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Fundamental Cause of Bio-Chirality:

Space-Time Symmetry.

Concept Review.

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Abbreviation:

Deoxyribonucleic acid (DNA). Biological world (BW). Charge symmetry (C-summitry).
Elementary particles (EPs). Elementary particles world (EPsW). Galaxy world (GW). General theory of relativity (GTR).
Physical world (PW). Parity symmetry (P-symmetry). Parity violation energy difference (PVED). Quantum theory of elementary particles (QPT), Standard model (SM). String Theory (StTh). Charge symmetry (C-symmetry). Space-time (ST). Space-times symmetry (STS).
Space-time relativity (STR). Special theory of relativity (SRT). Time reversal symmetry (T-symmetry).

Key words: bio-chirality, fundamental forces of nature, time-space symmetry; relativity, ribosomal protein synthesis; parity violation, relativity.

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Abstract

The search for fundamental determinants of bio-molecular chirality is a hot topic in biology, clarifying the meaning of evolution and the enigma of life's origin. Non-biological and biological entities obey the universal laws of nature grounded on space-time symmetry (STS) transformations. The fabric of STS is the immense subject of our review. The symmetry, encompassing behavior of elementary particles and galaxy structure, imposes its fundamental laws on all hierarchical levels of the biological world. Objects across spatial scales may be classified as chiral or achiral concerning a specific space-related symmetry transformation - mirror reflection. Chirality as a symmetry element reflecting the property of asymmetry (or dissymmetry) is the critical structural feature of natural systems, including sub-atomic particles and living matter. The inheritance of molecular symmetry from the symmetry of elementary particles points to the bi-directional causal pathway of prevalent bio-chirality. We assume that both extremities of spatial dimension naturally influence this transitional state of biological matter.

The current review promotes an integrative holistic approach to the new experimental results in fast-developing and divergent branches of STS and biological chirality. The generalized view on biological chirality is a necessary and promising avenue for adequately understanding the link between protein folding, cell morphology, neuronal signaling, and laterality of cognitive functions.

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General Introduction

Causal claims are an integral part of natural sciences. Biology arises out of the underlying physics [Ellis & Kopel. 2019]. Meaning that the origin, evolution, and maintenance of bio-specific effects, including biochirality, follow nature's fundamental laws [Gross 1996]. Not-trivial behavior of chiral molecular compounds, including spontaneous chirality switching [Kai et al. 2018], transient reversible inversion of chirality [Sakata et al. 2022], light-induced chiral switching [Li et al. 2019], and s chiral-induced spin selectivity (CISS) effects [Naaman et al. 2022; Evers et al. 2022] suggest that ribosomal protein synthesis is not the only mechanism involved in the induction and maintenance of prevalent molecular chirality. The progress in this field recurs the search for the fundamental cause of bio-chirality, common for all hieratical levels of the soft-matter organization.

As the fundamental determinant of existence, the fabric of space-time symmetry (STS) transformations is the immense subject of our review encompassing subatomic physics, galaxy structure, and the biological world, including the phenomena of intellect. Undoubtedly, non-biological and biological entities obey the fundamental laws of Nature [Wolf, et al., 2018]. The universe's integrity is a driving force of long-lasting theoretical development and experimental attempts in biology. The knowledge of the common principles of existence is necessary for solving the mystery why origin of life is associated with the prevalent homochirality of biomolecules [Devínsky. 2021; Barron, 1986; Manev, 2014]. From the time of Greek philosophy, intuitive perception of the unity of everything given in sensation has been advanced to the speculative and scientific levels. Kant (1724-1804) transformed the unity of universe hypothesis into an analytical statement that time and space are the most fundamental forms of existence. In addition, long before the Noether, Kant pointed out the philosophical significance of chiral objects (which he called the incongruent counterparts} to the concept of space [Van Cleve & Frederic. 1991; Hoefer. 2010] and conservation principles [Weizsacker. 1971]. After Newton, Leibniz,

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Mincowski [1859-1909], Poincare [1854-1912], and Noether (1882-1935) promote the concept of the ST continuum to the form of mathematical equations [Ezio, 1997], which open an opportunity to analyze space-time related variables. The relativity of space and time intervals disclosed by Minkowski and accepted by Lorentz become the main postulates of special relativity theory (SRT) of Einstein [Minkowski. 2007; Einstein, A. 1921; Lorentz et al. 1923]. The advances in SRT and general theory of relativity (GRT) theory were made by including the achievements of quantum theory of elementary particles (QPT) and the physics of gravity, bringing to the science the concept of space-time symmetry. Is become clear that the fundamental determinant of existence is not just a space-time continuum, by the dynamics of STS. The most surprising twist in the view on the fundamental significance of the Noether theorem is the discovery of the fragile nature of symmetry in the physics [Nakamura & Sato. 1962, Znojil. 2004] and biology [Noble et al. 2012]. An apparent sharp difference between the living and non-living worlds requires close attention to the diverse network of links and associations of STS with the notions of entropy, statistics, phase-transitions, thermodynamics, as well as homochirality of protein synthesis and physiology of biological information processing.

Physics

It is beyond the scope of this article to elucidate the physical significance of STS in the mathematical language (see, [Bernabeu 2020; Qadir & Camci. 2022], but the logical ground for understanding is provided.

Fragile Space-Time Symmetry

In physics and mathematics, ST structure is characterized by the symmetry variable [Höhn & Müller. 2016]. The definition of mirror reflection operation points to the dimension-dependent number of the isomers and dimension-specific symmetry groups. From the mathematical formalism of quantum physics, the equations of motion can operate differently or uniformly over time and space transformations, providing the degree of freedom to interpret the appearance of the physical world

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[Atkins. 1974]. The STS (in quantum mechanics, the parity transformation is the flip in the sign of one, several or all spatial coordinates) is mathematically linked to the variable of the symmetry groups (which can be chiral and achiral). Gauge symmetry group transformation, requiring the invariance of physical state in ST domain, mathematically is the change of the phase of the wavefunction of elementary particles. It is notable that all four fundamental quantum fields, including gravity, can be reconstructed within gauge symmetry fields theories, making it the backbone of modern physics [Lyre, 2009]. Space symmetry referring to isomerism, determines the existence of stereo-specific objects. One of the intriguing sub-classes of isomers are the enantiomers having dual representations. The pairs of enantiomers have the same constituents but opposite three-dimensional spatial arrangements or shapes or chirality. From a geometrical perspective, chiral objects are characterized by the absence of reflective or all symmetry elements. As the system of the whole numbers contains all natural numbers and zero, the system of symmetry transformation includes mirror reflection. In the case of chiral objects, mirror reflection produces two spatially non-identical enantiomers. Chirality, as the form of symmetry deficiency, plays a prominent role in the molecular biology of viruses [Ji et al. 2015] and higher organisms [Mezey. 1998; Wang et al. 2006]. Two enantiomers (chiral pair) are mirror images of each other (i.e., cannot be superimposed). The concept of chirality applies to objects of all known domains of space dimensions, including mega- and micro-scales**.** Lorentz symmetry group transformations reflect the fundamental symmetry of space and time, which are critical to many physical laws, equations, and theories, including the kinetic law of special relativity, Maxwell's equation for electromagnetism, Dirac equation for an electron, and the standard model (SM) of elementary particles (EPs) [Petitjean, 2019; Liu, et al., 2019; Petitjean, 2022; Anais & Pedro. 2019]. Notable that despite that, many predictions derived from the SM are confirmed experimentally, the theory contains unsolved problems that should be resolved. Physical events of different kinds, and scales, depending on the nature of fundamental forces involved, exhibit the effects of preservation / conservation and violation/alteration of charge symmetry

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(C-symmetry). parity symmetry (P-symmetry), and time reversal symmetry (T- symmetry) collectively known as CPT symmetry. We will narrow consideration to the P-symmetry, strongly linked to bio-molecular chirality [Barron, 2021; Huang, 2007; Quack & Stohner. 2001; Kumar, 2017]. Among many aspects of spatial symmetry, chirality gradually gains sharp attention. As mentioned before, chirality is the most common space-related (geometrical) characteristic of natural objects appearing in our universe at many levels of space size, from the world of EPs (EPsW) to the galaxy world (GW). The idea that not-interrupting chain of chirality transfer consists of distinct links between overlapping domains of spatial dimension has a long period of clarification. However, even now, we have luck or limited information regarding many links in this chain. In the history of science, we can see the corresponding continuity in the chain of logical conclusions. Ancient philosophers from the Democritus considered the shape (i.e., symmetry) of hypothetical atoms as determinants of the material world diversity. Later the intuitive symmetry consideration was used by Mendeleev for the establishment of periodic tables of elements. The symmetry arguments in physics and chemistry were traditionally used to find the solution to puzzles of symmetry transfer from atoms to molecules [Quack & Stohner. 2001; Kosso, P. 1999: Dunitz. 1996]. Consequently, it was found that molecular chirality is a determining factor in the external and internal symmetry of non-organic crystals and biological macromolecules, including proteins lipids, and DNA, [Dyakin, et al. 2017]. From a different perspective, an increasing line of convincing evidence suggests that stereo-specific chemical evolution may originate before the origin of terrestrial life from the contribution of the symmetry patterns of the macroscale galaxy dynamics [Cline, 2010: Takahashi & Kobayashi, 2019]. In other words, we have a bidirectional chain of chirality transfer across the space scale (see Fig. 1) as a causal factor of biochirality. Notable that formally opposing converse pathways point to the decisive role of fundamental forces of nature in the origin of bio-chirality. However, the phenomenological similarity and difference underlying the mechanisms of the succession of such events are not the mainstream of the scientific discussion. The progress in this

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direction should be grounded on more systematic and goal-oriented studies. The unifying view on the evolution of the time-space concept, covering the areas of spinors, quaternions, tensors, and differential forms, can be found in many published courses [Hestenes, 1966; Petitjean, M. 2021; Goodsell, 2000; Vaccaro, 2016; Billig, Y and Futorny, V. 2014].)

Symmetry and Relativity

In classical physics, symmetry, reference frames, and the relativity of frame-dependent quantities are intimately connected [Loveridge et al. 2018]. All variants of the relativity concept provide the distinction between the frame-dependent and frame-independent quantities of physical objects. In the Galilean relativity principle, the directions/angles, velocities, and time of events are invariant quantities with relativity encoded under the action of the Galilean group transformations. Einsteinian relativity considered additional invariants—the length of material bodies and time between spatially separated events with relativity encoded under the action of the Poincare group transformations.

The synthesis of symmetry and relativity concepts in the complex of theoretical approaches (including string theory (StrT), grand unified theory (GUT), and super unified theory (SUT) shaped the scientific conception of the physical and biological worlds [Huang, 2007-A, Gibney. 2014; Senami & Shimizu. 2020]. Symmetry arguments reveal critical importance in two opposing spatial domains of physics represented by the behavior of EPs [Gross 1996; Greensite & Matsuyama 2022] and the universe's structure [Kondepudi & Durand. 2001; Ananthaswamy. 2009; Palle. 2012; Vaccaro, 2016].

While the contribution of spatial symmetry of EPs to biological chirality is under theoretical development and experimental verification, the impacts of the mega-world and its mirror partner are mainly in the theoretical modeling. Hence, the chain of related questions remains open. As we can see, the history of science illustrates (represents) the chain of theories of natural events, including classical mechanics, electromagnetism, SRT, GRT, SM, and StrT. Notable that this chain represents the gradual

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evolution of the relativity concept in the direction of overlapping with the concept of symmetry. Spontaneous emerging and breaking of symmetry in space-time events are two complementary processes underlying the mechanisms of many physical phenomena in two opposing spatial domains of physics represented by the Higgs mechanism of EPs [Gross 1996; Greensite & Matsuyama 2022] and the universe's structure [Kondepudi & Durand. 2001; Ananthaswamy. 2009; Palle. 2012; Vaccaro, 2016] complemented by effects in condensed matter physics and biological objects [Brauner, 2010; Kharuk & Shkerin. 2018]. Beginning with Galilei, the many great names contribute to a proper understanding of the inherent link between the principle of relativity and the concept of symmetry. The most prominent of them are Newton, Lorentz, Minkowski, Poincare, Einstein, and Noether. Not trivial relations between the notion of STS and relativity principles are a continuous area of development and discussion in theoretical physics [Polulyakh. 2012; Friedman & Scarr. 2019; Mashhoon. 2019]. Generalized relativity principles say that all physics laws should be mediated concerning STS [Gross. 1996]. Accordingly, a generalized approach to understanding bio-chirality must be viewed in relation to STS.

The quantum mechanics, developing the mathematical language for relational formalism, bring more fundamental meaning to these affinity [Samokhvalov. 2020; Fields et al. 2021]. Accordingly, the identity of reference frames should be considered a form of symmetry. The quantum field theory (QFT) and theory of GRT, in their original forms, are both unsuccessful in description of the complete ensemble of the fundamental forces of nature. In the way to move forward, all modern attempts to develop the quantum theory of gravity, including string theory, are based on considering the STS [Dittrich. 2008; Fichet & Saraswat. 2020].

In fundamental physics relativity is recognized as “a first place where the idea of symmetry begins to be felt” [Penrose, 2011]. The physical properties of photon are the most convincing illustration of the natural link between the relativity principle and STS [Stedman. 1983; Cameron et al. 2017]. The history of science is the search for the mathematical expression of intuitive concepts of space, time,

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inertial motion, the principle of relativity, entropy, and symmetry. The idea of meaningful relevance between the relativity principle and the notion of symmetry has a long-term incubation period. It is a categorical imperative that the laws of nature must be the same for all observers. In the language of physics and mathematics, such invariability (or uniformity) is called symmetry. According to Newton (1642-1724), the relativity of inertial motion can be comprehended under a proper interpretation of notions of time and space (Newton, 1999). In agreement with this intuitive statement, it was shown that both the Galilean (1564 - 1642) and Lorentz (1853-1928) transformations might be derived from the relativity principle based on certain elementary assumptions regarding space and time (Arthur, 2007). In classical physics, the equality of physical laws is provided by Galilean transformations (G) and corresponding relativity principles {see equations (a) and (b)}. In this period of scientific experience, it was not expected the attention to the speed of light and, therefore, equality of physical laws was associated with the concept of relativity but not the STS. Experiments of Michelson and others (in the 1880s), showing the independence of the photon's speed from the relative velocity of its source and observer, inspired a new generation of scientists to find an agreement between classical and quantum mechanics. Conceptual changing postulated ontology of the universe from the three-dimensional absolute space to the four-dimensional space-time of relativistic physics open link between space-time symmetry and relativity principle [Field. 2001; Ajaltouni. 2014; Hon & Goldstein. 2005]. Explicit understanding the significance of closely related concepts of relativity and STS in physics requires the knowledge of a considerable mathematical background. This condition is an objective obstacle to sharing the achievements in modern physics with the field of bio-chirality.

The statement of Einstein (1878 - 1955) that "inertia resists acceleration relative to space" point attention to the inherent link between concepts of space, time, inertial motion, gravitation, and the principle of relativity [Lorentz, et al., 1923; Arthur, 2007; Pfister & King 2015; Valente, 2016]. The specific STS transformation, relating the speed of the physical object to the speed of light, which allows

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the laws of physics to be the same for all observers, is known as Lorentz symmetry transformation (L) (see equations a and b). The inclusion of gravity force and accelerating frame of reference undertaken by Einstein to move from SRT to GRT initiate essential new insight into the relativity principle, which finally brings an explicit recognition that the relativity principle is the symmetry-associated principle [Hon & Goldstain. 2005]. Hilbert and Klein's mathematical analysis of GRT field equations reveals some inconsistency. Resolving the problem, Noether comes to far-reaching conclusions (Noether's theorems). She showed that GRT could adequately describe natural events only under the assumption of an intrinsic link between concepts of symmetries, relativity, and gravity-induced curvature of space-time [Byer. 1999]. These theorems are perfectly in agreement with the role of four fundamental forces of nature in the macro- and mesoscale of physical events. Notable that an exploration of the symmetry role in the SRT shows that L transformation requires the speed of light invariance [Friedman & Scarr, 2019; Vilasi & Vitale, 2002**;** Samokhvalov.2020**]** – a conclusion consistent with the spirit of Noether's theorem. Relativity, space-time domain, and STS have become a significant focus of interest not only in the physics, mathematics, and philosophers of science, but also in molecular biology and neuroscience [Torretti, 1983; Auffray, & Nottale, 2008; Noble, 2012; Ross, 2021]. Noether's theorem [Noether. 1918] shows that a not-contradictive mathematical description of the conservation laws requires including the symmetry features. Consequently, in many theoretical works, it was confirmed that adequate solution of the equations of the Special (Friedman & Scarr, 2019) and GRT [Keller, 2002; Harrison, 2014] require specific assumptions regarding STS. Applying the relativity principle to the symmetry patterns of elementary particles (EPs) reveals that the helicity and chirality of EPs derived from the Dirac equation have a sharply distinct property (Dirac, 1928). The quantum mechanical variables of EPs, such as chirality and helicity, exhibit different behavior (being invariants or depending on the reference frame) for the massive (such as an electron) and massless (such as photon) particles. For example, the helicity of electron (spin ½ and velocity less than the velocity of photon in vacuum) depends on the reference

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frame, i.e., exhibit the relativity. The chirality of electrons is Lorentz invariant but is not a constant of motion. In contrast, for photon (spin 1), helicity is time-invariant. Notably, identifying the gravitational field with the ST curvature has led to the most influential predictions of general relativity, including the quantum structure of ST, the occurrence of the big bang, and the existence of black holes **[**Gronwald et al., 1998; Singh et al., 2004]. Our consideration of STS in most general terms is aimed to focus on the specific form of symmetry transformation in the space domain - mirror reflection, and their principal role in biological chirality. Accordingly, growing experimental evidence suggests chirality of the fundamental physical force may provoke asymmetric imbalance in a chemical system (either racemic or prochiral) [Guijarro & Yus, 2009]. As a result, it has become apparent that all above-mentioned fundamental principles of physical world (PW) applies to the biological world (BW) in general and to phenomena of biochirality precisely. Due to evolution and development, moving animals gained the ability of sensory perception of time, and space intervals, which in humans were transformed into intellectual reasoning regarding the relativity of movement, STS, and causality. Phenomenology is a philosophy of experience. However, the specific aspects of spontaneous symmetry breaking, and their physical ramifications are dispersed among the specialized literature of multiple subfields, making them not widely known or readily transferred to the area of biological science.

Fundamental Forces of Nature

From the geometrical perceptive, the objects across diverse spatial scales may be classified as chiral or achiral concerning a specific space-related symmetry transformation - mirror reflection. Chirality (or handedness) as a symmetry element reflecting the property of asymmetry (or dissymmetry) is the critical structural feature of natural systems, including living matter. According to SM, the symmetry parameters of elementary particles associated with the fundamental force of nature (electromagnetism, gravitation, strong interaction, and weak interactions) play a causal role l for all observed events in the universe at broad spatial scales from the subatomic (10^{-16} meters) to

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cosmological (10^{20} meters) levels. Biological matter, represented by amino acids, macromolecules, cells, organs, and organisms, corresponds to the narrow intermediate scale interval (1.0 - 10^{10} nanometers). The assumption that ST evolution is the primary source of the phenomena in mega- and micro-worlds [Vaccaro, 2016] immediately points to two complementary fundamental causes of biological chirality. In other words, the inheritance of molecular symmetry from the symmetry of EPs means the bi-directional pathways leading to the origin of prevalent bio-chirality. One thought an impact of the symmetry of atomic orbital on molecular chirality and others through an organism's environmental and ecological domains, which means that both extremities of spatial dimension naturally shape the appearance of all transitional states.

The unification of four fundamental forces of nature in the StrT allows presupposing the natural link between micro-, meso-, macro-, and mega- worlds (Fig 1) [Livio, 2012; Salam, 2005]. It is not accidental that the central StrT is an assumption of the symmetry between fermions and bosons, which can be tested experimentally [Ezio, 1997]. Recognition of the significance of STS in particle physics promotes the idea that parity violation (PV) on the micro-scale may contribute to the molecular component of biochirality. Indeed, one of four interacting forces (weak nuclear force) demonstrates the specific effect of parity violation, which is supposed to interfere with the geometry of sub-atomic particles and, consequently, the homochirality of molecular compounds, including DNA, proteins, and lipids. The experimentally observed parity PV for the weak nuclear force may presumably lead to the energy difference between the ground and excited states of biomolecules. The fact was predicted by theory and proved experimentally Ellis & Silk, 2014; Letokhov, 1975; Darquié, et al., 2010; Lin, et al., 2016]. Despite their different appearances, all four interacting fundamental forces of nature, and corresponding vector fields, exhibit inherent relation to the various forms of the STS. It is reasonable to expect that factors contributing to biochirality are probably not restricted to the impact of the weak nuclear interaction. For example, the possibility of PV in gravity is widely discussed [Yamada &

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Tanaka. 2020; Cai et al 2022].

Bio-chirality

Conservation quantities (conservation laws) in all domains of physics, including quantum mechanics of indistinguishable quantum particles (fermions and bosons), are always related to the symmetries of the system [Feynman 1957; Viazminsky. 2018]. The symmetries determinants, critical in classical and quantum information processing [Penchev.2021], are recognized as the mechanisms underlying biological information processing [Higgins et al. 2022; Hermann & Schmidt. 2022] According to current knowledge, "the mechanisms which ensure invariant left-right asymmetry of the heart, viscera, and brain represent a thread connecting biomolecular chirality to human cognition, along the way involving fundamental aspects of cell biology, biophysics, and evolutionary biology" [Levin. 2005]. The occurrence of such connection is bearing by the hieratical chain of chirality transfer [Dyakin et al.2017- A). Notable that the stereo-divergent chain of chirality transfer between hierarchical levels of biological organization was observed experimentally, including in Bottom UP and Top-Down directions [Chiccoli et al. 2013; Huang et al. 2021; Cheng et al. 2021; Zhang et al. 2022; Sevim et al. 2022].

The best-studied examples of the interplay of symmetry and asymmetry in biology are the bilaterality and handedness of animal body morphology and functions. Bilaterality (symmetry) and hemi-lateral asymmetry (handedness) are distinct features in the morphology and functions of the human body, nervous, sensory, and cognitive systems. Left–right asymmetry in morphogenesis occurs at the early stages of embryonic development [Levin. 2005]. In the human brain, functional hemispheric asymmetry is evident in division of labor between language (left hemisphere) and motor (right hemisphere) functions [Toga & Thompson. 2003; Li et al. 2020].

Hierarchical Levels

All forms of life, from single-cell eukaryotes to complex, highly differentiated multicellular

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"organisms, exhibit a property referred to as symmetry" [Gandhi, et al. 2021].

The common belief that molecular chirality is a central feature in the origin and evolution of biological systems is reflected in many reviews [Keszthelyi. 2009; Dyakin, et al. 2017-A, Barron, 2021; Wang, 2022]. The emergence of chirality of life, is associated with the break of symmetry at the molecular level. However, the causality of biomolecular asymmetry remains so far characterized as an "unanswered question" or [Devínsky. 2021; Lee et al. 2022]. Most common of them are: "did life begin by using both forms of chirality, and then one of the forms disappeared" and "did the choice of homochirality precede the formation of biomolecules"? In our view, the resolution of such uncertainty calls for broader outlook on biochirality phenomena. The science tracing the links between biological events, including the prevalent bio-molecular chirality with the laterality of perceptual, cognitive, and psychiatric functions, gains the name biological chirality or bio-chirality [Gal & Cintas. 2012]. The chain of chirality transfer within BW, ranging from molecular chirality to brain cognitive laterality (bio-chirality), is a well-studied phenomenon for animal organisms [Dyakin, et al. 2017-A, Tamada, A. 2019, Huang et al. 2021] discussed in detail in several comprehensive reviews [Devínsky. 2021; Barron, 1986; Mao, 2021]. A hierarchical chain of chain of chirality transfer within the bio-molecular system is experimentally observed for amino acid's spontaneous and induced self-assembly into chiral aggregates [Ribó. 2017; Huang et al. 2021]. The essential feature of the chain of chirality transfer in biology is bi-directionality, meaning that each link (and any sequence of the links) experiences the asymmetric impact 'from the left- and right- neighborhoods. The molecular chirality of plants and animals has many common features. Animals and plants originated from a common, single-celled, and motile eukaryote probably 1.5 billion years ago. Animal cells, developing motility, become the basis for the evolutionary origin of mobile multicellular bilateral organisms. Movement, associated with competition for food and predation, leads to elaborating sensory systems, contractile muscles, and a fast-reactive, bilaterally-asymmetric nervous system enabled survival [www/ 2020]. The bilateral symmetry of organisms is

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characterized by body shape divided along a plain of mirror reflection. Left-right morphological handedness and prevalent chirality of biological molecules are incidents/examples of geometrical similarity among chiral (not-superimposed) objects of differential hierarchical complexity. The corresponding complex of the experimentally observed facts supports the hypothesis regarding the chain of chirality transfer from molecular structures to the morphological and functional characteristics of the organism [Dyakin, et al. 2017-A]. The evolution of morphogenesis of moving animals is driven by the fluctuating asymmetry (FA) that represents small, random developmental differences between the right and left sides [Benítez et al. 2020]. A well-known example of chirality transfer from the molecular to the cellular level is that major cytoskeleton components of eukaryotic cells, such as actin microfilaments and microtubules, result in polar filaments of one chirality responsible for cell handedness [Satir, 2016]. The opposite chain of chirality transfer to BioW originates from the macro-domains of space, apparent in the structure of GW. The solar system containing the planet Earth encapsulating the BW is just one of many other intermediates (Fig 1).

The predominance of molecular handedness in biological objects is frequently considered a unique signature or property of life. This widespread point of view (being encouraging for many biologists) contains two essential destructive elements leading to deviation from objective reality. First, the word unique is compromising the truth of this statement. Second, it is misleading in the search for the origin of biomolecular chirality and laterality of cognitive functions. The escape from such a dead end is possible only based on a broad point of view based on the attention to the advances in understanding the fundamental laws of nature, signifying the significance of the symmetry concept. Our attempt is the generalized (i.e., philosophical) transection organism bio-chirality considered from internal, external, and behavioral aspects. The information processing mechanism of the human brains challenged with the task of discriminating the event across both space and time domains, examined by sensory perception and reasoning [Longo, 2011]. As we mentioned early, sensory perception of moving

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objects differentiates itself into the chain of more specialized patterns: perception of time-space intervals, symmetry, and causality. On another side, spontaneous symmetry emerging and breaking in space-time events are two alternative processes underlying the mechanisms of many physical phenomena ranging from condensed matter physics and the Higgs mechanism in the standard model of elementary particles to biology [Brauner, 2010; Kharuk & Shkerin. 2018]. The external determinants of the living organism bio-chirality are rooted in quantum physics. The quantum hydrodynamic approach to particle physics justifies the continuous spontaneous formation and annihilation of virtual particles and antiparticles (vortex-antivortex pair) in a quantum vacuum. The handedness of EPs, in combination with the experimentally observed asymmetry in spiral galaxies, originated from chirality from giant vortices of the central black hole [Huang, 2007-A: Tasker 2015] suggests that the left-handed bias of weak nuclear force and the rotation of the cosmic superfluid would explain the left-handed bias in biological molecules (bio-chirality) [Jordi, 2022]. Bio-chirality of the living organism has its internal determinants at the atomic and molecular levels. At the atomic level of events, the coupling of the symmetry parameters of elementary components, including protons, electrons, and photons, plays a critical role. In agreement with Lorentz-Poincare symmetry transformations and Noether's theorem [Blackmond, 2022: Noether, 1918], the dynamic changes of local quantities of the electromagnetic field associated with the helicity and chirality of spin and orbital components momentum of electrons, are coupled with the energy state through helicity and chirality of emission/absorption of photons. The underlying physical laws are considered as fundamental determinants of light-matter interaction [Cameron, et al., 2017; Bordács, et al. 2012; Forbes & Andrew, 2021]. The interaction between chiral matter and circularly polarized light (as events occurring in both space and time domains) is determined by the combination of physical parameters influencing the degree of stereo-specific effects [Crimin, et al., 2020]. Electron-photon coupling is an illustrative example of stereo-selective (chirality-dependent) interaction between mass carriers (fermions) and massless (bosons) EPs [Cottet, et al. 2015, Mun, et al. 2020]. The subjects of

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particular interest here are the laws common to the non-biological and biological worlds. In other words, the question is what kind of universal phenomena embrace the domains of non-organic and organic nature. The broad-view picture suggests that the emergence and evolution of the BioW on the Earth occur under the collective impact of GW and world of EPs. Consequently, the most fundamental law of BioW, associated with the spatial domain of existence, is biological chirality or bio-chirality.

Molecular level

The internal determinants of cellular and organismic bio-chirality are molecular complexes including, proteins, DNA, and lipids. Corresponding external determinants are related to the geo-centric realms of existence, such as the local environment and biosphere, as a whole (Fig. 1). Apparently, the distinction of determinants as internal and external is not absolute because the impact of fundamental forces of nature is essentially bidirectional. The spectrum of hypotheses considering the origin of biological homo-chirality is consistently expanding. Some analysts appeal to parity violation due to energy difference in the chiral molecules attributed to parity violation energy difference (PVED) [Devínsky. 2021; Barron, 1986, Davankov, 2018]. Others link the origin of prevalent bio-molecular chirality to the impact of external to organism factors such as the handedness of the axial and orbital rotations of the Earth, asymmetric fluctuation of the atmospheric and oceanic media [Guo & Sun, 2014], and spiral structure of galaxies. However, all of them are focused on considering the spatial symmetry attributes of the corresponding objects. Molecular chirality (i.e., an association with symmetry constraints) originates from the symmetry of atomic constituents, including electrons and protons, inherent to all members of the periodic table of elements. Experimentally observed CISS effects in α-helical proteins and DNA structures attract attention to theoretical consideration of the mechanism of electron spin selective transport in biological molecules [Crimin, et al., 2020]. The emergence of biochirality mechanisms is generally classified as biotic or abiotic. The discrimination between them should not shadow the fact that chirality linked to fundamental STS is the common feature of living and

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non-living (soft and solid) matter. This view is supported by the experimental observation of various spin-dependent molecular processes driven by the external and internal chiral physical force [Forbes & Andrew, 2021, Avalos, et al. 1998: Mineo, et al. 2014; Mondal, et al. 2016; Rosenberg R.A. 2019; Pavlov, & Klabunovskii, 2015; Dyakin et al. 2017-B; Dyakin et al. 2021; Chotera, et al., 2018]. Notable, that all organic molecules contain a limited member of evolutionary selected chemical elements (carbon, hydrogen, oxygen, sulfur, nitrogen, and phosphorus). The primary cause of such selection is the unique symmetry of atomic orbitals, allowing the ribosomal synthesis of homochiral proteins and vital stereo-selective interactions within the DNA-proteins-lipids complexes. It is the common view that the biological systems, representing thermodynamically open non-equilibrium state characterized by the bio-molecular phase transitions, are associated with the symmetry transformations (symmetry changes or "breaking") [Mondal, et al. 2016; Rosenberg R.A. 2019; Pavlov, & Klabunovskii, 2015; Dyakin et al. 2017-B] and not trivial bi-directional behavior of entropy (Kohut, 2016; Dyakin, et al. 2017-A). Notably, the evolution of galaxy clusters exhibits similar bi-directional (decreasing and increasing stages) entropy patterns [Korenić et al., 2019; Dyakin et al., 2022, Dyakin & Uversky. 2022; Voit, 2005]. The fundamental significance of biochirality at the molecular and cellular levels assumes the mechanisms of the organism/brain morphology, behavior, cognition, and consciousness are grounded on basic principles of spatial organization and function. Indeed, the biochirality concept is closely associated with all vital events of organism, including the fertilization, asymmetric cell division, organism development (bi-laterality), biological information processing (brain functional asymmetry), and aging [Rosenberg R.A. 2019; Pavlov, & Klabunovskii, 2015; Dyakin et al. 2017-B; Iqbal, 2011; Aoki. 2012], Szabados. 2022; Gal, 2013; Boyd & Famiano.2018; Chen & Ma. 2020]. The study of the mechanism of human consciousness and cognitive functions traditionally concern the sensory perception of space-time geometry [Stocke. 2014; Moser et al. 2015; Hameroff. 2001; Pillai & Jirsa. 2017; Signorelli et al. 2020].

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The view that "time and space are tightly blended in the brain" is supported by most advanced studies of perceptual and cognitive functions [O'Keefe. 1978; Peer et al. 2015; Buzsáki & Llinás. 2017; Bihanabc. 2020]. Notably, the functions of place cells are attributed to the population of pyramidal neurons, which presumably serve as a gravity-based three-dimensional compass in the brain [Angelaki et al. 2020]. Understanding molecular chirality as a unique characteristic of biological structures is misleading. Three-dimensional shapes of both biological and non-biological constructs exhibit intrinsic chirality at the molecular level. The intrinsic determinant of molecular chirality is the symmetry of quasi-stable atomic complexes, which, in turn, is driven/governed by the symmetry of sun-atomic elementary particles. An illustrative example of symmetry constraints, common to organic and non-organic molecules, is chiral-icosahedral shells observed for Au60 spere and capsids (icosahedral shells of proteins around a single RNA molecule) of many icosahedral viruses [Valeriy. 2005; Mullins et al. 2018; Laurent et al 2021].

After Words

The commutative power of experimental results and theoretical developments suggest that the non-equilibrium state of the universe characterized by the increase of entropy is inevitably linked to the compensatory processes of self-organization (decrease of entropy). At the molecular level, such compensatory events are associated with the mechanism of chirality dependent protein folding as distinct phenomenon of life. Notably, from a theoretical perspective, self-organization is considered a new form of global STS, namely, scale-invariance reflecting the dynamics of energy/matter at all levels of organizational hierarchy, from elementary particles through cells and organisms to the universe as a whole [Kurakin. 2011; Gaite. 2020].

Conflict of Interest statement

The authors declare that there are no conflicts of interest.

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Equations (a) and (b). (a, b). Galilean and Lorentz L transformation (G and L): coordinates (t′,x′,y′,z′) of an event in K′ system correspond to the event's coordinates (t,x,y,z) in K system.

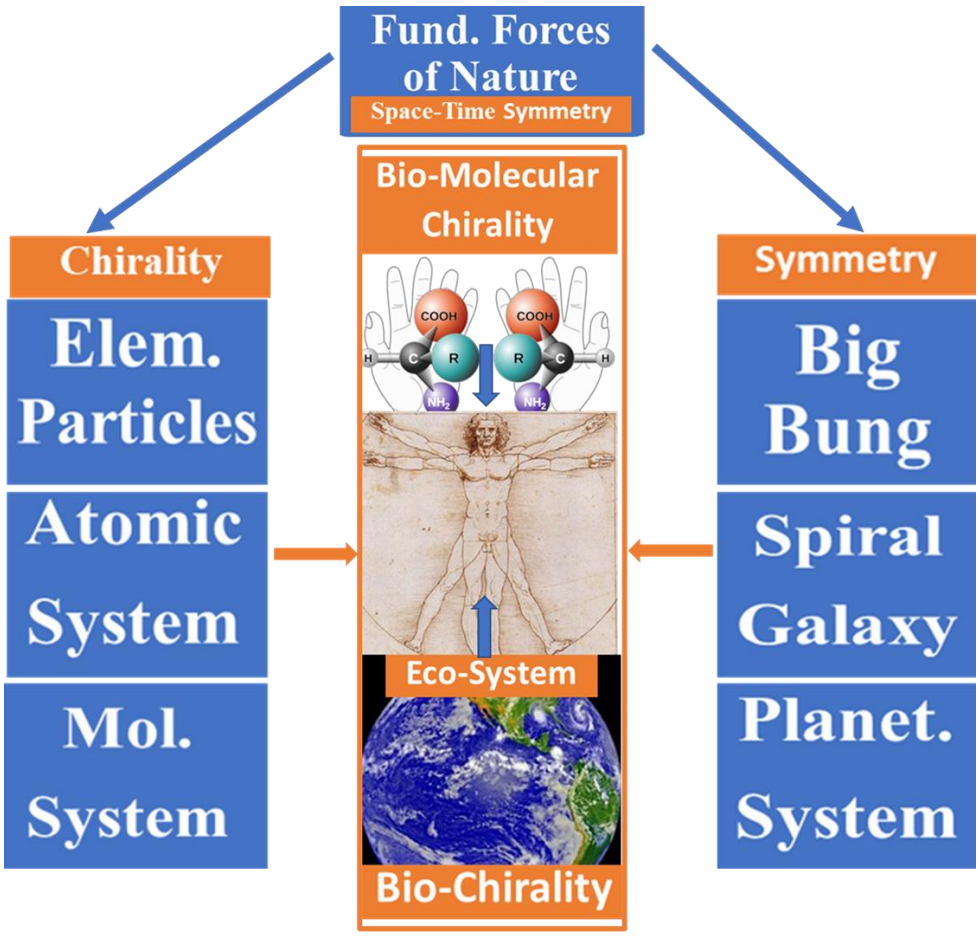
(a)

$$x' = x - vt$$
$$y' = y$$
$$z' = z$$
$$t' = t.$$

(b)

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}$$
$$y' = y$$
$$z' = z$$
$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Fig. 1. Bidirectional chain of chirality transfer. Internal and external determinants of Bio-Chirality. After the Big Bang, the four forces divided as the cooling Universe underwent sequential phase transitions. Adopted from [Huntley. 2012] and [WWW. 2022] with alterations.



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