of amino acids can only change from one shape to another by mechanically passing through various shapes in between. But Luo and Lo say that if this process were a quantum one, the shape could change by quantum transition, meaning that the protein could ‘jump’ from one shape to another without necessarily forming the shapes in between… Their astonishing result is that this quantum transition model fits the folding curves of 15 different proteins and even explains the difference in folding and unfolding rates of the same proteins. That’s a significant breakthrough. Luo and Lo’s equations amount to the first universal laws of protein folding. That’s the equivalent in biology to something like the thermodynamic laws in physics (“Physicists Discover Quantum Law of Protein Folding”, *MIT Technology Review*). There is now further evidences that interdependencies among amino acids also reduce functional protein sequence to a great extent: This measure of functional information (for the RecA protein) is good as a first pass estimate, but the situation is actually far worse for an evolutionary search. In the method described above and as noted in our paper, each site in an amino acid protein sequence is assumed to be independent of all other sites in the sequence. In reality, we know that this is not the case. There are numerous sites in the sequence that are mutually interdependent with other sites somewhere else in the sequence. A more recent paper shows how these interdependencies can be located within multiple sequence alignments.These interdependencies greatly reduce the number of possible functional protein sequences by many orders of magnitude which, in turn, reduce the probabilities by many orders of magnitude as well. In other words, the numbers we obtained for RecA above are exceedingly generous; the actual situation is far worse for an evolutionary search (qtd. in “Probability of a Single Protein Forming by Chance”). Also, proteins seem to act as unified whole and not as assemblage of amino acids: “A mathematical analysis of the experiments showed that the proteins themselves acted to correct any imbalance imposed on them through artificial mutations and restored the chain to working order” (“Evolution’s New Wrinkle”). There are also studies which point to the quantum coherence-like state in proteins: If you take certain atoms and make them almost as cold as they possibly can be, the atoms will fuse into a collective low-energy quantum state called a Bose-Einstein condensate. In 1968 physicist Herbert Fröhlich predicted that a similar process at a much higher temperature could concentrate all of the vibrational energy in a biological protein into its lowest-frequency vibrational mode. Now scientists in Sweden and Germany have the first experimental evidence of such so-called Fröhlich condensation (in proteins) … (“Quantum Coherent-like State Observed in a Biological Protein”). There are also hints at the simultaneous working of classical and quantum information channel in protein sequence:

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Investigation of the properties of peptide plane in protein chain from both classical and quantum approach is presented. We calculated interatomic force constants for peptide plane and hydrogen bonds between peptide planes in protein chain. On the basis of force constants, displacements of each atom in peptide plane, and time of action we found that the value of the peptide plane action is close to the Planck constant. This indicates that peptide plane from the energy viewpoint possesses synergetic classical/quantum properties. Consideration of peptide planes in protein chain from information viewpoint also shows that protein chain possesses classical and quantum properties. So, it appears that protein chain behaves as a triple dual system: (1) structural – amino acids and peptide planes, (2) energy – classical and quantum state, and (3) information – classical and quantum coding. Based on experimental facts of protein chain, we proposed from the structure-energy-information viewpoint its synergetic code system ("Classical and Quantum Information Channels in Protein Chain"). Now, as the study of Vattay et al. (2015) have found, this finding of only one quantum critical state among many is incredibly small of the order of 10^-50 for various biomolecules: That's a discovery that is as important as it is unexpected. "These findings suggest an entirely new and universal mechanism of conductance in biology very different from the one used in electrical circuits." The permutations of possible energy levels of biomolecules are huge so the possibility of finding even one that is in the quantum critical state by accident is mind-bogglingly small and, to all intents and purposes, impossible… of the order of 10^-50 of possible small biomolecules and even less for proteins," … "what exactly is the advantage that criticality confers?" ("The Origin of Life and the Hidden Role of Quantum Criticality").

Also, we can see that deriving the "Simple Sequence Repeats" (SSRs) in DNAs is highly complex task as any repetitive sequence which has a length of more than 20 base pairs or more is highly unlikely to emerge by random chance alone, and we have $3x10^9$ base pairs of the human genome.

Natural Selection in Microcosm and Macrocosm:

A whole host of parameters and constants like the relative mass of most of the elementary particles, the ration of electrons to protons, relative strength of four types of fundamental forces, and relative masses of various elementary particles seem to fine-tuned so uncannily that were they not extremely close to these values they now possess, complex life could never have emerged in the cosmos in the first place. As we have already seen in the previous section of our study, even a minor change in any of the parameters and values of fundamental constants would give rise to a cosmos which would extremely dangerous to lifeform of any conceivable kind. Paul Davies has famously stated, "The cliché that 'life is balanced on a knife-edge' is a staggering understatement in this case: no knife in the universe could have an edge *that* fine" (qtd. in "Evidence That Demands A Verdict: A Review"). Authors Ricardo B. Ferreira and João B. Ferreira in their article "The Live Universe. A Biologist's Perspective", endeavour to draw a parallel between the living world and the multiversal conceptualization of the universe: Using biological systems as an analogy and adopting a broad definition for life, we may speculate the existence of a living multiuniverse, capable of natural evolution, in which each individual universe spontaneously goes through birth, development, reproduction, aging and death. The possible roles of supermassive black holes (SMBHs) and human-like

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intelligence on the future evolution of our universe are briefly discussed. Lee Smolin in his 1997 work first introduced the idea of the “Evolving Universe” in which the majority of the populations of universe are tuned toward the production of maximum number of black holes.

In the field of biology, it was Darwin’s remarkable insight which led to the paradigmatic shift in our view of the biological world where species were no longer began to be seen as timeless and designed but a product of the random natural force of selection: “The theory of evolution by cumulative natural selection is the only theory we know of that is, in principle, capable of explaining the existence of organized complexity” (Dawkins, *The Blind Watchmaker*317). Theodosius Dobzhansky similarly opines, "Nothing in biology makes sense except in the light of evolution" (“Nothing in Biology Makes Sense”). Lee Smolin has attempted to borrow the idea of natural selection in the field of cosmology in his 1992 book *The Life of the Cosmos*. Now, Smolin’s hypothesis was formulated based on the then popular notion of the Big Crunch scenario where fowling a supermassive black hole-dominated scenario, galaxy centers will devour all their available supply of the entire gas, dust and debris and thereby undergoing luminous Quasar phases before wandering through the intergalactic space and occasionally colliding with other similar ultramassive black holes that have grown in similar ways until the gravitational pull will all eventually cause to merge them together into one colossal black hole. Even though traditionally, all theories have posited the existence of singularities near the center of the black holes,most current theories are believed to suffer a complete breakdown near such extreme spacetime configurations (Begelman, 2003; Kim and Park, 2015). However, as Ferreira and Ferreira (2017) in their study describe: Under such conditions, the structure of ordinary matter is disrupted. Assuming SMBHs are permanently “eating” the universe from within, growing almost unlimitedly, and combining that with a spatially flat, expansioning universe, the following scenario may be hypothesized: SMBHs undergo a dramatic change once they reach a critical mass/pressure stage: they originate a big bang for a newly born universe by connecting such singularity to a distinct set of dimensions, operating as a linkage between “father and son” universes. As a result, the unstructured matter elements escape (under a tremendous amount of pressure) into another “space” at zero or low pressure. Matter and energy are eventually projected in all directions at great but varying speeds (eventually ensuring that the offspring universe will comply with the Hubble law; as pressure drops dramatically: a big bang takes place and a new universe is born.We see in our universe how giant stars often collapse into black hole following Supernovae explosions. Now, as the core collapses it reaches some extreme points of unimaginable density, where quantum phenomena could cause a bounce and thus the black hole could explode in a new big bang and expand into a whole new baby universe, now separate from its parent universe. The ending of time in the previous universe marks the beginning of time in the new universe. According to Smolin, during such final moments of extreme collapse, tiny random variations of the fundamental physical constants in the baby universe can take place during such rebirth. Thus, every new offspring universe should differ from the laws and parameters of its parent universe’s particles or in the relative strength of the physical forces. “Because of their inherited characteristics, universes with star-friendly parameters will produce more stars and reproduce at a greater rate than those universes with star-unfriendly parameters. So, the parameters we see today are the way they are because, after accumulating

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bit by bit through generations of universes, the inherited parameters are good at producing stars and reproducing" (Rifkin, "The Logic and Beauty of Cosmological Natural Selection").

Table 2: Detailing the components of a von Neumann's (1951) self-reproducing automaton.

Components	***Description***	***BIOLOGY (cell)***	***COSMOLOGY (universe)***
Blueprint	Gives instructions for the construction of the automaton	Information contained in the DNA	Physical constants
Factory	Carries out the construction	Cell	The universe at large
Reproducer	Reads the blueprint and produces a second blueprint	The reproduction of the DNA	CNS:? **Intelligence unravelling the universe's blueprint**
Controller	Ensures the factory follows the blueprint	The regulatory mechanisms of the mitosis	CNS:? **A cosmic process, aiming at universe reproduction**

As described in Clément Vidal's "Computational and Biological Analogies for Understanding Fine-Tuned Parameters in Physics."

When we look at such pictures as the one captured by Hubble Space Telescope comprising of various, high redshift galaxies, we are in fact, looking back at a time billions of years past, which parallels when we look at the remnants of the primitive cellssome 3.7 billion years ago, although according to the theories of molecular genetics life is touted to have arisen as early as some 4.2–4.3 billion years ago.Now, speaking of the role of black hole as a determinant of our cosmic evolution, we can cite Bojowald's (2007) idea of "cosmic forgetfulness" which proposes that our current universe might be the result of a final stage of collapse of an inconceivably large black hole which spews out all the remnants of the past universe in a big bang-like exploding event. Then gradually, as the universe started to expand and cool from its extremely high density and high temperature phase, matter began coalescing into stars, solar systems, planets and galaxies. Black holes would then merge to grow into even bigger, supermassive black holes thereby fuelling another new cycle. Also, even if we follow only the Big Bang paradigm, we see that as our universe continues to age, lighter elements continue to be transformed into progressively heavier elements and as the stellar fuel is consumed, the heavier elements progressively get accumulated inside stars till the point it reached when these heavy elements get ejected into the interstellar medium following the cataclysmic death of these massive stars via supernovae. Now, over extremely long periods, these heavier atoms will once again start clumping and collapsing within black holes as the gravity seeks to rip apart these black holes. "Thus, by ripping apart atomic structures, SMBHs could eventually "give birth" to juvenile universes with a renewed atomic composition. This might just be the "evolving" counterpart of Bojowald's cosmic

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forgetfulness" ("The Live Universe. A Biologist's Perspective", 4). Also, supermassive, rapidly rotating Kerr black holes van serve as possible portals/passageways to other universes (Hawking et al., 2016). At the end of the wormhole connecting two different universes, black holes could be positioned that in turn will connect these two different, parallel universes in which scenario, in one universe, the black hole will continue to suck matters down their throats while in the other they will be ejecting these matters in their white hole incarnation. In a 2012 article Retter and Heller have hypothesized that certain orphan GRBs or GRBs without accompanying supernova explosions could be signs of such brief bursts of white holes through which matter from an alternative universe gets dumped into ours. Now, from an Einsteinian General Relativity paradigm,singularities occur at the centres of black holes which signal breakdown of all known domains of physics (Kim and Park, 2015). Wormholes can be alternative solutions to these singularities. Shinkai and Hayward (2002) also theorzises that in a wormhole throat the horizons of spacetime bifurcatesinto two separate regionswhere one regionassumes the form of an inflationary universe and another one collapses to a black hole, where the total injected energy stays respectively negative or positive. Haggard and Rovelli (2015) have also posited the possibility that during such a collapse, instead of forming singularities, white hole can occur due to the accumulation of quantum effects which allow the black hole to quantum tunnel into white hole. Another possibility is that our universe is in fact, located inside a wormhole which is in turn part of a larger, higher-dimensional universe (Poplawski, 2010). Another possibility is that a four-dimensional star from other universecollapsed to form a 4-D black hole which then played an important role in giving birth to our universe(Pourhasan et al., 2014, "Out of the White Hole: A Holographic Origin for the Big Bang"). Hawking et al., 2016 have also posited a similar kind of picture where a black hole in another universe could act like a wormhole that connects our own universe. Poplawski (2010) also hypothesizes that SMBHs can act as a gateway for matter in other universes which then get ejected via white holes into ours.As Rifkin opines, "If cosmological natural selection proves true, life almost certainly is not unique in the history of the cosmos. As was shown with biological natural selection, we are of nature and part of nature. The universe could be further understood as a self-coherent and self-creating whole, without the need for anything outside itself to give it law, meaning or complexity" ("The Logic and Beauty of Cosmological Natural Selection"). Various researches have even attempted to expand the theory of Cosmological Natural Selection by including the role of intelligent life in it (Harrison 1995; Gardner 2000; 2003; Baláz 2005; Smart 2008; Vidal 2008; Crane 2009; Stewart 2009). Now, string theory is often invoked to describe the vast and varied landscape of multiverse where the mind-0boggling number of 10^500 vacua is often compared to the ways of shuffling a DNA. As Susskind states, "What string theory brings is something about the number of possibilities. But its numbers are far, far larger than the number of atoms in the universe — the number 10 to the 500 [10^500] gets bandied about. This does not mean 10^500 different pocket universes, but 10^500 different types of them in a string theory 'landscape' — each one being repeated over and over again [in different instances of the type]. So, on the one hand, string theory gives you the analog of the different number of ways of re-arranging a DNA molecule. What cosmic inflation theory gives you, on the other hand, is how do you bring these different [pocket] universes into

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existence?" (qtd. in Kuhn, “Confronting the Multiverse”). Similarly, Vilenkin also states, “That's why a multiverse of innumerable bubble or pocket universes can have a very wide variety of physical properties. A property of inflation is that it will explore the whole landscape of these possibilities, or 'vacua,' because quantum mechanics allows tunneling through energy barriers to other minima. Moreover, quantum mechanics tells us that if a transition between two minima is not absolutely forbidden by some law, then it must inevitably happen. This means that all possible transitions between all possible states must happen.” (qtd. in Kuhn, “Confronting the Multiverse”). Susskind also states that the string theory is a theory of the genetic code of the universe: “String theory is a theory of the “DNA” of a universe, but we only get to study a single “life form” – our own local patch of space. It’s as though Gregor Mendel had only a single pea and a simple magnifying glass to work with, from which he was expected to discover the double helix and the four bases A, C, G and T” (qtd. in “Stringscape”). Also, while the string theory is seen as the genetic code of the universe, the holographic theory is often touted to be the DNA equivalent of a theory of quantum gravity: “The holographic principle is the genetic code of quantum gravity, and a complex jungle of theories realizes that underlying genetic code in myriad ways. We are now beginning to understand how the holographic DNA of string theory shapes the family resemblances among the flora and fauna of this vast ecosystem” (Hellerman, *String Theory: Genetic Code of the Cosmos*, 5).

Now, let us see some similarities between this idea of cosmic natural selection with that of the Darwinian paradigm which has become a cornerstone in modern day evolutionary biology. Dawkins has commented on the explanatory power of Darwinian Theory of Natural Selection thus: “The Darwinian theory is in principle capable of explaining life. No other theory that has ever been suggested is in principle capable of explaining life… Darwinism is the only known theory that is in principle capable of explaining certain aspects of life... even if there were no actual evidence in favor of the Darwinian theory” (*The Blind Watchmaker* 287-288). Dawkins further states the central role of slow, progressive, and incremental accumulation of variations through mutation and natural selection in determining the course of evolution: We have seen that living things are too improbable and too beautifully 'designed' to have come into existence by chance. How, then, did they come into existence? The answer, Darwin's answer, is by gradual, step-by-step transformations from simple beginnings, from primordial entities sufficiently simple to have come into existence by chance. Each successive change in the gradual evolutionary process was simple enough, relative to its predecessor, to have arisen by chance. But the whole sequence of cumulative steps constitutes anything but a chance process, when you consider the complexity of the final end-product relative to the original starting point. The cumulative process is directed by nonrandom survival (*The Blind Watchmaker* 43). Black holes seem to play the role of the Dawkinsian ‘Blind Watchmaker’ in the cosmic context which helps introducing step-by-step accumulation of changes in the daughter universes. Black holes can also permit universe of increasingly larger organized complexity to take shape from a primoradial universe of extreme simplicity. Dawkins remarks on the significance of ever-increasing organized complexity in each new universe: “Organized complexity is the thing that we are having difficulty in explaining. Once we are allowed simply to postulate organized complexity, if

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only the organized complexity of the DNA/protein replicating machine, it is relatively easy to invoke it as a generator of yet more organized complexity... But of course, any God capable of intelligently designing something as complex as the DNA/protein machine must have been at least as complex and organized as that machine itself... To explain the origin of the DNA/protein machine by invoking a supernatural Designer is to explain precisely nothing, for it leaves unexplained the origin of the Designer" (*The Blind Watchmaker*140).Dawkins also states, "The theory of evolution by cumulative natural selection is the only theory we know of that is in principle capable of explaining the existence of organized complexity. Even if the evidence did not favour it, it would still be the best theory available!" (*The Blind Watchmaker* 317). Dawkins has also stressed on the role of 'gradualness' in the process of naturals selection: "Evolution ... must be gradual when it is being used to explain the coming into existence of complicated, apparently designed objects, like eyes ... Without gradualness in these cases, we are back to miracle, which is simply a synonym for the total absence of explanation" (*River Out of Eden: A Darwinian View of Life*132). In the same work, he then goes on to say - If the universe were just electrons and selfish genes, meaningless tragedies ... are exactly what we should expect, along with equally meaningless good fortune. Such a universe would be neither evil nor good in intention ... In a universe of blind physical forces and genetic replication, some people are going to get hurt, and other people are going to get lucky; and you won't find any rhyme or reason to it, nor any justice. The universe we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil and no good, nothing but blind pitiless indifference. ...DNA neither knows nor cares. DNA just is, and we dance to its music (133). Dawkins has also commented on the role of mutation in increasing uncertainty in the course of evolution: "Mutation is not an increase in true information content, rather the reverse, for mutation, in the Shannon analogy, contributes to increasing the prior uncertainty. But now we come to natural selection, which reduces the 'prior uncertainty' and therefore, in Shannon's sense, contributes information to the gene pool. In every generation, natural selection removes the less successful genes from the gene pool, so the remaining gene pool is a narrower subset ... what is the information about? It is about how to survive"(qtd. in Dawkins,*A Devil's Chaplain* 77). In his essay *The Necessity of Darwinism* Dawkins remarks, "Darwin's theory is now supported by all the available relevant evidence, and its truth is not doubted by any serious modern biologist. But, important as evidence is, in this article I want to explore the possibility of developing a different kind of argument. I suspect that it may be possible to show that, regardless of evidence, Darwinian natural selection is the only force we know that could, in principle, do the job of explaining the existence of organised and adaptive complexity" (qtd. in *New Scientist*, Vol. 94, No. 1301). In the same essay, he further writes, "The more statistically improbable a thing is, the less can we believe that it just happened by blind chance... Darwin showed how it is possible for blind physical forces to mimic the effects of conscious design, and, by operating as a cumulative filter of chance variations, to lead eventually to organized and adaptive complexity, to mosquitoes and mammoths, to humans and therefore, indirectly, to books and computers." Dawkins also states,"the universe is nothing but a collection of atoms in motion, human beings are simply machines for propagating DNA, and the propagation of DNA is a self-sustaining process. It is every living object's sole reason for living" (Dawkins qtd. in

Michael W. Poole, "A Critique of Aspects of the Philosophy and Theology of Richard Dawkins," *Science and Christian Belief* 6, 1994, 58), and expresses his belief in the maximization of survival of DNA which he posits to be the only purpose of life: "everything makes sense once you assume that DNA survival is what is being maximized" (Dawkins, *River Out of Eden*, 106).

Conclusion: The study seeks to explore and analyze certain parallels that exist between the microcosmic world of living entities and the macrocosmic world. The first section of the study has looked at the striking similarities between galactic webs and the neural circuitry of the human brain. Recent researchers have found tantalizing parallels between the simulated picture of gigantic cosmic webs composed of enormous structures called clusters, superclusters, and filaments, and the structure of neural circuitry with all its nonlinearities, hidden variables, and underlying mechanisms. The second part of the study has tried to throw some light on the coincidences between life-friendly ingredients and our cosmos' choice of parameters. The laws of nature together seem to constitute a system that is extremely fine-tuned, where even a tiny alteration can destroy the possibility of development of life in it altogether and this bears some striking resemblances with the probability or improbability of finding a fully functional protein from amidst a vast range of possibilities or with the highly improbable event such as a piece of DNA to evolve into a gene.

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