PUNTI DI VISTA / VIEWPOINTS

The Origin of Life as a Result of Changing the Evolutionary Mechanism

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To study the origin of life it is important to have a clear view of where non-living nature ends up and living nature begins.

According to Maynard Smith and Szathmáry ([2000], pp. 3-4), "entities are alive if they have the properties of multiplication, variation, and heredity (or are descended from such entities…)." There are also other definitions emphasising few essential features of living organisms such as (in a different combination) self-reproduction, metabolism, mutability, genetics, evolution, but not all authors are so laconic, and the lists of life's fundamental properties can include up to seven (Koshland [2002]) and more items. However, all these definitions give sketchy notions of the life's starting point. In the current literature, it is widely quoted NASA's definition: "life is a self-sustained chemical system capable of undergoing Darwinian evolution" (Joyce [1994], p. xi). The moment when Darwinian evolution first began to operate is considered by Joyce as "the defining moment for life" (Joyce [2002], p. 215). This notion commands wide support in the origins-of-life community and can have a claim to be exhaustive definition of life today, but it also does not yield complete clearness in defining the moment of

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life's beginning. The problem is that different authors seem to define the beginning of Darwinian evolution variously. Some relate it with the advent of RNA replication; others, – with coming into existence of a certain "general mechanism for self-replication that allows the polymer sequence to change somewhat over time, but retain its heritage in most of the sequence that is unchanged" (Joyce [2002], p. 215); the majority do not trouble themselves to define this moment at all. There are also attempts to bypass the difficulty of the starting point of life by means of certain transitions of, for instance, a hypothetical 'protobiont' being simpler than the most primitive alive organisms on many orders and at the same time having a capacity to evolve (Oparin [1968]), or 'the Domain Protolife' (Pappelis and Fox [1995]) being the further development of Oparin's idea. As a result, the qualitative leap between non-living and living matter is replaced by a gradual quantitative change.

Many researchers working in the field of the origin of life prefer not to confront this problem at all, supposing it has no practical value or, as Cleland and Chyba ([2002], p. 389), postpone its solution until the creation of a certain "general theory of the nature of living systems and their emergence from the physical world." Today we know that the diversification and the unique properties of life are a consequence of long evolution. However, non-living matter is known to evolve as well – it is during its evolution that huge diversifications of particles, atoms, molecules, planets, stars and galaxies have arisen and continue to arise. So, what is the difference between the one process and the other? In this difference, probably, the main enigma of life is hidden.

Environment and Conditions of Existence

There is a must previously to touch upon the terms 'environment' and 'conditions of existence,' – their exact definition and correlation with each other has a basic value to comprehension of the mechanisms of evolution of matter.

'Environment' can be defined as a part of the material world. The part can have any dimension, and its borders do not necessarily coincide with the boundaries of phase transitions. So, the space occupied with an elementary particle, and the habitat of a species, and the biosphere of the Earth, and any part of the universe can be considered as an environment. An environment always consists of an uncountable set of manifestations of the material world – ecological factors: temperature, pressure, physical fields, substances, organisms and so on, changing in space and through time.

As for 'conditions of existence,' this expression traced to Cuvier is used by Darwin [1872] on a par with 'conditions of life' in place of 'environment.' Soon after the first edition of "On the Origin of Species…" has appeared, Huxley in his special work has definitely made 'conditions of existence' a synonym of 'environment': "By Conditions of Existence I mean two things, – there are conditions which are furnished by the physical, the inorganic world, and there are conditions of existence which are furnished by the organic world" (Huxley [1894], p. 433). Speaking about conditions which are furnished by the inorganic and organic world (climate – temperature, moisture, – food, number and kind of living beings – 'rivals,' 'enemies,' 'helpers'), he, as a matter of fact, was classifying ecological factors, i.e. the components of an environment. By this, he has created confusion in the minds of biologists for decades. Conditions of existence are not inherent to environment, for the conditions of existence of each physical object are defined not only by its environment, but also by its own properties: features of its structure, kind and strength of internal links, a capacity to compensate external actions, and many other things that altogether define 'conformity of a non-living entity with its environment' and 'adaptiveness (fitness) of living beings.' It means that changes of the conditions of existence of an entity can be caused by both environmental changes and changes of the entity itself. That is, by 'conditions of existence' we must mean nothing else than the value of an environment (the value of separate ecological factors and their combinations as well as the value of the dynamics of an environment in space and through time) for a concrete physical object.

Since there are no identical physical objects in the macrocosm, different entities, including different living organisms, always have different conditions of existence in the same environment. So, the environment with the pressure of one atmosphere and temperature of 6000 °C permits existence of nitrogen molecules and does not permit existence of oxygen molecules.

Conformal Evolution

In prebiotic times, the conditions of existence of entities could only change together with changes in their environments (of temperature, redox properties, chemical composition, etc.), and these changes in turn were followed by structural transformations of matter. Such strong determination of the structure of systems by an environment permitted the only way of their evolution – that is, simultaneously with evolution of their environment. Therefore, we would like to introduce for the evolution of inanimate matter the term 'conformal evolution' (from the Latin *conformis*, 'conforming'). It is clear that such evolution is 'non-adaptive.' The characteristic feature of conformal evolution is quite strict conformity of the structural organisation of physical entities with ambient parametres.

Adaptive Evolution

An opportunity to change the situation has been provided when replicating nucleic acids (Dawkins' replicators) had arisen as a result of spontaneous assemblies and coherent stage-by-stage catalytic processes somewhere in an extremely peculiar environment. How this proceeded in detail, and what kind of nucleic acids the molecules were is shrouded in mystery today.

The replicating nucleic acids were a product of conformal evolution, but their structure had some important potentialities that predetermined their role in the further transformations of matter.

Content of structural information in the nucleic acid molecules and an opportunity to materialise it repeatedly in templating processes have predetermined the transition of such systems to a special mode of creation – 'self-reproduction.'

Prior to the development of proofreading and repair mechanisms (some units of these mechanisms were probably carried out by replicases from the very beginning), the changeability of such complex entities as polynucleotides was inevitably to be very high. Variability seems never was a bottleneck of the evolution mechanisms. Moreover, individual variability and adaptive changing are mostly alternative phenomena. Hence, in order to start progressive improvement of the conditions of existence of the entities by means of accumulation of very small useful structure modifications, the accuracy of their self-reproduction had to be increased significantly. The high fidelity of replication is considered as necessary for life basing on information-carrying molecules (see e.g. Eigen [1971]).

With the high fidelity of self-reproduction, the phenomenon of inheritance – the most important component of the evolutionary mechanism discovered by Darwin – is connected directly. Darwin ([1872], p. 80) wrote: "Unless favourable variations be inherited by some at least of the offspring, nothing can be effected by natural selection." Without inheritance, natural selection by itself, and even together with variability and high rate of reproduction, plays rather a destructive than creative role. It is the acquisition of the inheritance (the specific high fidelity of nucleic acids replication) by the entities that marked switching on a new mechanism of the evolution of matter – 'Darwinian selection,' or 'biological selection.'

Due to the mechanism of biological selection, the sufficiently accurate self-reproducing entities have received the capability to adapt to their environment. The content of the process consists in gradual changing of the structure – and functions accordingly – of the entities in the direction of improvement of their conditions of existence irrespective of the direction of an environmental change, even if the environment becomes more hostile. Thus, the part of the material world included in biological selection has received escalating independence (autonomy) of its evolution from evolution of an environment. The beginning of biological selection meant the transition from conformal evolution to adaptive or Darwinian evolution with formation of characteristic phyletic lines of ancestors and descendants step-by-step changing towards increasing adaptiveness. We are of the opinion that the moment of this transition has become the borderline between non-living and living matter.

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Light Perception and Timekeeping Systems in Plants: The Biological Value of the Domain of Time

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It has been known for some time that plant movements occur with a circadian rhythm. Androsthenes of Thasus, navarch of Alexander the Great (IV century BC), described the nyctinastic movements of leaves in many woody species, even though his observations had no follow-up for two thousand years. In the past decades scientific investigation has increased our knowledge, and disciplines like botany, plant physiology, genetics, molecular physiology, biochemistry, and ecophysiology have recognised in plants complex organisms capable of making adaptation choices. Consequently the question arises whether plants are able to measure time and whether or not they are making sense of time. A plant, like any organism, is immersed in the environment, mean-