

Review Article

An Executive Information System: Inherent Information and Functional Information

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Abstract

This review article deals with quantum biology, the new tool that helps traditional biology unravel some mysteries concerning life and living organisms on Earth. We use Einstein's famous equation to explain how an unknown energy realm creates the material universe. We demonstrate how material existence precedes living existence and elucidate how non-living atoms transition to living molecules, Francis Crick's faded dream that comes to reality. Finally, we expose the two types of Information available inside a cell to sustain life in living organisms and elaborate on a new formulation of the biogenesis theory.

Introduction

In the 40th anniversary edition of "The Selfish Gene," Richard Dawkins' multi-million bestseller book, I read Robert L. Triver's foreword. I agree that no species can be elevated above the other [1]. Peter Wohlleben, through personal experiences, shows us that animals have an inner life and that some grieve, feel shame, and discipline their kids [2]. However, there is one objective basis upon which we can trace a demarcation line between humans and the rest of the animal kingdom. Humans are persons; animals are not [3]. We are the only species that cook our food. We entertain abstract thoughts, have a chin, and articulate coherent language. Only humans have a quest for knowledge; for that cause, we have scientists who investigate natural phenomena. Professor Harari demonstrates we have imagination and we tell stories [4]. We also have belief systems, and some are Jews, Muslims, Christians, Buddhists, and atheists. Animals are neither theists nor atheists; they wake up to fetch food, eat and drink. They reproduce based on the program inside their DNA. Humans also reproduce by instinct, but in addition, they use in vitro technologies to thwart their challenges. On page 77 of chapter 4 of his book, Professor Dawkins admits that humans are a "very special case."

Yes, there are some bases upon which we can separate humans from animals: we have a will and are medium consciousness. Humans and animals might have evolved

through natural selection, but the process was not blind; it was governed. There is a program behind evolution; functional Information is at play at every step of the road. I like how, in his foreword of "The Selfish Gene," Professor Trivers himself came to the conclusion and described natural selection as a non-random differential reproduction of genes [1]. Dawkins himself went further in the preface to the first edition: we are robot vehicles blindly programmed to preserve the selfish molecules known as genes. I agree with Professor Dawkins, except that "programmed" and "blind" are antipodal. If it is programmed, then it cannot be blind because a program always connotes a goal.

The nihilistic pessimism in "The Selfish Gene" is blatant. Nevertheless, the book's hypnotic power will be attenuated if we can demonstrate with perspicuity and convince the scientific community that an Executive Information System is behind life on Earth. As Dawkins himself says: "If something is true, no amount of wishful thinking can undo it." Thus, our goal in this article is to provide tangible evidence that living organisms operate under the spell of an Executive Information System.

First, we will use Einstein's famous equation to recall how an unknown energy realm creates the material world. Second, we will show how material existence allows living existence

More Information

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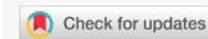
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to take place. Then, we will demonstrate how non-living atoms transition to living molecules, Francis Crick's faded dream that comes true. Finally, we will expose the two types of Information readily available in living cells and reformulate the old biogenesis theory.

As Professor Dawkins said in the epilogue to the 40th anniversary edition, I quote:

"In some ways, I would quite like to find ways to recant the central message of *The selfish gene*."

We humbly present one possibility through this literature review.

Energy-mass equivalence: The birth of the universe

Einstein's works remain pivotal in science; almost everything in modern physics revolves, directly or indirectly, around this man [5,6]. Through his famous equation, we learn how the material universe comes into existence. $E=MC^2$ clearly shows two different realms at play: the energy realm and the material world. Many people study this equation yet cannot notice an energy world separately from the material world. Energy is not matter; matter is not energy; they are equivalent, not equal.

Modern physics teaches us that massless bosons will appear when a spontaneous symmetry breaking occurs in a continuous symmetry field [7,8]. The additional work of Peter Higgs demonstrates that massless bosons are the precursors of massive particles [9]. Thus, as high-speed immaterial particles move through the nascent Higgs field at the Big Bang, they slow down, interact with the field, and acquire mass. In other words, when Information deploys Order, Disorder impedes the process. Our investigations have found that the energy realm is an infinite concatenation between Information and Order; thus, we postulate and symbolize energy by $I\infty O$. Entropy emanates from the symmetry breaking.

We must distinguish spontaneous symmetry breaking from explicit symmetry breaking. The latter has an external well-known cause; the former has an unknown internal cause. Thus, the unknown cause that disrupts the symmetrical arrangement of the continuous energy field moves out and expands with the inflation. The Higgs field appears at the Planck length, giving birth to space, time and mass.

According to cosmologists, fermions are formed within the first three minutes. Then, quarks are bound to make hadrons; the bosons mediating the strong force hold the hadrons together to form the first atomic nucleus. Hydrogen is the first element of the periodic table to be formed, and it has no neutron but only one proton inside its core. Within the following seconds after the Big Bang, protons and neutrons collided in the hot and dense nascent universe. The building blocks of matter, governed by codes locked inside their core, upgrade from hydrogen to helium. With Information propping

Order, the nuclear reaction squeezed two neutrons and one additional proton inside the hydrogen atoms to make helium. Gravity took off and clustered vast amounts of gases to form the first stars, which were made of 75% hydrogen and 25% helium, whence the rest of the elements of the periodic table will derive. The heaviest elements we know in the periodic table were cooked later inside stars before being disseminated in the universe through supernovae [10,11].

The mathematics behind the standard model of particles in physics demonstrates that the fermions are asymmetric, providing good evidence that the material world is born out of symmetry breaking. The self-organization of the universe is not random; things unfold based on sets of codes. Now that we have an idea of how energy makes matter, let's see how material particles arrange themselves before accommodating life.

Material existence and living existence

No matter how the James Webb Space Telescope (JWST) changes our understanding, material existence will always precede living existence [12,13]. The JWST's revelations nonplus some physicists and cosmologists, but we remain serene, on the contrary, because we perfectly understand what is going on. These new revelations confirm our findings and support our research. Time always unfolds from past to future in this material world; therefore, the material composing the body must be made before life incarnates inside it. Both material and living existence follow evolutionary patterns. First, atoms are formed, and then they come together to build molecules, which assemble to make tissues, organs, systems, and finally, the organism.

Before life emerged on Earth, atoms and molecules must be formed in the first place. Thus, oxygen meshes with hydrogen and carbon to make water and Carbon Dioxide, two indispensable elements to sustain plant life. Autotrophs are made first, and then heterotrophs come on the scene. The observation shows the first mainly supports and feeds the latter.

To summarize the evolutionary process, the mineral reign was the first segment of the puzzle to be set up, followed by the vegetal dominion and the animal kingdom with humans on top. Notice how the mineral dominion serves the vegetal reign, which, in turn, serves the animal rule, and when animals die, their bodies decompose into minerals to close the cycle. Let one link miss, and the whole agenda of life will fail. Material existence comes first, and then living existence follows when life incarnates in objects.

From non-living($i\infty o\sim d$) to living($i\infty o/d$)

The story reports that in the wake of World War Two, Francis Crick, one of the co-discoverers of the molecular structure of DNA, segued from physics to biology [14]. His



intention was to solve big puzzles that still crippled biology. He focused on two main topics: how inert massive particles transition from non-living to living molecules and how the brain creates consciousness.

Science provides rational explanations of natural phenomena, and today, we can boldly claim that the first puzzle that tormented Crick is solved [15]. We can explain rationally how non-living atoms transition to living ones. For that cause, we will focus on the Executive Information Systems behind life.

Life as we know it on Earth always occurs within a boundary fence, which we often call a cell membrane. It is evident and well observed in the laboratory that life ceases whenever the boundary fence breaches and spills its contents. In multi-cellular organisms like us, the blood is one of the precious contents we preserve and prevent from spilling out. All living organisms keep life in their bodies by maintaining a tightly controlled balance between degradation and synthesis [16]. Thus, life stops when the equilibrium between degradation and synthesis ruptures. Today, we know this equilibrium as the entangled system of Degradation/Synthesis. Its equivalent inside atoms and molecules is Disorder/Order.

Energy($I\infty O$) is fundamental, then emerge massive particles ($I\infty O\sim D$). Mass is acquired through the Higgs mechanism, with Disorder continually impeding the Information process; hence, a temporary concatenation between Order and Disorder. Non-living atoms become living molecules when the partial concatenation between Order and Disorder forms an entangled system, as the work of the Nobel laureate Ohsumi implicitly shows [16]. Through anabolism and protein synthesis, Order and Disorder at the core of non-living atoms we ingest become entangled; notice that life is always maintained in the cell by the controlled balance between degradation and synthesis.

The oxygen we breathe is not a living thing. The water we drink is composed of inert molecules of oxygen and hydrogen; their configuration is $I\infty O\sim D$, an infinite concatenation between Information and Order with Disorder in partial concatenation. However, when these atoms enter protein synthesis and constructive metabolism, Order and Disorder transition from a partial concatenation to form an entangled system, a combination that sustains life; hence, the new configuration $I\infty O/D$.

Notice that inert matter didn't become living molecules in the open air; non-living atoms must enter an organism, a perimeter where life is already thriving, to transition to living molecules. Life always proceeds from life. Life must be there to impart life to inanimate matter, and it does so by converting partial concatenation ($O\sim D$) inside massive particles into an entangled system (O/D). Nothing is alive in this material world without its atoms and molecules possessing this configuration

(O/D) at their core. The entangled system Degradation/Synthesis (or O/D) is a synonym for living entities; it sustains life in the organism. Remark how scientists can synthesize proteins in the laboratory, yet nowhere close do we have life in these substances.

Only three things characterize all life forms on Earth: the boundary fence, functional Information, and the entangled system Degradation/Synthesis. These three elements must be considered as the universal life criteria. Anything else is superfluous. Reproduction, for instance, is not as standard to all life forms as we previously thought because many hybrid animals don't reproduce. Thus, the actual element that separates life from non-life is the entangled system Degradation/Synthesis or O/D inside massive particles constituting the organism. To bring something to life is to change the configuration state of its massive particles; Nature does so by shifting its atoms and molecules from ($I\infty O\sim D$) to $I\infty O/D$.

Inside the living cell: Inherent information and functional information

Is the Information inside human beings selfish? If we know the origin of those pieces of Information, we can tell whether they are selfish or not. Even the Information found in Nature does not appear selfish because the soil yields a hundredfold whatever seed we give to it. One thing is to understand the laws of Nature to send rockets into space; another is to grasp their origin and the purpose behind them.

Contrary to some scholars' belief, natural selection cannot teach us about our identities. It is important we distinguish abiogenesis from natural selection; often, we confound the two phenomena. Abiogenesis speculates how life emerges from non-living matter, and natural selection explains how we gain the current biodiversity in the world [17]. Thus, if we want to comprehend our own identities, we must seek them in abiogenesis and, even before that, in the energy realm. Abiogenesis can be well situated between material existence and living existence. Natural selection occurs in living existence. I do not believe life spontaneously emerges from inert matter; it takes life to create living organisms [18-21]. The observable science does not support abiogenesis [22-25]. Therefore, biogenesis resonates with my research rather than abiogenesis. If life only comes from life, where does the original life come from? Life is energy; it emanates from the energy realm to incarnate in objects to form living organisms.

Nobody knows how the first living cell was formed; however, many hypotheses circulate, and the most notorious is chemical evolution [26,27]. The tale goes this way: a collection of carbon, hydrogen, and oxygen atoms assemble in a specific pattern to form a fatty acid. A glycerol backbone joins two fatty acids upon which a phosphate group is attached to form a molecule with hydrophobic and hydrophilic properties. These phospholipid molecules assemble to form a cell



membrane that will encapsulate several organelles to start life. The interesting part of this scientific narration is the two properties of the phospholipid molecules. Who or what tells them to hate or love water?

Selfishness and altruism are all words readily available in the pool of data we call Information. To quote Dawkins: our loving and hating, fighting and cooperating, giving and stealing, our greed and our generosity all originate in the Information behind life.

If we admit the tale above to be true, something might have taught these molecules to behave in a certain manner. Someone or something has programmed oil and water to hate each other. Today, we know that inside every massive particle, Information, Order, and Disorder are at play. Electrons inside massive particles have charges, spins, and angular momenta; these are inherent Information.

Within each atom, there is a nucleus around which electrons cloud within some specific energy levels. Since electrons move around in a circular movement, we associate an angular momentum with them, although nobody knows what it is exactly. The planetary model of Niels Bohr supports the idea of angular momentum [28]; thus, spin and angular momentum both require Information and Order. They don't occur haphazardly. We assume electrons have angular momentum because they travel a circular path around the nucleus.

Some physicists have urticaria when some think the electron spins, but these fellows are not wrong since nobody knows how things actually unfold inside an atom. So far, nobody in the physics department can tell if an electron is spherical or not; we don't know their shape. We only know they behave like waves and particles at the same time. That said, whether spin or angular momentum, these two proprieties require Information. At least, the Stern-Gerlach experiment showed electrons have a spin [29].

From that perspective, we can say the phospholipid bilayers of the first cell membrane did not dispose of themselves out of thin air; there was inherent Information inside every massive particle constituting these molecules [30,31]. The hydrophobic fatty acid tails come together because something instructed them to behave that way. As Dawkins said in chapter two, "Soap bubbles tend to be spherical because this is a stable configuration for thin films filled with gas." Stable means Order has prevailed. Today, we know that infinite concatenation between Information and Order is energy. Someone or something configures soap bubbles' atoms that way, and that something is energy. Yes, "there is a need to think of design, purpose, or directness" because these atoms don't act randomly. There is inherent Information operating at the core of these atoms and molecules.

In addition to inherent Information inside every massive particle, living organisms have functional information locked up in their DNA, as broadly explained in the works of Stephen Meyer. These two types of Information are behind life and constitute what I call an Executive Information System [32]. Indeed, there is a signature in the cell [33].

To quote Professor Dawkins again from his first chapter: "Our genes may instruct us to be selfish, but we are not necessarily compelled to obey them all our lives." Order and Disorder are present in every massive particle of our bodies; thus, as medium consciousness, humans have volition and must choose between two disparate pathways. They can go with life and make more of it or go against it and make less of it. Unfortunately, as two-way operators, our minds incubate and yield quick results through chaos because we live in the material world, while the energy realm seems distant. Professor Dawkins is right when he concludes in chapter three that DNA (Information) inside living organisms works in mysterious ways; it does indeed.

Toward a new formulation of the biogenesis theory: A poly-frequency broadcasting system

The new hypothesis derives from the old biogenesis theory formulated by Louis Pasteur, which stipulates that life can only come from life [23,24,34]. The neo-biogenesis theory we develop identifies the energetic source of life [35]. Life is energy and is an infinite concatenation between Information and Order ($I\infty O$). Notice how, throughout his book, Professor Dawkins treats genes as intelligent beings. We share the same thoughts and see a program (Information) behind natural selection [36]. Like John Wheeler, we admit everything is Information [32]. And Professor Dawkins concludes on page 44 that "genes are forever." Indeed, Information is everlasting. Life as we know it on Earth will not be possible without Information (inherent and functional).

Therefore, our neo-biogenesis theory specifies that life from the energy realm incarnates in the material world through an evolutionary process, moving gradually from a simple form to a more complex one, as described above. First, material existence occurs under the supervision of inherent Information, which governs massive particles; then, living existence follows with functional Information to control metabolism and protein synthesis. The transition from non-living to living molecules is only possible when the partial concatenation between Disorder and Order ($O\sim D$) at the core of massive particles shifts to form an entangled system (O/D).

One study shows that mafic rock glasses might have catalyzed the formation of polynucleic acids in the Hadean earth environment, starting from nucleoside triphosphates, which I remark is a form of energy. The study didn't tell where that primitive energy form originated. However, noticing that life might come from an energy form is clever [37]. Whether life comes from elsewhere or springs on Earth,



it must necessarily start from an energy source ($I \infty 0$). Thus, from the protocell LUCA (Last Universal Common Ancestor), things evolve to yield the biodiversity we see in the world [38-41]. Each living entity in the world is a frequency inside a boundary fence. Life uniquely animates each organism, making the entire existence a poly-frequency broadcasting system. The source is one, but the end is diverse and various. As Darwin keenly noticed, all species on Earth are of the same and unique extraction. We are all made of the same stuff and have the same essence. Subsequently, all living organisms die in the same pattern: losing vital energy [42]. All deaths pass through spontaneous symmetry breaking, disrupting the entangled system Degradation/Synthesis (or Disorder/Order at the core of massive particles) that sustains the vital energy in the organism [43,44].

Conclusion

Evolution is a fact, but Darwinism is not, although Charles Darwin has done a remarkable job. As some scholars thought, life is not an emergent property of complex chemical reaction networks. Life does not spontaneously emerge from inanimate objects because of the Executive Information System in living organisms. Life is fundamental. Life is coded, and the code behind life suggests an author. Whatever is programmed cannot be blind, and above all, a program cannot set itself up.

Material existence antedated living existence. While inherent Information governs material existence, functional Information rules over living existence. The two types of Information form an Executive Information System in all living organisms on Earth.

Inherent Information tells atoms how to behave, and functional Information tells proteins how to fold. The first instructs atoms and determines how to make bonds; the second controls protein synthesis and presides over living organisms' behaviors. "The genes are the immortals," said Professor Dawkins; indeed, they are. Only Information and Order are fundamentals; that's the energy behind the material world and all within it. Energy is forever; our essence comes from it. Life is energy, and all living organisms die when they lose it; therefore, we must seek our identities in the energy realm instead of the material world. As the Hungarian theoretical biologist Tibor Ganti has already suggested, perhaps we should look for the essence of life at the level of atomic interactions. And today, we know what is inside atoms: nothing more than energy.

References

- Dawkins R. *The Selfish Gene: 40th Anniversary Edition*. Oxford University Press. 2016. 4th Edition.
- Wohlleben P. *The Inner Life of Animals: Love, Grief and Compassion-Surprising Observations of a Hidden World*. Greystone Books. 2017.
- Zanou AE. *Could Humanoid Robots Become Conscious?* Social Science Research Network/Elsevier. 2021.
- Harari Y. *Sapiens: A Brief History of Humankind*. Harper. 2015.
- Einstein A. *Does the Inertia of a Body Depend on Its Energy-Content?* *Annalen Der Physik*. 1905.
- Halpern P. *Einstein's Dice and Schrodinger's Cat: How Two Great Minds Battled Quantum Randomness to Create a Unified Theory of Physics*. Basic Books. 2015.
- Prigogine I, Lefever, R. *Symmetry Breaking Instabilities in Dissipative Systems*. *Journal of Chemical Physics*. 2003.
- Goldstone G, Salam A, Weinberg S. *Broken Symmetries*. American Physical Society. 1962.
- Higgs P. *Broken Symmetries and the Masses of Gauge Bosons*. American Physical Society. 1964.
- Weinberg S. *The First Three Minutes: A Modern View of the Origin of the Universe*. Basic Books. 1993.
- Weinberg S. *Beyond the First Three Minutes*. IOP. 1980.
- Mann A. *The James Webb Space Telescope prompts a rethink of how galaxies form*. *Proc Natl Acad Sci U S A*. 2023 Aug 8;120(32):e2311963120. doi: 10.1073/pnas.2311963120. Epub 2023 Aug 2. PMID: 37531390; PMCID: PMC10410697.
- Hawking S. *The No-Boundary Proposal and the Arrow of Time*. *Vistas in Astronomy*. 1993.
- Markel H, Franklin R, Watson J, Francis Crick and the Discovery of DNA's Double Helix. WW. Norton & Company. 2021.
- Zanou, AE. *A Question of Epistemology: What is Science?* Social Science Research Network/Elsevier. 2022.
- Ohsumi Y. *Historical landmarks of autophagy research*. *Cell Res*. 2014 Jan;24(1):9-23. doi: 10.1038/cr.2013.169. Epub 2013 Dec 24. PMID: 24366340; PMCID: PMC3879711.
- Darwin C. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*. 1859.
- Lanham U. *Oparin's Hypothesis and the Evolution of Nucleoproteins*. *The American Naturalist*. 1952.
- Aristotle. *The History of Animals* (Translated by D'Arcy Wentworth Thompson). *Classics.mit.edu*. Book V. 350 BCE.
- Tirard S. J. B. S. Haldane and the origin of life. *J Genet*. 2017 Nov;96(5):735-739. doi: 10.1007/s12041-017-0831-6. PMID: 29237880.
- Pouchet FA. *New Experiences on Spontaneous Generation and Vital Resistance*. Masson & Fils. 1864.
- Axe D. *The Case against a Darwinian Origin of Protein Folds*. *Bio-Complexity*. 2010.
- Pasteur L. *Memory on the Organized Corpuscles which Exist in the Atmosphere. Examination of the Doctrine of Spontaneous Generations*. *Annals of Chemistry and Physics*. 1862.
- DOETSCH RN. *Studies on biogenesis by Sir William Roberts*. *Med Hist*. 1963 Jul;7(3):232-40. doi: 10.1017/s0025727300028374. PMID: 14028366; PMCID: PMC1034828.
- Roll-Hansen N. *Revisiting the Pouchet-Pasteur controversy over spontaneous generation: understanding experimental method*. *Hist Philos Life Sci*. 2018 Nov 1;40(4):68. doi: 10.1007/s40656-018-0229-7. PMID: 30386943.
- Haldane J. *The Origin of Life*. *Uv.es*. 1929.



27. Kauffman SA. Approaches to the origin of life on Earth. *Life* (Basel). 2011 Nov 18;1(1):34-48. doi: 10.3390/life1010034. PMID: 25382055; PMCID: PMC4187126.
28. Berry RS. How good is Niels Bohr's atomic model? Taylor & Francis Online. 2006.
29. Zhu G, Singh C. Improving students' understanding of quantum mechanics via the Stern–Gerlach experiment. *American Journal of Physics*. 2011.
30. Bertani B, Ruiz N. Function and Biogenesis of Lipopolysaccharides. *EcoSal Plus*. 2018 Aug;8(1):10.1128/ecosalplus.ESP-0001-2018. doi: 10.1128/ecosalplus.ESP-0001-2018. PMID: 30066669; PMCID: PMC6091223.
31. Tamm LK, McConnell HM. Supported phospholipid bilayers. *Biophys J*. 1985 Jan;47(1):105-13. doi: 10.1016/S0006-3495(85)83882-0. PMID: 3978184; PMCID: PMC1435076.
32. Wheeler J. *Information, Physics, Quantum: The Search for Links*. 1989.
33. Meyer S. *Signature in the Cell: DNA and the Evidence for Intelligent Design*. HarperOne. 2009.
34. Świeżyński A. *From Spontaneous Generation to Cosmic Abiogenesis. An Attempt at Systematization of Biogenesis Theories. Studies in Christian Philosophy*. 2020.
35. Lin J, Oxford RL, Culham TE. *Toward a Spiritual Research Paradigm: Exploring New Ways of Knowing. Researching and Being*. Information Age Publishing Inc. 2016.
36. WATSON JD, CRICK FH. The structure of DNA. *Cold Spring Harb Symp Quant Biol*. 1953;18:123-31. doi: 10.1101/sqb.1953.018.01.020. PMID: 13168976.
37. Jerome CA, Kim HJ, Mojzsis SJ, Benner SA, Biondi E. Catalytic Synthesis of Polyribonucleic Acid on Prebiotic Rock Glasses. *Astrobiology*. 2022 Jun;22(6):629-636. doi: 10.1089/ast.2022.0027. Epub 2022 May 19. Erratum in: *Astrobiology*. 2023 Apr;23(4):476. PMID: 35588195; PMCID: PMC9233534.
38. Joyce GF, Szostak JW. Protocells and RNA Self-Replication. *Cold Spring Harb Perspect Biol*. 2018 Sep 4;10(9):a034801. doi: 10.1101/cshperspect.a034801. PMID: 30181195; PMCID: PMC6120706.
39. Lane N, Allen JF, Martin W. How did LUCA make a living? *Chemosmosis in the origin of life. Bioessays*. 2010 Apr;32(4):271-80. doi: 10.1002/bies.200900131. PMID: 20108228.
40. Ma W. The essence of life. *Biol Direct*. 2016 Sep 26;11(1):49. doi: 10.1186/s13062-016-0150-5. PMID: 27671203; PMCID: PMC5037589.
41. Ganti T. *The Principle of Life*. Omikk. 1987; 5th edition
42. Parnia S. *Erasing Death: The Science That Is Rewriting the Boundaries between Life and Death*. Harper One. 2013.
43. Prigogine I, Stengers I. *Order out of Chaos: man's new dialogue with nature*. Bantam. 1984.
44. Zanou AE. Why Does the Physical Body Die? *Journal of Biology and Today's World*. 2022; 11: 1-4.