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Life origination hydrate hypothesis (LOH-hypothesis): What questions can be hypothetically answered at present?

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Abstract

We develop the original Life Origination Hydrate Hypothesis (LOH-hypothesis) of repeated origination of the living matter simplest elements (LMSEs) from CH_4 (or other CH_4-hydrocarbon), niter, and phosphate under the Earth's surface or seabed within honeycomb structures of hydrocarbon hydrates. The LOH-hypothesis gives a new possibility for understanding the monochirality of nucleic acids. A PC experiment and a laboratory chemical experiment capable of testing the LOH-hypothesis are proposed.

1. Introduction: the main principles

We proceed from the assumption that the gross-scale processes in nature proceed progressively in the direction of decrease in the free energy in each Universe subsystem that can be approximately considered as an isolated one. Just as a result of the directedness of natural phenomena, researchers are principally capable of mental doubling back the way the nature went and, thus, of revealing the main milestones in Nature's movement. A naturalist must search for a "hook" in the environment in order to catch on it and, having the thermodynamic laws as the guiding thread, to guess the logics used by Nature in its development. The revealed size correspondence between the structural elements of nucleic acids and the structural elements of gas-hydrates, in particular, of hydrates of methane and other hydrocarbons, is such a "hook". The understanding that water structures similar to the water structures in gas-hydrates exist in undisturbed fluid aqueous media, at least as short range ordering, when the temperature is low enough for the structures not to be disturbed by the thermal motion and is high enough for the structures to be formed as a result of diffusion processes minimizing the free energy of the system. (This idea was also used by us to formulate the physicochemical grounds of the processes underlying the metabolism of living cells [1].)

The LOH-hypothesis is based on the notion that all natural phenomena proceed as a result of regular and inevitable chemical transformations regulated by the universal physical and chemical laws, that RNA and DNA formed simultaneously, and that the LMSEs originated from simple mineral substances at the expense of their internal energy. The last feature discriminates it principally from the hypotheses by Oparin and his followers, who thought mistakenly that external energy of electric discharges, hydrothermal sources, etc. is necessary for living matter origination. In contrast to the Panspermia, the LOH-hypothesis considers the question about how rather than where the living matter originated. The mechanism proposed by us might be realized in any celestial body under appropriate conditions. When reconstructing Nature's way, we are governed by the following principles: (1) The principle of simplicity. According to I. Newton [2], no causes beyond those necessary and sufficient for explanation of a natural phenomenon should be introduced into a hypothesis; Nature is simple and doesn't luxuriate in excesses. (2) The principle of repetition of supposed events and of the presence of individual features in the reproduced events. The matter is that, in Nature, there are many similar but somewhat differing events and there are no unique events without close analogues. (3) The principle of the unity of the event point. Separation of an event into several sub-events proceeding in different points with the subsequent interaction between the sub-events decreases the probability of the resulted event, because it multiply decreases the degree of repetition of the event as a whole.

2. The questions answered in the context of the LOH-hypothesis

The LOH-hypothesis was initiated by the results of our studies of water-vapour interaction with functional polymers and monomers that are employed as models of biologically active substances and by the uncovered size coincidence between the structural gas-hydrate cavities, on the one hand, and the N-bases, riboses, and phosphate groups, on the other hand. According to the LOH-hypothesis [3–7], the LMSEs, i.e., N-bases, riboses, nucleotides, nucleosides, DNA, and RNA, originated and, possibly, originate in our days from CH_4 (or other CH_4-hydrocarbons), niters, and phosphates under the Earth's surface or seabed within honeycomb structures of hydrocarbon hydrates. The underground deposits of CH_4 and other hydrocarbons are produced by the reaction between H_2 and CO_2, and CO_2 is produced from carbonates as a result of their thermal decomposition induced by the gravitational compression of the young-Earth crust. Thus, the living-matter sources are H_2, carbonates, and phosphates resulted from transformation of the nebula. The nebula that was the progenitrix for the Solar System arose after the star explosion. The hypothetical sequence of the processes that led to formation of protocells is illustrated in the figure. Such sequences proceeded repeatedly, each sequence in one point.

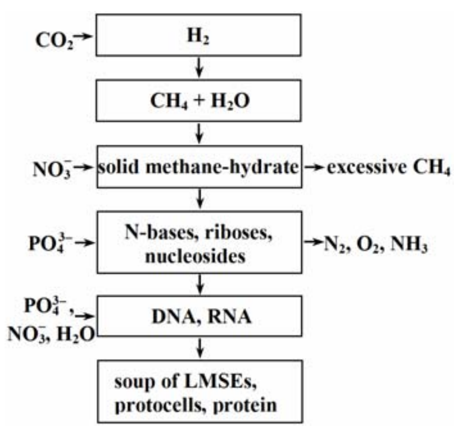

Figure: The sequence of formation of protocells from minerals within methane-hydrate structure.

The LOH-hypothesis is supported with numerous thermodynamic calculations. It allows for answering the following questions. (1) In what phase did the LMSEs form? (2) From what substances did the LMSEs form? (3) By what mechanism did the N-bases, riboses, and nucleosides form? (4) Is Nature capable of synthesizing LMSEs from minerals with no external energy? (5) How had methane hydrate originated? (6) How had CH_4 and NO_3^- met together? (7) Why no substance but NO_3^- reacted with CH_4-hydrate? (8) How did DNA- and RNA-like molecules form from nucleosides? (9) Is there a relation between DNA and RNA formation, on the one hand, and the atmosphere composition, on the other hand? (10) Why do only five chemical elements usually enter the DNA and RNA composition? (11) Why are N-bases entering DNA and RNA similar in their composition and structure? (12) Why are N-bases and riboses limited in size? (13) Why are N-bases not identical? (14) Why do only five N-bases usually enter the DNA and RNA composition and why do other N-bases, such as xanthine, sometimes enter the DNA and RNA compositions? (15) Could D-ribose (DR), desoxy-D-ribose (DDR), Thymine and Uracil exist simultaneously in a reaction mixture containing CH_4 and niter? (16) How had it happened that the sequences of N-bases in DNA and RNA molecules are not random? (17) Why did Nature choose DR and DDR, but not their L-enantiomers or mixtures of enantiomers for DNA and RNA syntheses? (18) How did protocells originate? This presentation contains the experimental and observational facts that led us to formulation and development of the LOH-hypothesis, thermodynamic estimations showing that the LMSEs can be produced at the expense of the internal energy of the source substances with no external heat flows, answers to the above-listed questions, available independent environmental observations counting in favor of the hypothesis, and descriptions of the experiments that could be performed for its validation and subsequent development.

References

[1] Kadyshevich, E.A. and Ostrovskii, V.E.: Hypothetical physicochemical mechanisms of some intracellular processes, Thermochim. Acta, Vol. 458, 148-161, 2007.

[2] Newton, I.: Philosophia Naturalis Principia Mathematica, Londini, 1687 (in English: Mathematical Principles of Natural Philosophy, California Press, 1999}.

[3]–[6] Ostrovskii, V.E. and Kadyshevich, E.A.: Life Origination Hydrate Hypothesis (LOH-hypothesis), OLEB, Vol. 39, 219-220, 2009; Generalized hypothesis of the origin of the living-matter simplest elements, transformation of the Archean atmosphere, and the formation of methane-hydrate deposits, Physics-Uspekhi, Vol. 50, 175-196, 2007; Thermodynamics of formation of nitrogen bases and D-ribose from mineral substances, Thermochim. Acta, Vol. 441, 69-78, 2006; Hydrate model of the equilibrium DNA–water systems, Intern. J. Nanosci., Vol. 1, 101-121, 2002.

[7] Kadyshevich, E.A. and Ostrovskii, V.E.: Hydrate hypothesis of living matter origination (LOH-hypothesis): Thermodynamic grounds of formation of living matter simplest elements from hydrocarbons and niter, J. Therm. Anal. Calor., Vol. 95, 571-578, 2009;