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Conceptual Models regarding Internal and External Dynamics and Their Interaction in Biological Phenomena

*Hosei University
2-17-1 Fujimi, Chiyoda-ku, Tokyo
yuichi.nishida.7g[at]stu.hosei.ac.jp
Yuichi Nishida

Much research has been done on the evolutionary processes and general properties of life from the fields of systems biology, mathematical biology, and evolutionary biology. Life is a system in which micro and macro are coordinated and subsystems are organized to maintain metabolism and function. Life also has systems that maintain homeostasis within the body. Life adapts to time and space, responds to change, and exchanges information. In addition, the evolutionary processes and mechanisms of living systems are attempted to be elucidated from the perspective of chaos theory. Life phenomena are said to be systems that resist the law of increasing entropy by acquiring energy from the environment and generating entropy. Thus, life is a complex process in which information, energy, material interactions, dynamic systems, and environmental changes are variables. This study proposes and discusses several hypotheses that explain and generalize these mechanisms and processes. This study considers the relationship between diffusion and convergence, temporal continuity, selection and adaptability, adaptive time and space micro and macro, temporal stagnation and spatial expansion, universal properties, edges of chaos, and entropy in life phenomena. Moreover, We propose several novel hypotheses on the stochastic distribution of genomic information, its interaction with space-time probability space, and evolutionary processes in the dynamism of life phenomena, and discuss their relationship with probability statistics, fractal geometry, and chaos theory.

Key words: Life System, evolution, genome information, probability distribution, organizing

1.1 Background and Objectives

The spontaneous generation of some order or pattern from a spatiotemporally uniform state is called self-organization of the system into that state. Fatty acids aggregate to form vesicles, spontaneously forming a stable order in thermal equilibrium [Ohta, 2008]. [Ohta, 2008].

Life uses a mechanism called Brownian ratcheting, which uses an asymmetric ratchet-type potential to rectify diffusion in order to resist the increasing entropy of the environment. In this process, only fluctuations in one direction are extracted from thermal fluctuations using asymmetric walls [Toyabe, 2022] The process is called Brownian ratcheting.

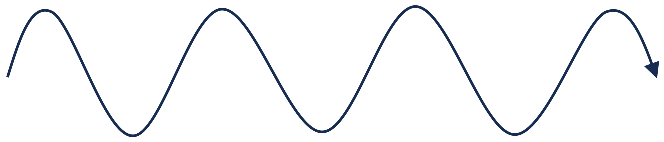
Life is also explained by a binding closed circuit, in which binding conditions due to non-equilibrium processes perform tasks, which in turn construct binding conditions (Montèvil M, 2015) .

Moreover, for a chaotic solution with initial value sensitivity to continue traversing a limited region of phase space in three or more dimensions without crossing orbits, the orbits must necessarily have an infinite nested structure, i.e., a self-similar structure. [Ohta, 2008] [Ohta, 2008].

method

New hypotheses on the mechanisms of biological systems of organisms and their material interactions, changes in the dynamics of the system, adaptive space and evolutionary mechanisms, and genome interactions in the evolutionary process will be developed through theoretical analysis using abstract models.

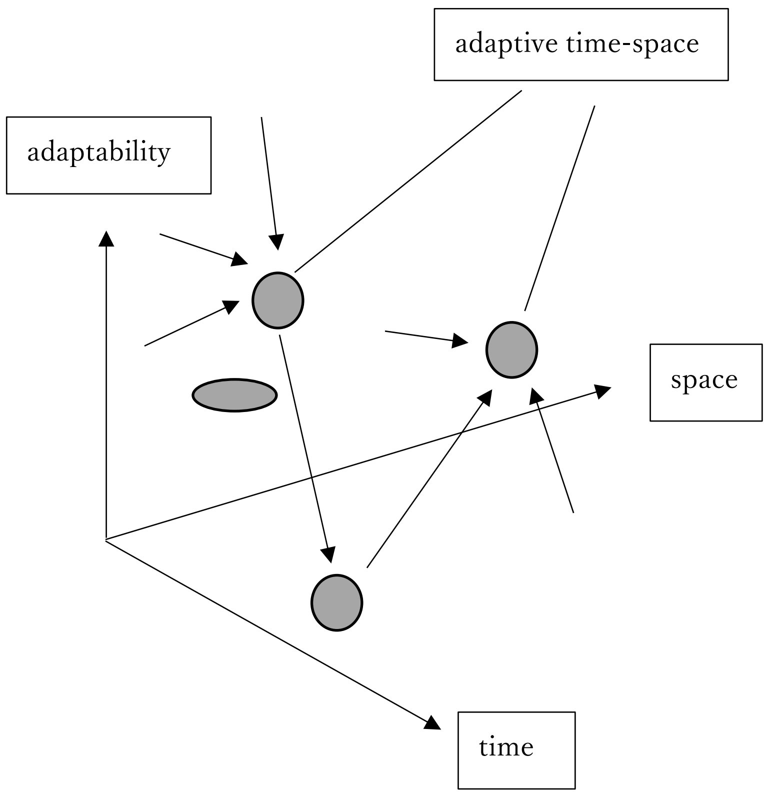
1.1.1 Hypothesis 1 Individuals with stable homeostasis are less exposed to inadvertent risks and remain in the environment for longer periods of time.



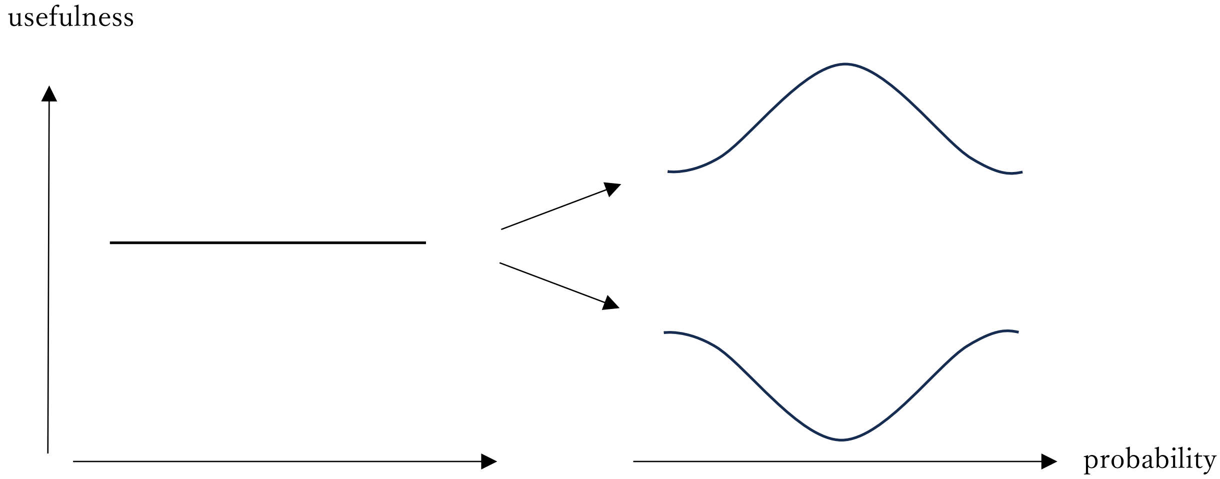
1.1.2 Hypothesis 2: Nucleotide chains, being equivalent and equally spaced, are equally affected by entropy and may be suitable for storing genomic information with a high degree of accuracy.

1.1.3 Hypothesis 3 When the trait is important, the trait is frequently encountered with the complementary strand, and the genomic information resists environmental entropy. On the other hand, if the trait is unimportant, there will be few encounters with the complementary strand, and the genomic information will be cluttered by the entropy of the environment.

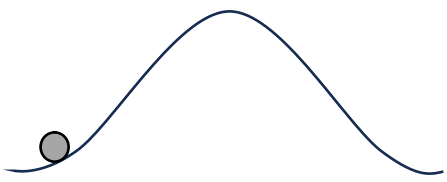
1.1.4 Hypothesis 4 Life phenomena may be described as a process of sustained material interaction mediated by adaptive spatiotemporal and adaptive information linkages.

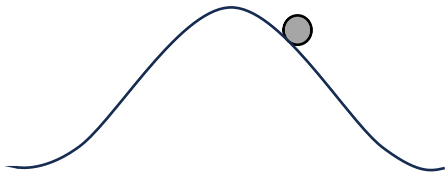


1.1.5 Do genomes in the environment separate genomic information into highly useful and less useful information?

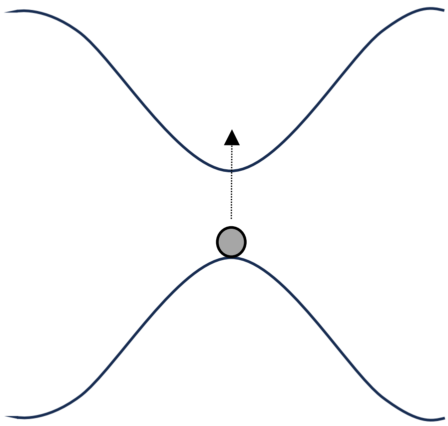


1.1.6 Individuals that analyze selection pressure earlier are more likely to overcome it.

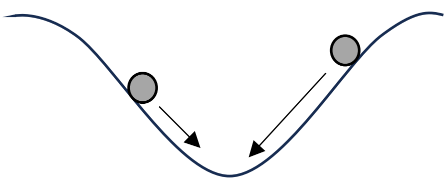




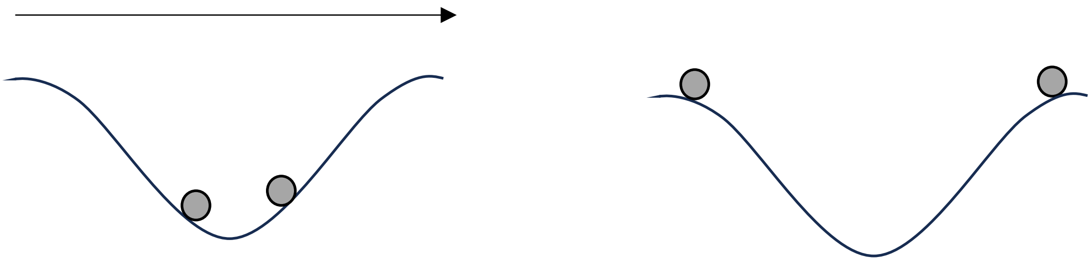
Individuals with greater environmental support, greater stamina, and those protected by a stable system will overcome selection pressure.



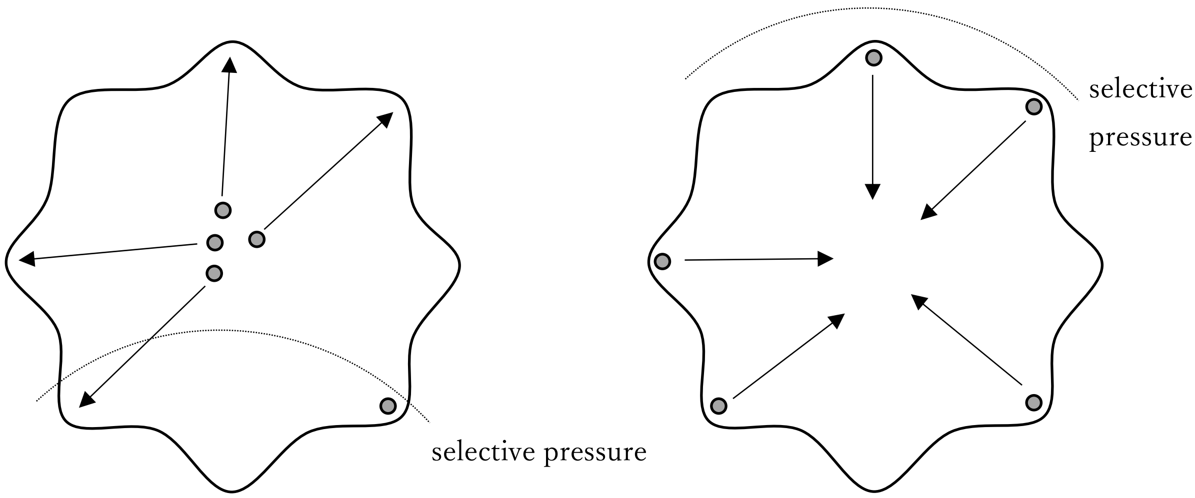
In the hollows of time space, many individuals congregate and genetic homogenization and coevolution occur.



Such spacetimes are less sensitive to selection pressure, and when the selection pressure is eliminated, individuals are supplied from the time space hollows.

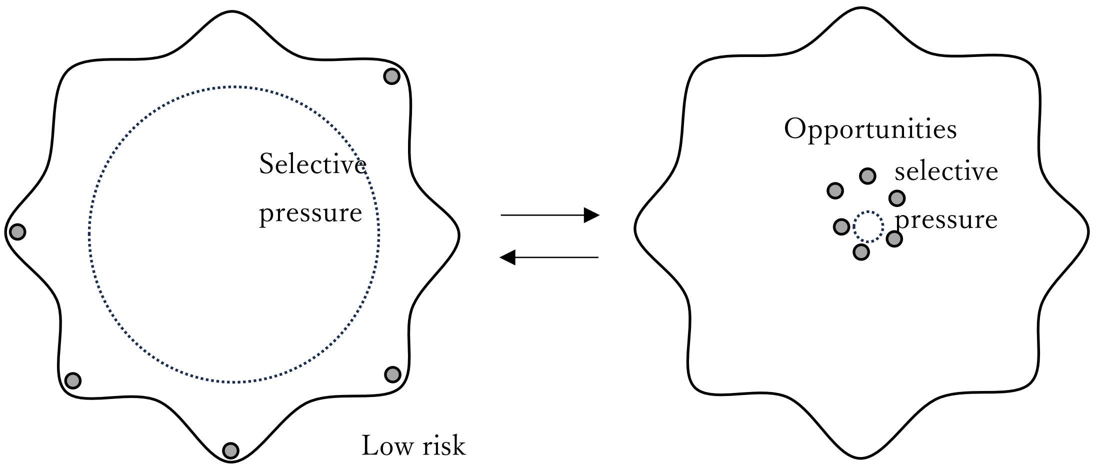


1.1.7 Life is protected from selection pressure in the space-time depression, and when selection pressure decreases, life diffuses out of the space-time depression and comes into contact with other individuals.



Through a series of such processes, life organizes an adaptive genome, increasing abstraction and stability.

Also, is the evolutionary process of life based on an adaptive space-time inversion phenomenon due to the expansion and contraction of selection pressure?



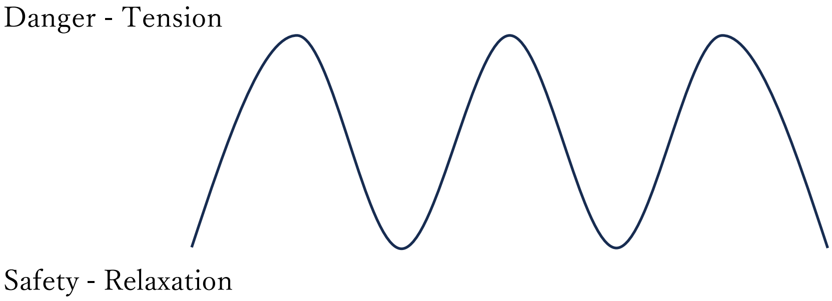
Wisdom, abstraction, and combining system

New information, analytical capabilities, efficient biological systems

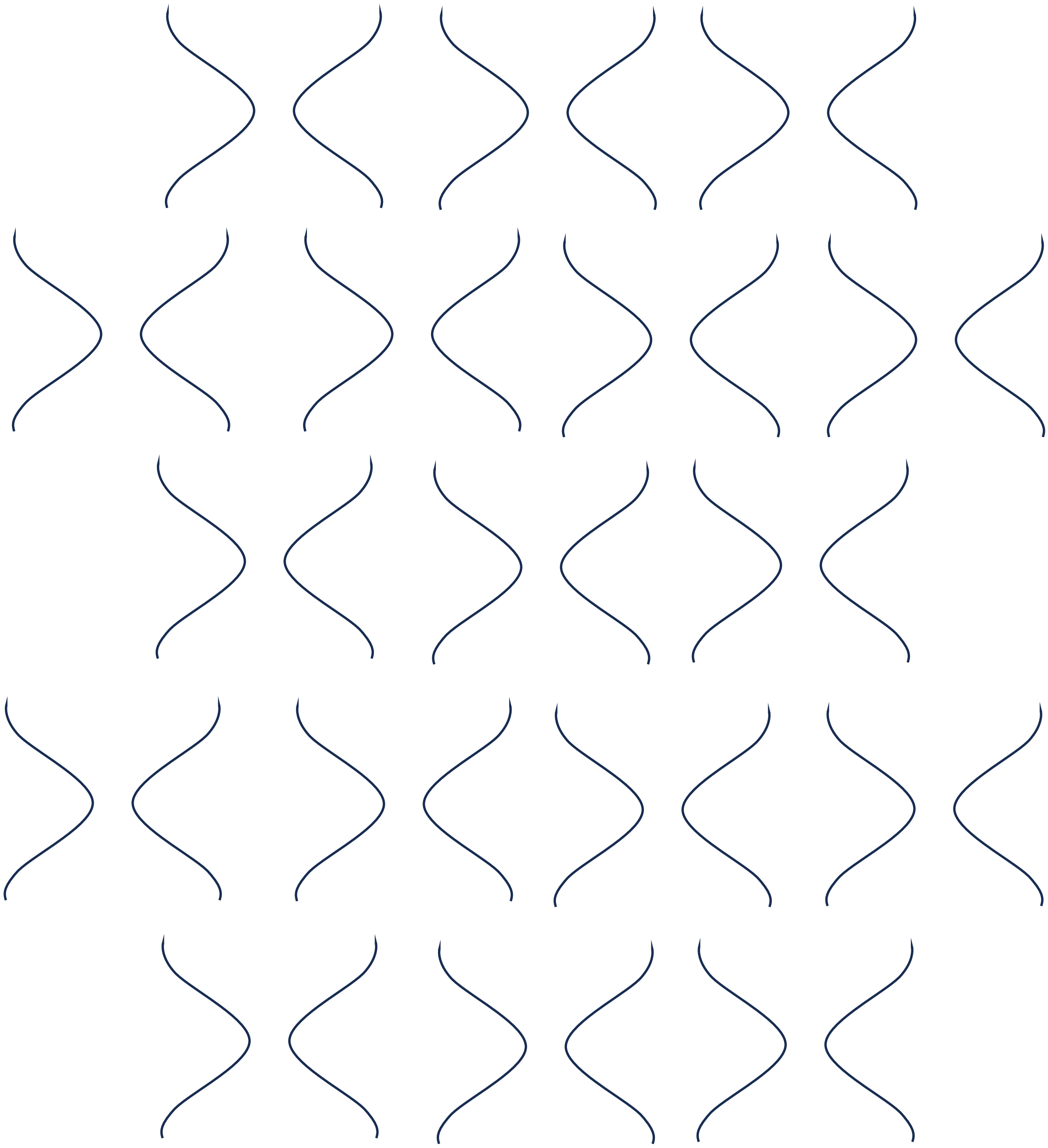
1.1.8

The repetition of tension and relaxation is both a support from the outside world and a selection pressure for the organism in terms of effective use of resources, processing of information, construction of forms, evolution of communication systems, organization of individuals, effective use of time, and relationship with the environment.

Individuals may be said to develop average and dynamic adaptability through an iterative process of organizing safety-relaxation and risk-tension to their own adaptive advantage.



Is there adaptive range expansion and contraction in space-time, and does life repeatedly organize space-time and overcome selection pressure to enhance time - space abstraction, temporal coping with adaptive space-time changes, temporal dwell, the ability to analyze adaptive space-time, and spatial expansion?



(This is untested hypothetical paper and additional experiments are needed to establish evidence.)

2.1 Background and Objectives

Life phenomena form biological tissues and resist the increase of entropy in the environment by absorbing and expelling substances. Life phenomena have a homeostasis, or homeostasis, and their activities are established by the alternation of phenomena such as absorption and efflux, tension and relaxation.

The property of life to resist increasing environmental entropy is described as a microscopic equation of increasing entropy by distinguishing thermodynamic processes into reversible and irreversible processes, corresponding to the Boltzmann symmetry in this equation. In Boltzmann-type equations, the collision term is preferential and the flow term is odd with respect to the Liouville operator L [Prigogine, 1984]. The Boltzmann symmetry is described by the following equation.

The non-equilibrium process of resisting entropy in the environment of life is also supported by the light energy supplied by the sun [Tanaka, 2007].

Life is said to be the physical realization of a recursive information system [Tanaka, 2007].

The mechanism of circadian rhythms in organisms is explained by gene regulation by negative feedback [Mochizuki, 2021]. The mechanism of circadian rhythm of organisms is explained by gene regulation by negative feedback [Mochizuki, 2021].

Genomic information donates genetic information to build biological systems, and biological systems accept feedback about whether their traits are adaptive or not, depending on the environment. Selection underpins the formation of order through information [Tanaka, 2015].

In the process of development of an organism, existing tissues support the development of new tissues, but the existing tissues also select cells.

While organisms acquire new traits from foreign genomes, such as viruses, their genetic information can be disrupted.

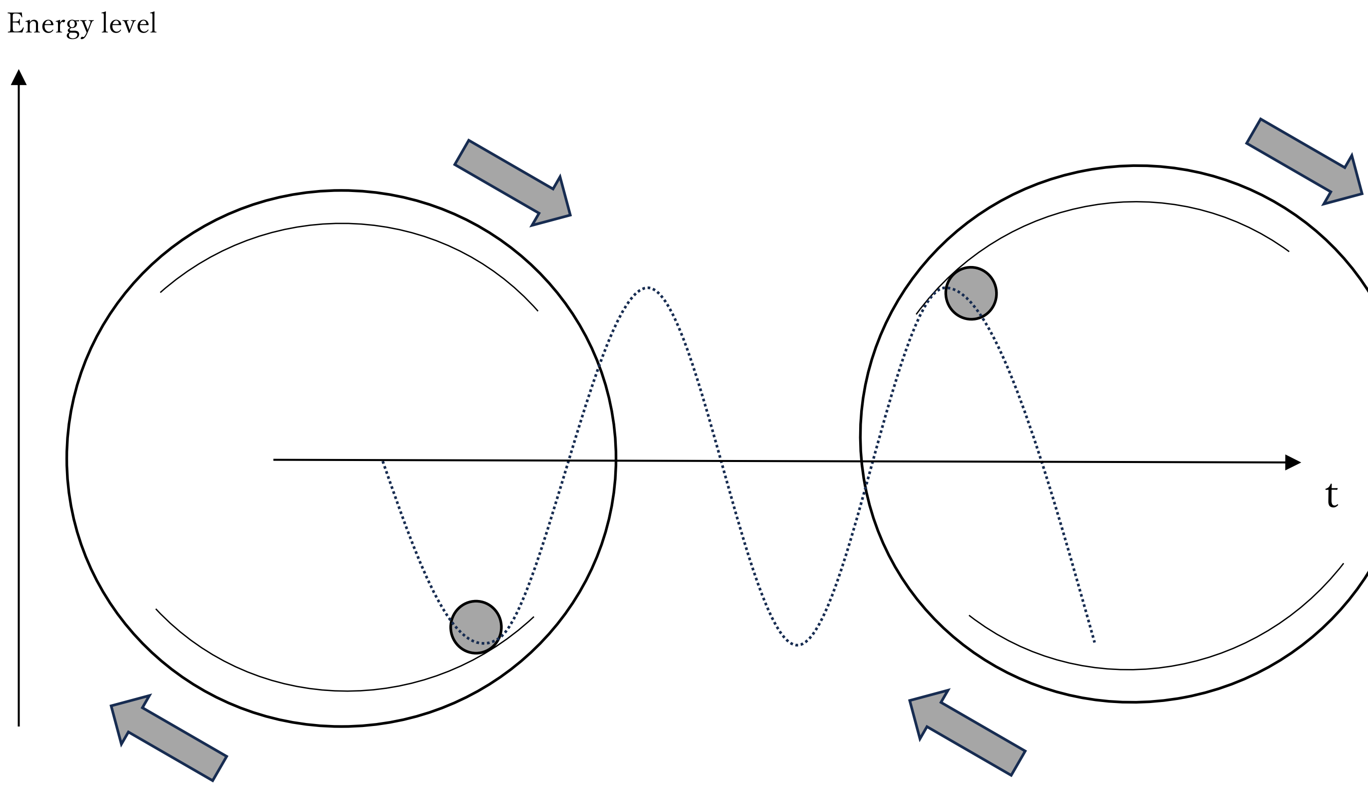
In addition, organisms receive support from the environment in the form of nutrition, information, and space for survival, and they are subject to selection pressure from toxins, hazards, and events that threaten their survival.

Method

We will analyze such external inputs and outputs in life phenomena, the repetition of the same phase, the maintenance of homeostasis thereby, and the mechanisms of autonomous evolution. In most cases, we focus on the mechanisms of support from the environment and selection by the environment that promote individual growth and evolution. We will attempt to describe an abstract physical model of an autonomous living system that evolves and persists through interaction with its environment.

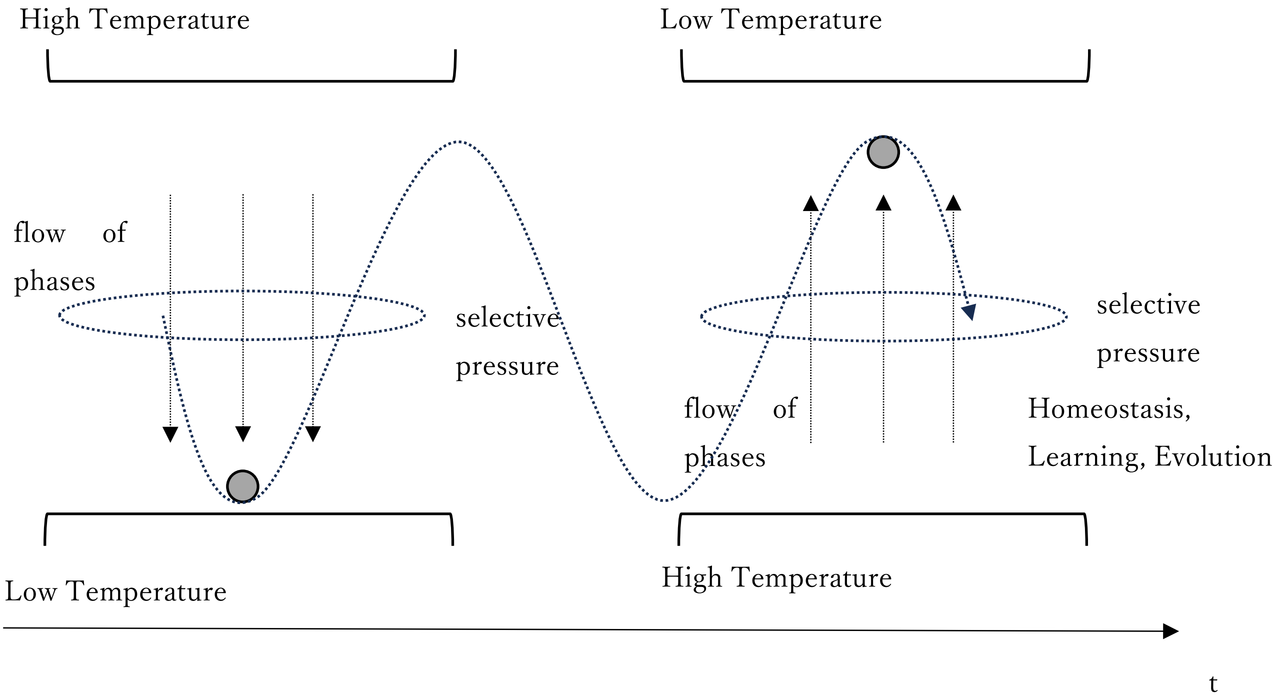
2.1.1 It seems possible to generalize the life phenomenon as the following schematic diagram

A wheel with support on one axis and culling on the other rotates, and the sphere repeatedly rises along the rotation of the wheel and falls under gravity, generating a rhythm whose waveform oscillates in the direction of the time axis.

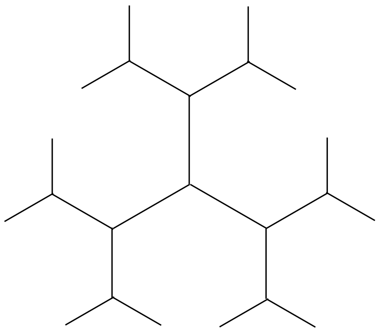


By repeatedly alternately receiving such support and selection pressure from the environment, life may evolve and increase its ability to resist increasing entropy in the environment. The ability to organize the support and selection pressure from the environment may be an indicator of the adaptability of individuals.

In addition, such a process is also a circadian rhythm of cyanobacteria by phosphorylation and dephosphorylation of proteinsand changes in the motility and metabolic mechanisms of biomolecules induced by temperature changes. [Mochizuki, 2021]. [Nakamura, 2014]. processes may be related to the environmental cycles that exist on Earth.



The Bethe lattice is a model of a tree-like structure with repeated branches. In a Bethe lattice, a lattice point is placed at the end of a bond placed around a lattice point, and then a lattice point is repeatedly placed at the end of a bond placed at that lattice point, creating an infinitely large lattice.

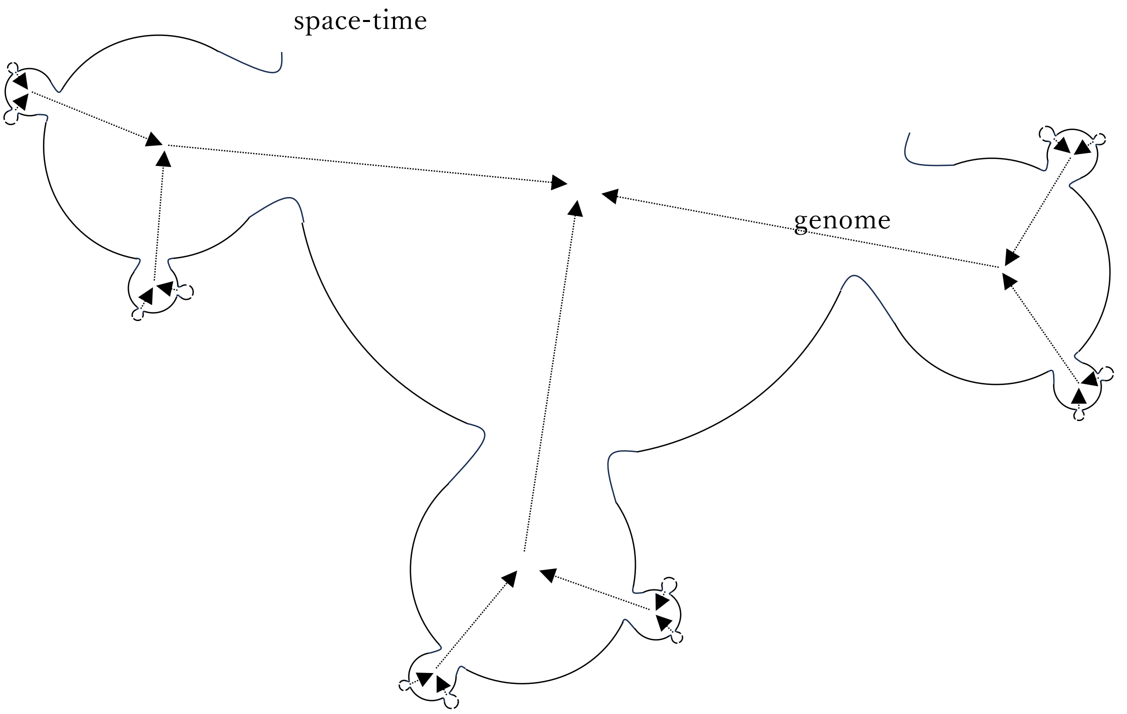


Bethe Lattice

As a way of expressing the relationship between the gene frequency of an organism and the degree of adaptation of its environment, a selection topography exists in which the planar axis represents the trait and the height represents the degree of adaptation [Simpson, 1949] . In a selection landscape, genetic divergence occurs when one population is pulled up to another differently adapted vertex at a contour line determined by the characteristics of the environment [Schluter, 2012].

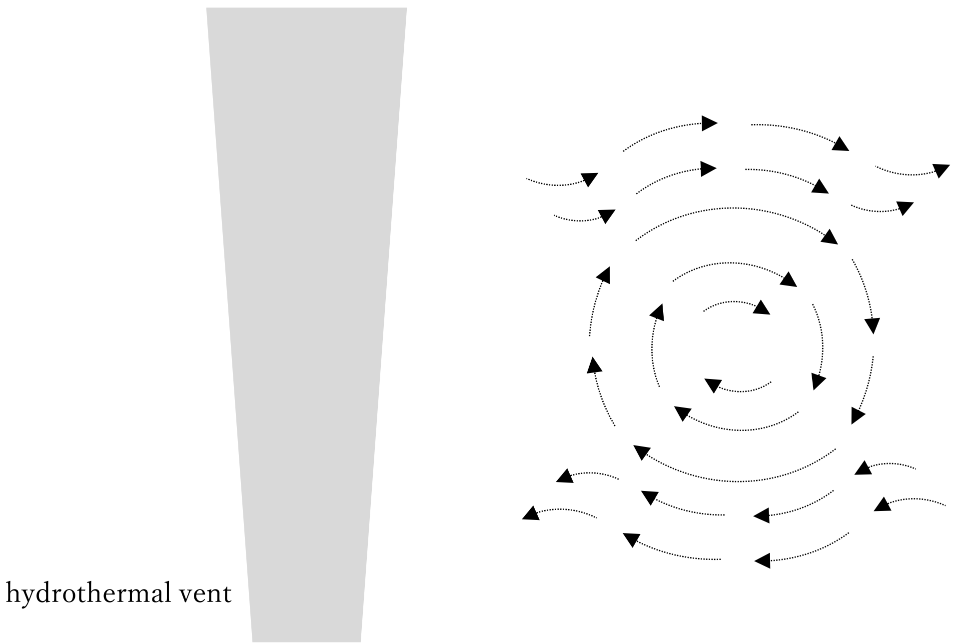
In general, isolation and interaction cause systems to cooperate and evolve. Geographic environmental conditions can be considered as a mechanism that generates such asymmetry in probability space. We propose the following hypothesis that the formation and evolution of subsystems and their organization in the evolution of life are facilitated by the space-time isolation and their combination and dissolution due to geographical environmental conditions.

It may be possible to generalize the following about the evolutionary process of life, the interaction of the genome with adaptive spacetime and the increasing hierarchical levels of individual organization (this schematic diagram also represents the possibility of stochastic interactions).

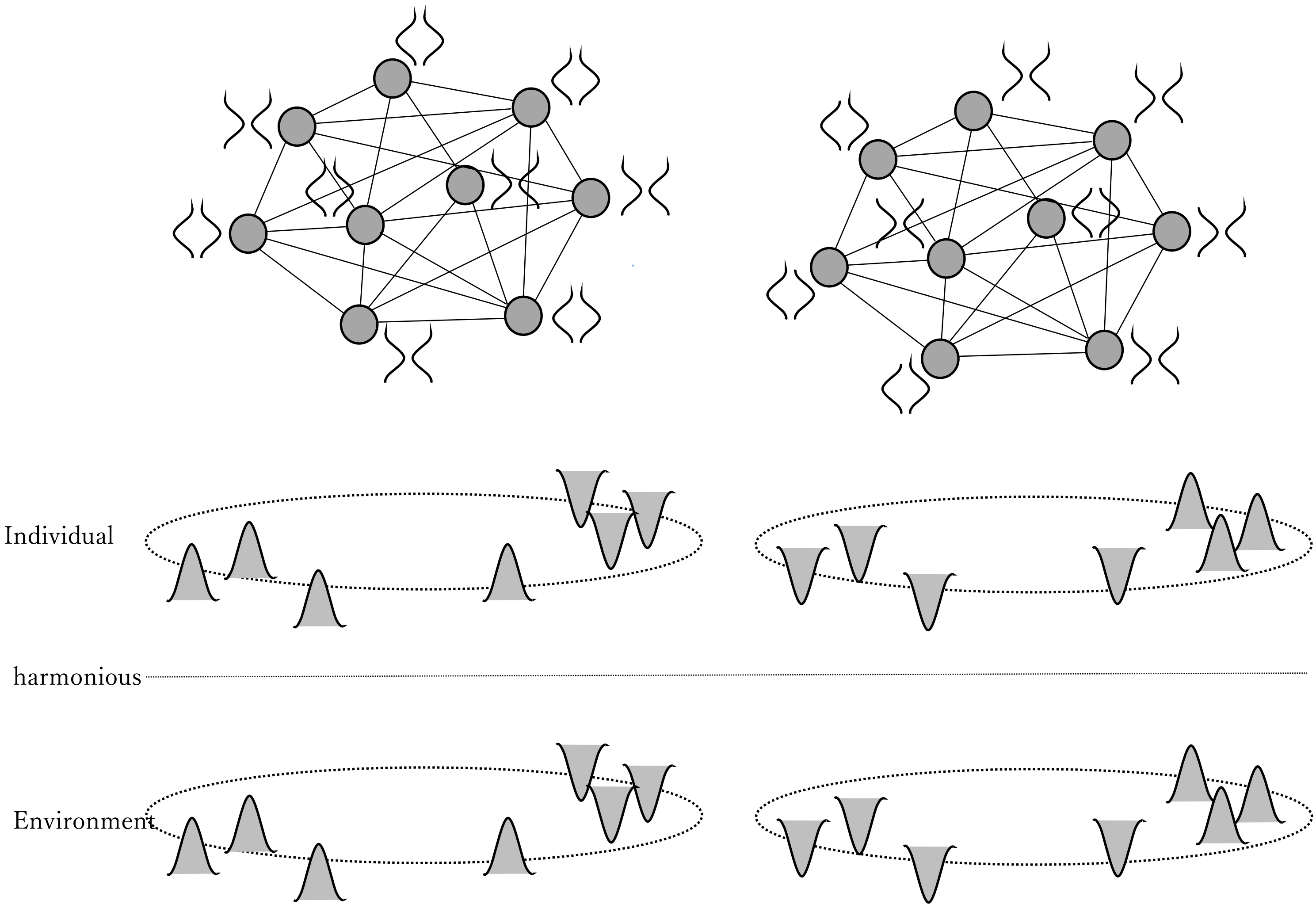


The flow in the vicinity of hydrothermal vents forms a spiral vector field in the space between the smoke and seawater in the same direction, similar to the vector field of angle and angler velocity of a pendulum.

Life may have evolved in the repetitive and recurrent material cycles and phase flows in such a spiral vector field.



Life phenomena may be generalized as a system that organizes a network of systems that repeatedly absorb and expel and resist the increasing entropy of the environment.



3.1 Background and Objectives

Limit-cycle oscillations have the property of metastability, which means that even if an external disturbance causes the motion to deviate from the limit-cycle orbit, it will usually return to the original orbit as soon as possible. If this tendency is sufficiently large, only the phase is disturbed by external disturbances. In a coupled system of oscillators, the phase description is applicable to weakly coupled oscillatory systems, since for an individual oscillator, influences from other oscillators can be regarded as external influences [Kuramoto, 2023]. The phase description is applicable to weakly coupled vibrational systems [Kuramoto, 2023].

3.1.1 Hypothesis

One might say that living systems microscopically decompose, disperse, and buffer the entropy of the environment as the propagation of oscillations to parts, protecting the homeostasis of basic metabolic activities.

(This is untested hypothetical paper and additional experiments are needed to establish evidence.)

Discussion

RNA and vesicles can be said to have a self-repairing function by association, and this property may have been important as a biomolecule for life.

Water may have contributed to the formation of the chaotic edges of life phenomena by facilitating interactions between biomolecules, enhancing temporal and spatial continuity, and mediating heat exchange.

The boundary between physicochemical phases and the boundary in the process of selection may be said to separate uniform materials by the asymmetry of the two phases.

In life, the mechanism of sequestering important things from discomfort to pleasure can be described as an organizing process.

Life can be said as an autonomous and temporally stagnant system that uses energetic passive processes and physicochemical phase inversions inside and outside the living system to generate a loop system in which divergent processes are output as inputs to convergent processes, which are in turn input again as convergent processes, and by the assembly and coordination of such mechanisms.

In addition, the organization of parts is considered necessary to maintain a survival advantage.

In contrast to inorganic chemical reactions and selection processes, organic reactions and changes in form are mechanisms that can address and organize these processes.

In this context, the processes of abstraction-selection (temporal asymmetry), organization (flow asymmetry), and learning (asymmetry of past and future meaning)-are thought to play a part in non-equilibrium life phenomena.

In this context, the fractal structure of the space-time probability space may support the self-similarity of genomic information.

In such a process, bottlenecks may also act to incorporate another subsystem, to increase the energy to overcome selection pressure, to increase the functionality of the system to overcome selection pressure, or to reduce selection pressure by shifting the time here and there.

When selection pressure increases, organisms with complementary metabolisms or those that survive in isolated, more homeostatic environments may have an increased probability of survival, and such processes may remain part of the organism's metabolic mechanisms.

The information stored in the genome might be likened to a viability quotient that makes itself more adaptable and less of a barrier to survival. The balance between diffusivity and aggregation of biomolecules may be important for efficient utilization of biomolecules, disciplined by their relative importance, where more important material is aggregated and utilized and less important material is diffused and pooled. It might be said that life phenomena are increasing in persistence through repetition of analysis (diffusion) and abstraction (convergence), with analysis supporting abstraction and abstraction supporting analysis. Furthermore, the repetitive nature of life phenomena may be said to be a result of spatial and temporal expansion mutually supporting and cooperating to analyze and learn from changes in the environment and to select robust individuals. Moreover, one might say that the nonlinear nature of this repetitive phenomenon supports the nonlinear dynamics of biological phenomena. The macroscopic and microscopic aspects of the living system may have mutually cooperated and evolved for the rationale that the more stable the homeostasis of the living system is, the more advantageous it is for its own survival. The homeostasis of life may repeat itself in a fixed periodic rhythm, and by separating those parts that cannot synchronize with the cycle from those that can, it may identify those parts that are to be eliminated and those that are not. For a function on time consisting of multiple variables, if the derivative and integral are repeated, this function will optimize and be less likely to diverge and converge, and it may be that life uses these properties of nonlinear functions to maintain homeostasis. The living system constructs a system in which the genome is in reality dynamically equilibrium and stagnant in time, copes with probability distributions, organizes ways of coping, stores information, and individuals try to enhance the viability level of the genome by constructing such a system and selecting individuals that could adaptively cope with information withdrawal and selection pressure Does it attempt to do so? In general, life may be said to be a system that uses the viability level of the genome to acquire a genome that stays in the environment and enhances its own viability level from the passage of time and changes in the environment. Water as a solvent may have facilitated the diffusion and aggregation of matter, providing life with specific conditions for the law of increasing entropy. The residence of life phenomena in the environment may be a phase of combining and binding information. Life may be said to persist in space and time, resisting selection pressure by virtue of its genomic viability level and the viability support from the environment.

Individual survival is a phase in which the living system searches for genomes, materials, and environments that enhance its ability to resist increasing environmental entropy, and individual death is a phase in which the living system ceases to search for genomes, materials, and environments that enhance its ability to resist increasing environmental entropy. The individual biological system may also be a system that observes the world. Biological systems may also be responsible for protecting their own genome and preventing the entry of unwanted genomes. Adaptive spacetimes for life may enhance life's residence as a dimple in spacetime, and life may evolve through the combination of systems protected from selection pressure in such spacetimes. In the global environment, where higher temperatures are associated with increased entropy and lower temperatures with decreased entropy, the intermigration of materials between the equatorial and polar regions may have influenced the coordination mechanisms of living systems and the evolution of life. Hydrothermal vents are also can be said where high-temperature and low-temperature environments are realized on very small scales. Selection, learning, persistence, convergence processes, abstraction, increased allocated resources, and increased viability levels may be relevant concepts in life phenomena. The fact that the process of selection is an irreversible process may also be important because it generates a non-equilibrium process in which life resists increasing entropy in the environment. In addition, the concepts of entropy of value and entropy of fitness may be used for a deeper analysis of the relationship between living systems and entropy. Center-to-center orientation, recurring phenomena in the earth's environment, adaptability through stability, value discernment, and energy conservation due to the ability to organize and predictability through the ability to learn, are thought to be part of the mechanism by which life resists increasing entropy in the environment. Fractal geometry, network topology, and hierarchical structures in living systems may be important to discipline the flow of time, information, and energy and to resist the increasing entropy of the environment (they connect simple and complex, contrasting and asymmetric, equilibrium and non-equilibrium, with time, energy, vector (These are systems that connect simple and complex, contrasting and asymmetric, equilibrium and nonequilibrium, by varying time, energy, and vector).

Complementarity and coordination between the inner and outer surfaces may also be applicable to life phenomena in general.

A universal property (as the sense of maintaining organizational structure and dynamism under different environment and conditions), mechanism, or phenomenon may be said to be robust with respect to changes in entropy, remaining to the end when entropy decreases and diffusing when entropy increases. It may be described mathematically as a change in the variance of the statistical distribution of the probability density function. One universal mechanism may be that the separation of systems using asymmetric phases and their complementary coordination resists the increase in entropy.

It may be said that the edges of chaos are prone to the accumulation of universal mechanisms as a system in which chaos forms order.

Also, it may be possible that universality, regression to the mean, and the edge of chaos are related.

The repetitive nature of life phenomena may give life inertia.

Life is thought to move back and forth between increasing uncertainty and stability, learning and predicting repeatedly in the process, enhancing the mechanism for maintaining homeostasis and the ability to cope with uncertainty.

Furthermore, in phases with increasing uncertainty, there is a signal for stabilization, and in phases that stabilize, there is a signal for increasing uncertainty.

For this reason, both existing and new systems are useful, and living systems may be said to function as dynamic systems on temporal, ecological, and global scales.

Extreme environments are good targets for exploring the origin of life on Earth from the viewpoint that inorganic chemical reactions and life can coexist.

As we compare organisms and inanimate objects, what is the relationship between extreme environments and viruses? What about temperature, communication, stress, minerals, information, life and death (and transgenerational change) as related to these?

The phenomenon of life may be said to be a process of acquiring the property of resisting the increase in the entropy of the environment through repeated abstraction by overcoming the selection pressure, collecting the interaction of materials adaptive to the spatiotemporal probability density distribution of the selection pressure and the genome that defines it.

One might also say that life phenomena are phenomena that strengthen the system of interactions of matter that resist the increasing entropy of the environment by repeatedly abstracting from the decreasing and increasing entropy and the selection of the edges of chaos that are adaptive to past learning and future prediction.

The reason for the great evolution of life on Earth may stem from the diversity of the global environment and its harmony, its homeostasis and autoregressiveness as a whole.

The adaptability of life is the ability to be organized while organizing itself for the survival of the system, and the network structure seems to support both.

It might also be said that life resolves conflicts of traits originating from different time and space by storing traits in genomic information as genes that are equivalent in terms of physical properties.

The genome in life may also have originated and evolved life by organizing matter and interactions with these different physical properties.

Finally, I would like to point out the essentiality of organizational structure in living systems by stating that organizations are dynamically equilibrium systems that are established and function through coordination and differentiation, that influence their environment while being influenced by it, that define and image the whole while each refers to the other, and that as a whole are preserved and evolve as systems oriented toward survival, cooperation and the acquisition of results.

A system in which diffusion and convergence processes are self-reverting may have been stable while evolving, and the nested structure of the earth, hydrothermal vents, and life may have led to a gradual expansion of the range of survival while strengthening the basis of viability as a system in which life acquired functional parts, organized those parts, and became autonomous and evolved The micro- and macro-freedom of these systems, and their ability to adapt, adapt, and evolve, may have led to a gradual expansion of the range of survival while strengthening the basis of viability. These micro- and macro-freedom, the complementarity and reciprocity of organizing and be organized through the separation, combination, and transformation of entropy, energy, information, and time may have supported and facilitated the emergence and evolution of life.

[Citation.]

ConvertinoA. Cushman MatteoSamuel.(2023). Entropy, Ecology and Evolution: Toward a Unified Philosophy of Biology.

KuramotoYoshiki.(2023). The World of Rhythmic Phenomena.

MochizukiAtsushi.(2021). Introduction to Theoretical Biology.

Montèvil MMMossio.(2015). Biological organisation as closure of constraints. journal of Theoretical Biology.

NakamuraSatoshi.(2014). Extremophiles -Think about the Origin of the Life and Learn from the Diversity-. CORONA PUBLSHING.

OhtaTakao.(2008). Physics of Nonequilibrium Systems.

PrigogineIlya.(1984). FROM BEING TO BECOMING TIME AND COMPLEXITY IN THE PHYSICAL SCIENCE Japanese Edition.

SasaiKazuto.(2020). Asynchronous time-space model for evolutionary market.

TanakaHiroshi.(2007). Life - Evolving Molecular Networks.(Author translation). Personal Media.

TanakaHiroshi.(2015). Systems Biology of Life Evolution (Author translation). NIPPON HYORON SHA.

ToyabeShoichi.(2022). NIPPON HYORON SHA.

WindelspechtS. Marder MichaelSylvia.(2021). Essentials of Biology Fifth Edition (Original), Japanese Edition translated by Haruhiko, Fujiwara.

Hideki Toyoda.(2013) Item Response Theory Intermediate Level.

Leon M. Lederman Christopher T. Hill Symmetry and The Beautiful Universe Japanese Edition translated by Kobayasi, Sigeki.

Sugimoto, Daiichiro.(2017). Why bring up entropy just now? MARUZEN publishing (Author translation).

Ilya Prigogine Isabelle Stengers. Order Out of Chaos Japanese Edition translated by Fushimi, Koji Fushimi, Yuzuru Matsueda Hideaki.

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