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ON SEARCHING FOR COMPONENTS OF LIFE[1]

The close of 20^{th} century is the time pertaining to biology. In the recent years, the scope of biological issues has extended to include, among others, realm of plausible events; it, basically, refers to the possibility of existence of life in space as well as to the attempts to explain and predict proto-biological processes on the basis of accomplishments in the field of non-linear non-equilibrium thermodynamics. This possibility is, first of all, an endeavor to indicate some universal regularities concerning development of matter and basis of biological variety. Biology is a field of knowledge which undertakes tasks of explaining the functions and structure of living organisms, and shifts the stress from the necessary to the possible; it also points out what is repeatable and local, yet occurring in unrepeatable and global conditions of space and time.

The world of living creatures, until now seen from the point of view of 'chemism', physical processes and deterministic laws of science, today reveals itself as full of dynamics, development, emergence of new concepts and ability to increase the level of organization. These days, not only biology, but physics, chemistry, economics and other disciplines as well strive to describe more process than structure, more change than being. As a matter of fact, the essence of matter and being is perceived in its capability to undergo evolution. The aim of this article is to present some of the qualities of life. Seven selected components (indications, features, characteristics) of living systems are described, though many more could be mentioned. From simple processes of abiogenesis as far as to the development of human intelligence the process of life was directed by universal mechanisms.

The process of abiogenesis was universal, i.e. referring to the whole Universe. The outer space is filled with organic compounds – 'bricks', which make up living structures. The most important of these bricks – hydrogen, carbon, nitrogen, phosphorus, sulfur, potassium, magnesium and calcium – have become the fundamental substance of life. A number of organic compounds existing in abundance have been discovered in interplanetary dust; they include: hydrogen cyanide, acetylene cyanide, carbon oxysulfide, methyl cyanide, methanamide, ethyl alcohol, and dimethyl ether. In retrospect, one can remark that, in order to exist, life has chosen carbon compounds. It should not be surprising, for a characteristic feature of carbon is its ability to form varied and dynamic living systems. **The first clue of life is**, then, **the choice of active elements of life**. The name 'element

[1] Wersja polska pt. „Co powinien widzieć lekarz o komponentach życia?" znajduje się w: Centaur Lubuski. Biuletyn Informacyjny Lubelskiej Izby Lekarsko-Weterynaryjnej nr 4(1997) 85-86.

of life' is not applicable to silicon since it constitutes permanent connections. Strong chemical bonds prevent silicon compounds from transforming; silicon forms planetary shells and is resistant to temperature.

Amino acids were the most important compounds from among various organic compounds. The Miller experiment, repeated many times, has indicated that glycin and alanine had occurred most abundantly; aspartic acid, glutamic acid, leucine, lysine, threonine and serine had appeared as well. The above amino acids were formed from hydrogen cyanide (HCN) and cyanogen (C_2N_2), influenced by ultraviolet radiation, ionizing radiation and thermal energy. The amino acids existing in proteins are synthesized most easily and most ordinarily in abiotic way. There are many other amino acids, but only the most prevalent ones have become bricks of protein, and thus – bricks of life. Then, **the second feature of life is using the most widespread elements**, which are assembled into more complex systems.

The most basic elements of living systems are nucleic acids and proteins. The oldest molecules, being 3.8 billion years old, are known as *Cabeccia umbellata* and resemble yeast by their appearance. *Cabeccia umbellata* were the antecedents of bacteria called procaryote. The latter were characterized by self-repeated nucleic structure in the form of circular DNA thread, and protein enzymes being capable of catalyzing vital functions of cell. However, procaryote had a major defect, i.e. they could not evolve, since 'information included in their genetic apparatus is too small to allow for increasing and intrinsically diversifying the system.'[2] It would have been possible to enlarge the amount of information by expanding the volume of threads of nucleic acids; that, however, would have resulted in a reduction in system stability and less precision of copying. The example of procaryote indicates **the third characteristics of life – development through internal diversification.** Lack of inclination to evolve is vegetation – a dead end.

The next step in evolution was the emergence of eucaryote. There are no paleontological traces as to the existence of their predecessors – pre-eucaryote. Eucaryote cannot have developed from procaryote, either. On the whole, there are three plausible hypotheses of eucaryogenesis: parallel evolution, compartmentation and endosymbiosis. A follower of the first hypothesis is L. Kuźnicki,[3] of the second one – Cavalier-Smith,[4] and of the third one – W.J.H. Kunicki-Goldfinger.[5] The last hypothesis is worth noticing here, since it points out the universal **fourth feature of life**, which **is symbiotic susceptibility**. None of symbionts enters symbiosis because of altruism; their motives are purely egoistic. Both eucaryote and procaryote evolved from eobionts. Pre-procaryote are typified by possessing a membrane which separates them from the environment (like mucopeptide), while pre-eucaryote have not developed a cell wall. Both forms existed close to one another as long as there was enough food in the neighborhood. When the nourishment went scarce, pre-eucaryote commenced a new way of nutrition. Since their membrane was not surrounded by a cell wall, contractile proteins could appear there, which caused changes in shape and absorption of food from the neighborhood. Pre-procaryote

[2] A. HOFFMAN, Wokół ewolucji (On Evolution), Warsaw 1997, 79.
[3] Biologiczne systemy ruchowe – ich geneza i występowanie (Biological Motor Systems – their Origin and Occurrence), in: Komórka – jej budowa i ruch (Cell – its Structure and Motion), ed. by L. KUŹNICKI, Ossolineum Press, Wrocław, Warsaw 1987, 248-54.
[4] The Origin and Early Evolution of the Eucaryotic Cell, Soc. Gen. Microbiol. Symp. 32, 33-84.
[5] Dziedzictwo i przyszłość. Rozważania nad biologią molekularną, ewolucją i człowiekiem (Heritage and Future. Reflections on Molecular Biology, Evolution and Man), Warsaw 1976, 280-291.

might well have been that food. Ameba-like form, viscosity and contractility were of advantage to pre-eucaryote, as far as selection was concerned. Predatory pre-eucaryote were anaerobic bacteria; they 'hunted' on the boundary of water phases with air and slimy bottom. Having been in contact with atmosphere, which consisted of more and more oxygen, pre-procaryote gained the ability of oxygenic respiration (additionally to fermentation). As the time passed by, configuration of these two organisms became a symbiotic one, and pre-procaryote, absorbed by pre-eucaryote, re-formed and developed mitochondria and chloroplast. Mitochondria have been serving eucaryote as organelles of oxygenic respiration.

Development is directed by laws of nature. Any evolving system cannot evade general, universal regularities governing the world. From the point of view of deterministic laws of physics, evolution is impossible, since laws of nature always tend to keep balance (equilibrium), i.e. to cease evolutionary transformations. Systems, however, do not grow independently of their environment. Changes in external conditions as well as some internal processes may be conducive to the initiation of fluctuation. Having surpassed critical value, fluctuations can intensify disproportionately to incentives. Too high a fluctuation can lead to system destruction, or due to changes in neighborhood (mutual exchange of energy and matter) another way of arrangement and functioning can appear, i.e. dissipative structures (forces that produce and disperse excess entropy) would rise. Dissipation of energy occurs when a system exists far from balance. Imbalance is a lack of stability, a bifurcation point where a sort of branching or alternative ways of further development emerge. Bifurcation point is a state in which system has freed itself from deterministic laws of nature; in a state of imbalance an unrestrained choice of ways of functioning appears and a degree of internal complexity increases. **The fifth feature of life,** then, **would be a capability of initiating and expanding a space of freedom**. The analysis of chemical properties of nucleic acids and proteins, executed by a German physician and chemist, Manfred Eigen, has confirmed that in a state of imbalance the two groups combined into a superior structure, i.e. a hypercycle, which was the simplest living system. There appeared then two major, coupled properties of living systems: replication capability of nucleic acids and information capacity of proteins.[6]

Organisms aim at maintaining their stability in unstable and quickly changing external conditions. This stability 'is sustained by a game played by numerous, mutually exclusive forces.'[7] Miscellaneous tendencies are steered by a superior system — an organism. This is a state of labile equilibrium. If a system did not have a kind of plasticity, it would soon be subject to a chaotic and non-directional evolution. That is the fate of specialized species, such as the ones with a 'stiff' way of nutrition, which, affected by rapid changes of boundary conditions, cannot keep alive. Therefore, **in order to live, an organism has to learn how to generate a state of dynamic equilibrium** (**the sixth property of life**). Imbalance is triggered by various crises and cataclysms, and it appears within shortage and surplus as well. Different misfortunes, 'although leave devastation behind them, yet [they] offer organisms new methods of expansion aside, i.e. off the beaten track.'[8]

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[6] M. EIGEN, Stufen zum Leben. Die frühe Evolution im Visier der Molekularbiologie (Steps to Life. Early Evolution in the Light of Molecular Biology), Munich, Zurich 1993.
[7] M. RYSZKIEWICZ, Przepis na człowieka (A Recipe for a Human Being), Warsaw 1996, 99.
[8] J. H. REICHHOLF, Twórczy impuls. Nowe spojrzenie na ewolucję (Creative Inspiration. A New Attitude Towards Evolution), translated from German by B. Miracki, Warsaw 1996, 175.

Excess and insufficiency may regard food. If there is much nutrition, the number of individuals of a species which acquire this food is on the increase. Reproduction leads to exhaustion of environmental resources and then to deficiency. Insufficiency promotes the emergence of specialized forms, and differentiation, new species as well as new means of nourishment come forth. Transformation into, as yet, unused resources and the occupation of free ecological niches appears an evolutionary necessity. It may well seem contradictory, but **logic of life demands as large procreation as possible (the seventh property of life**). A species with a high number of descendants stands a better chance of survival in new-sprung conditions. Only then can a species become preserved when it reproduces – that is a trait of life and a call of evolution. In spite of impoverished environmental conditions, as a result of specialization varied species and breeds can live next to each other. As J.H. Richholf mentions, 'there are hundreds of species of trees on a single hectare of a rain-forest, while in forests rich in nutrients there are only several of them [species]. The list of animals living in regions poor in nutrition in comparison with well-supplied areas is still ampler.'[9] The above considerations have ethical implications, since they imply the significance of retaining the variety in human cultures (monoculture, technology do not guarantee survival to the species of man). Biological diversity and multiplicity of cultures may constitute a specific synthesis and a chance for *homo sapiens*.

The aforementioned, sought-after universal components of life do not frame the whole picture of the issue. In summary, one can enumerate other characteristics, such as: simplicity, breaking of symmetry, non-linearity, game of appearances, or even shrewdness (ingeniousness) as far as protection from enemies is concerned. There must be a great number of indications of life, since evolution has been shaping the environment, and extending and 'piling up' the area of adaptations for as long as billions of years.

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[9] Ibid., 168.