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How a New Essence, We Dubbed Information, Has Emerged

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Abstract: The article presents only the author's view on the formation of the notion of information. The basic idea is that the information comes into existence with the emergence of organic molecular structures of increasing complexity. In the prebiotic physico-chemical systems, emerging molecules are carriers of *structural* inert information that reflects the fixed coordinates of the atoms in the molecule being in a stable state. Emerging irregular polymers (RNA world) acquire the potential of the digital encoding and transmission of information messages. Their structural information contained in the sequence of nucleotides evolved into *symbolic* (prescriptive) information in the process of molecular semiosis. It would be more accurate to say that these molecules as a result of natural evolution and selection for survival become *operational*. The meaning of this term is that the memory fixed in a sequence of monomers forming these molecules can now be used not only for the reproduction of its own structure, but also in a symbolic form can be employed in the biosynthesis of another class of polymers (proteins).

Keywords: irregular polymers; matrix reproduction; accidental combinations; memory; symbolic relations; prescriptive information

1. Introduction

In our time of science and education everyone is well aware what the essence of information is. This confidence is quite justified, as we continually receive and transmit to each other all sorts of messages. This belief persists even when Shannon gave a mathematical basis for the concept of information and a little “clouded” the seemingly clear idea by the “obscure” word – entropy [25]. The formal similarity of Shannon's formula for the amount of information in a text message with the Boltzmann's formula for the thermodynamic entropy does not go beyond the fact that they operate with varying probabilities of completely different parameters, characteristic for the elements of these

systems. Boltzmann's equation describes the evolution of a closed system to the most probable state with maximum entropy. This is a spontaneous process, not dependent on the observer. Shannon's formula describes especially technical aspect of text message transfer through the communication channel, i.e. it characterizes the channel's carrying capacity.

Since 1953, molecular biologists have firmly gained control over the term information (and the meaning behind it) to describe the functional role of nucleic acids in living organisms. Communicative function of information in the booming field of communications and computer technology has given way to a deeper, more significant aspect of the phenomenon of information. Firstly, it became clear that the mysterious genes, which the geneticists blame for the inheritance of characteristics of living organisms, were basically areas of the nucleotide sequence of the DNA, which recorded (encoded) information. It is a kind of instruction for the synthesis of the necessary functionally active protein in a new cell-descendant. Awareness of this special, almost mystical role of information as a real physical reason for the formation of the new material object with the specified properties was a turning point in understanding the meaning of the phenomenon of information. It appears to us as a multifaceted phenomenon, which occupies at the same time rather a vague place between the physical world and the world of abstract categories born of our mind.

Secondly, it was quite logical not to limit the scope of information presence only to the living world and the human psyche. The next step was the recognition of the fact that the widely debated prebiotic evolution of matter was a creative process that accompanied the birth of the new structural information. Brillouin L. [7]. proposed to distinguish between *free information* (as a description) and *constrained information* pertaining to the properties of the material structure. However, he did not claim that the information was a material part of the system. They began to correlate information with the increase of the structural complexity of emerging molecules.

The classic definition of biological information by H. Quastler, contains two fundamental issues in its generation: 1) *random selection* of one of the possible elements in its medium and 2) *memorizing* this choice [23]. These items are fully applicable to the process of formation of any purely physical object. The definition used the term "random selection." In the process of formation of inorganic structures, as well as of simple organic molecules, the selection event also has its place, but it is not an entirely random selection. In this case, only the moment of initiation is random. Fixing the structure and achievement of steady state are achieved by the action of the laws of physics and chemistry, prescribing the conditions necessary to overcome energy barriers. The act of *realization of potential possibilities in the objectively accomplished process* represents the information aspect of this process. The phrase "random selection" used by H. Quastler accurately conveys the mechanism of spontaneous polymerization of the primary polynucleotide in a prebiotic system. Selecting from a pool of four types of nucleotides and the inclusion of another monomer are practically equivalent from energetic and steric points of view for the formation of single-stranded oligonucleotides *de novo* (so the choice is really random).

Apparently, the structural information contained in a random sequence of 4 varieties of monomers (letters) can be regarded as a kind of primary supply having yet a very vague meaning (content). The nucleotide sequence (as such), i.e. properly "sequence," has become the major element of the structure of the information carrier molecule. It was a brilliant discovery of Nature. The sequence of the monomers may vary slightly during the replication process, changing the meaning of the enclosed proposal. In the same time the physical structure and the structural information of the interatomic

bonds remained virtually unchanged within acceptable linear dimensions. It should be noted that the energy value of the emerging biologically meaningful information cannot be determined only on the basis of the production of the thermodynamic entropy of free energy dissipation in the cell and in the process of conversion of part of this energy into a structure of chemical bonds of information macromolecules [10]. In other words, it is not only the thermodynamic entropy which is produced entirely in the cell that refers to the process of replication within the polymer information system, but also its other manifestation — the information entropy pertaining to the accumulation of replication errors [21]. In the primary stage of prebiotic systems there appeared more and more combinations of nucleotides, which at the next stage of the evolution of this system could already appear as instructions (a kind of matrices) for the biosynthesis of the polymer molecules of another class — polypeptides. Since the polypeptides are constructed from monomers of 20 types, the transfer of information for their synthesis may be effected only through *a symbolic codes system*: a triplet of nucleotides in the matrix (codon) corresponds to an amino acid in the protein. This very brief excursus into the history of awareness of the role played by information in the development of life on Earth allows us to make a conclusion about the fact how complicated the phenomenon of information is, the phenomenon which until recent times we knew simply as information (notice).

2. The concept of information space and the real source of birth of information

Modern information theory cannot do without the idea about the structure of *the information space* expressed in one way or another. This may be a spherical surface for binary coding, with non-Euclidean metric [18]; “information space” for encoding of 4-letter sequences [12]; “Software Space” [9]; “potential information” [5]. These abstract spaces represent a set of *conditional* points (nodes), whose numerical values are the probabilities to achieve steady-state event of any material or mental structure (statements). Such an event could be the formation of simple inorganic molecules and crystal growth, and polycondensation of monomers into a polymer sequence. All these events, of course, have one thing in common — they are accompanied by the birth of information. There is a well-founded view that information is neither matter, nor energy [27]. The laws of conservation do not apply to it. The inception of structural information in the above-mentioned prebiotic nucleotide sequence contains uncertainty. Does this information act as a mandatory participant (reason) or as a product? If the first statement is true, then the information from the virtual source (information space) should become a program for the formation of material structure, where it will be fixed. Since the nature of the information carrier from the virtual world into the material world is not known to us, it makes sense to discuss the second option.

Thus, the appearance of the structure is the way of generation of information. The process of spontaneous formation of more complex structures from simple elements is a process of true self-organization, in contrast to the artifact of self-organization, which requires the presence of external information [4]. The true self-organizing characteristic of the prebiotic stage of evolution of matter occurs spontaneously, i.e. by random interactions of source elements. The probability of meeting two or more members of the act of more complex structure formation is quite high provided that there is suitable material and energy supply. Fixation of a stable structure, as mentioned above, is achieved solely by the action of chemical and physical laws. But we are interested in the fate of the information that has arisen with the structure. Can it be the kind of information that can be transmitted to the receiver and used in any way for the construction of, for example, new instances of molecules with

identical structure? It turned out that it could, but not any sort of information would suit for that. The information that has appeared in such a way is not the intangible space of probability of realization of a sign of the “Software Space” type. Its reality is felt particularly in the form of measurable by physical methods coordinates of the atoms in the molecules and in the more sophisticated molecular complexes. It is true that, from this point of view, we identify structural information with the physical parameters of molecules. This means that in the case of simple structures it does not make sense to speak of information as a separate entity. At the stage of birth of structural information there is a fundamentally important point of bifurcation, where the ways towards the further evolution of the two types of emerging structures diverge. The first branch is the world of inorganic and small organic molecules (including regular polymers), which have no internal development potential. Their structure does not meet the conditions required for the potential digital media, as these molecules are *non-operational*. In principle, it is possible to read information only halfway as it satisfies the selection criterion and fixing one of several possibilities, but it cannot be transmitted to the receiver for implementation. The second type of structures is the type of spontaneously arising irregular polymers with a random sequence of 4 kinds of monomers (mononucleotides). This is the world of RNA; and today it is quite rightly considered the forerunner of life. Polyribonucleotides are a unique substrate meeting the implementation of two fundamental functions necessary for the emergence of the primary living systems. They may be information carriers and have an acceptable broad spectrum of enzymatic activity.

Apparently, the polymerization of nucleotides with random sequences in the primary physical and chemical systems may be carried out not only *de novo*, but also through the formation of a complementary replica on the matrix of the original sequence. Replicas’ function during that period is likely to have been performed by ribozymes or catalytically active mineral surfaces [16]. Such method of multiplication in the system of replica copies has provided the operation of significant amount of primary carrier pools of yet structural information which may not be considered as instructions for the synthesis of other classes of molecules (polypeptides) [13]. The evolution of the structural information of the primary carriers into prescriptive information is usually associated with molecular semiosis when the primary biologically important functions and *meanings* appear. Contemporary scenarios of the molecular events of this period are the attempts of reconstruction of the so-called LUCA (Last Universal Common Ancestor). They develop the fruitful *hypercycle* concept [14]. Most attractive is the idea of the *noncellular* but compartmentalized LUCA [17; 19]. This prebiological system is supposed to have been a heterogeneous population of genetic elements, polymerizing and breeding in the network of inorganic cells constructed from zinc sulfide or iron. Most likely, such cells arose in the field of terrestrial hot springs and served as incubators suitable for primary metabolic reactions and spontaneous synthesis of primary biopolymers [22]. This scenario, like others, has a formidable logical limit, called *Eigen’s threshold* [13]. It is impossible to simultaneously increase the complexity of the genome, and to maintain the necessary precision of copying. However, in real life this threshold was overcome step by step with the help of small, evolutionarily beneficial deviations and achieving of minimum initial complications, which together *triggered* the Darwin—Eigen cycle [20]. I have deliberately drawn the reader’s attention to one of the known origin of life scenarios. The key event of this scenario is the emergence of the primary *information system* and, at the same time, a new type of information — *symbolic*.

3. Many-sidedness of the information phenomenon

We have briefly discussed the first three manifestations of information: potential (or information space), structural and symbolic. The first of them is a kind of a mental construction, a product of abstraction of a thinking person. Undoubtedly, it is a necessary way to describe reality in its most general form. The procedure of correlating these three types of information with each other is quite interesting. It seems to me controversial to derive structural information from symbolic, and the latter — directly from the potential, as suggested by G. Battail [5] who considers it as one of the main essences of the physical world, along with the matter and energy. However unlike them, the information exists only in the world of living beings where it can be generated and multiplied (where it can proliferate) and may be at the same time annihilated (lost). The author introduces the notion of *potential information* to denote the information which exists in the form of some immaterial essence in non living world. In the living world potential information turns in to symbolic one through materialization into the form of the base sequence of genomes. At the next stage of its passage it looks as structural information of functional macromolecules and structures of cell metabolism. I can agree with the notion of potential information, not in the pre-biological world but rather in the world of ideas that exist in the person's head. The logic of the materialist worldview requires the primacy of the physical structure formed based on the properties inherent to its elements. We cannot say anything definite about the origin of the primary elements and the source of their properties. But this cannot be said by the opponents of the materialist worldview either. The idea of the *primacy* of the formation of new molecule types, structural information that can evolve into symbolic information, seems more plausible to me.

Above we have noted the obvious property of structural information — *inertness*, which is a consequence of the considerable stability of the structure of its carriers at the stage of pre-biological evolution of matter. The structure of these carriers has a sufficiently small number of degrees of freedom of the constituent elements. Hence there is a natural understanding of insufficiency of inorganic objects forms and their inability for progressive evolution in comparison with the diversity of the world of the living. It is necessary to distinguish between two types of self-organization of biologically significant molecular structures. Pre-biological systems are characterized by *probability*, or true self-organization, whereas primary biological objects have *prescribing*, or information-dependent self-organization. Apparently, the second method for synthesize the new copies of oligonucleotides (replica formation) was present still in pre-biological systems. It is based on the principle of *non-random complementary* selection of the next monomer.

The situation changed dramatically when some fairly stable molecules capable of template-based reproduction emerge in the prebiotic system. These are irregular polymers (nucleic acids constructed of four kinds of nucleotides). At the same time, there was a spontaneous process of the formation of polypeptides that *are not capable* of self-replication. Both these processes are usually seen as inherent to the initial stages of life. The populations of arising molecules have become the unique substrate for the emergence of the principle of digital encoding of information in nucleic acids. The molecular device of recoding a nucleotide sequence in the amino acid sequence should be considered the key event in the origin of life. The resulting system with the information-dependent determination of the structure of functionally active molecules (polypeptides) became the carrier of an infinite number of

degrees of freedom and started its work as the generator which has been processing *potential* information into *structural and symbolic* information for more than $\sim (3.5-4) \times 10^9$ years [5].

Thus, examining the stages of the birth of a new observable physical essence [4] of our world, which we call information, we have come to a very important milestone in the evolution of the primary biological system, when we can speak about the symbolic information. In fact, from that moment on the active (prescriptive) function of information starts revealing itself. And this is done through the establishment of a symbolic matching (designation) between an element of a sequence and an element of an entirely different order. For example, a codon of three nucleotides in the DNA corresponds to an amino acid in the protein, or a spoken word matches an object or an action. This principle is implemented in tangible symbolic systems (genetic cell system) and in verbal systems providing communicative function in the community and the work of human thinking apparatus. Abel [3] has recently justified the notion of "Prescriptive information" (PI) whose main essence is prescription (instruction) of the method of particular functions appearance in biological systems. PI is an absolutely necessary working element contained in the genome structure which ensures creation and support of deterministic relations in the physical and chemical chaos of the cell. The prescribed selection of the amine acid sequence in the forming molecule of the enzyme or other functional agent determines the choice of the passageway of any metabolic chain [1; 2]. In cognitive semiosis, the appearance of PI is considerably reduced and even not mandatory. Another image of semantic information, "Descriptive information", dominates here, which is typical for information system of symbols on the basis of neuronal network of the higher animals and human. Descriptive information in neural networks is not necessary to be thought about as something strictly neutral and serving only to fix in the memory the events of the outside world and transfer to another competent receiver as symbols of different physical nature. It seems that it is needed, above all for its owner. Its primary preverbal function is the formation of perceived space of the external world and of the individual "I/Ego" in it; and it is actually primarily *descriptive*. DI transfer in the form of characters to another receiver makes it largely *prescriptive* for the recipient, although not as severely as is the case in the genetic system. And here is one more significant difference from the genetic systems. If in the latter, the appearance of new motifs is a sequence of rare random events — mutations, the birth of new information in the neural networks of the human brain, most likely, is subject to certain rules. These rules are formed as a result of the analytical work on the brain over the incoming and fixing imprints of real events of the outside world. Apparently, the brain uses these rules for the conscious (and unconscious) combining (formation) of new ideas, meanings, logical constructions out of the available set of facts.

In genetic systems the principle of symbolic coding of information lies in the basis of the mechanism of the biosynthesis of polypeptides having a biological activity, but not being capable of self-reproduction. It should be noted that this process occurs only in the concrete material substrates — information systems, which are the basis of the living objects and thinking subjects. **Biological information systems** can be defined as *linearly organized sequences of molecular structural elements (for a genetic system) or as dynamic sequences of discrete states of brain neurons and their synapses, which are able to be transformed into new combinations and thereby generate new information during the periods of their instability*. These combinations of elements return to the stable state, which provides one of the most important properties of these information systems — *memory*. The number of potential combinations of the elements of genetic information system which it can assume during the periods of its reorganization that expresses the freedom inherent to the system; this freedom increases

with the size and complexity of the genome. *Freedom* is largely a philosophical category and cannot be measured with a value which would be permanently inherent to a given system. The presence of freedom in material objects is evident when we compare simple systems of inanimate nature with living organisms, which are based on information systems. It is a combination of freedom of information elements in the genomes that provides the emergence of new genes for the future biological functions or ways of regulating the activity of the existing genes. Based on the above, we suggest the following definitions: 1. **Freedom of information system** *can be defined as unity of the number of potentially achievable combinations of genetic elements and acceptable waiting time before transition to the one of the numerous new combinations of its information elements.* In other words, that is the reasonable correlation of times between arising challenge in environment and creation of adequate adaptations.

The opportunity to freely combine elements in a space of virtually infinite number of degrees of freedom that emerges with the primary genetic system makes it possible to dub this stage of the evolution of matter *Age of Freedom*.

Speaking of the symbolic information we mentioned its *active* (prescriptive) function that detailed in the papers [3 - 4]. Apparently, this property—activity—needs a reasonable agreement with the known chemical inertness of the DNA and the stability of its nucleotide sequence at replication. But it is a purely structural aspect of the medium. The word “activity” is hiding a molecular mechanism for the correlation between the change in the sequence of bases in DNA (mutations) and the subsequent inclusion of amino acids in the synthesized protein. Without it, it does not make sense to talk about the further progressive evolution of the whole primary prebiotic system. A random search for new combinations of nucleotides in the primary gene was supposed to generate new variants of polypeptides that may be active enough, as at replication or other essential biochemical functions in the system. Today, we know how this already finished translation mechanism works. But until now, we cannot offer any plausible scenario of *occurrence* of this mechanism at the dawn of life.

We do not know at what point in the evolution of precellular system the natural selection began its positive work, maintaining its local area in which randomly occurring variants of the nucleotide sequences gave rise to polypeptides with a given biologically significant activity. However, the molecular mechanism supporting this correlation seems to have existed in the form of a simple decoder. It should be seen as an indispensable tool of the nascent molecular genetic *semiosis*. It seems that today we can only offer potentialities of RNA world (an effective RNA-machine) that provide preribosomal translation of primary matrices [20]. The core of these processes, as well as of the cognitive semiosis based on neural networks, is based on the principle of establishing a *symbolic* link (matching) between system elements that do not have a natural affinity for each other. For example, nucleotides and amino acids; words of speech and subjects. In the interpretation of this principle there is an interesting ambiguity. In the group of biologically important compounds (nucleotides) there are pairs having a natural chemical affinity for each other (A — T; G — C). The question is whether to consider the establishment of links between these nucleotides as symbolic? Links in these pairs are quite stable only when nucleotides are oriented against each other in complementary chains of double helix, i.e. as a result of a cooperative process. Apparently, the emergence of complementarity can be seen as a result of the dual nature of the efficient causes: physical and information. The chemical affinity at nucleotide level is only a prerequisite for arising symbolic compliance on macromolecular level, i.e. elementary prerequisite for the information act. And the formation of replica in the original

matrix is an act of formation of a new molecular structure in an information-dependent manner; it is an act of establishing a primary symbolic link. Intramolecular bonds (within a double-helix structure) are not fully symbolic. The true symbolic link was formed at a time when the structure of the resulting polypeptides became correlated with the sequence of nucleotides in the primary storage media. No one has doubts about the way the molecular mechanism of transfer of information works and about the principle of its decoding in the ribosomes. Secret is in the process of its inception. In fact, from that moment biosemiosis begins, i.e. a new type of information — prescriptive, emerges within the system; and the first meanings arise. Of course, you can challenge the legality of the search in these primary prebiotic systems of the so-called meanings as a reality beyond our control. The concept of meaning is easily transformed into the concept of purpose. And it is a step from the world of molecules and cells into the area of freedom of will and logic. Here you need to draw down the curtain. At the end of this section, I want to reiterate a very important condition necessary for the implementation of active (prescriptive) function of genetic information. It is obvious that in addition to the mandatory molecular mechanism for the actual information content of correlation between the structures of the two classes of polymers, the presence of the entire material and energy infrastructure is required. Of course, the media themselves cannot be the source of the activity. Only the constant flow of free energy and reproduction of a significant pool of activated precursors of polynucleotides and polypeptides synthesis maintain the high thermodynamic potential of the system and are the real driving force behind the biosynthetic activity. Apparently, these circumstances are not the last to determine the formation of a *holistic* view of living systems.

4. Information entropy. Its disproportionation

The idea of *information* entropy as another face of the general entropy process arose from the need to explain what mechanism supported a summary positive balance of entropy in the developing biological systems [21]. The complexity of the correct interpretation of the efficiency of the Second Law of thermodynamics in biological systems continues to be relevant and some times elusive for understanding of the problem. This is reflected in the concluding sentences of the problem analysis which was made by [24]: "In the center of attention here is the main paradox that the increase in the orderliness of biological systems is accompanied with a spontaneous production of positive entropy". We consider that continuous mutation process in genetic systems during the evolution is the process of information entropy production. The resulting unsteadiness in the genetic information system is a necessary condition for the generation of new information [8]. Transfer of gene complexes to the next generation that is supported by the selection and provides better information, is that causal physical link between the positive entropy events in the past generations and anti-entropy processes in their descendants. Information entropy, being the internal property of genetic systems, violates the existing stable condition and arouses the appearance of modified sequences in genomes whose carriers will be come objects of selection.

The process of new genetic information generating is directly conjugated with the changes of entropy (both thermodynamic and information) but, however, it should be recognized that there is a fundamental difference between the thermodynamic entropy and the information one in probabilities of occurrence of elementary events which make sense of each entropy type. The growth of the thermodynamic entropy results in processes of biochemical transformations which are accompanied with the dissipation of part of the free energy of the participants (presented in the system or entering

into it). The probability of elementary acts is very high because the reactions of this type come with the release of energy. Part of this energy is retained and will be then implemented for the processes of thermodynamically improbable events, such as the synthesis of universal macroergic compounds.

On the contrary, information entropy which we want to characterize as a source of subsequent, related changes is the result of very improbable events, because these events (mutations) occur in macromolecular, highly organized systems which have largely deterministic character of consecutive reactions process. This kind of entropy in no way affects the physical orderliness of the nucleotide sequences (only the semantic!) and, therefore, does not contribute to the change of thermodynamic entropy of the system (they are something like immiscible substances). Information entropy contributes to the implementation of the ranges of freedom which are possessed by the carrying genetic information nucleotide sequence. Time of waiting for occurrence of the elementary entropy events of this kind significantly (many times) exceeds the time of the occurrence of such events for the thermodynamic entropy—the other face of entropy as a physical phenomenon. Owing to this modest contribution to the overall entropy balance which is the driving force of biological systems evolution it becomes possible to overcome determinism of strict sequence of DNA replication events and the generating of new information.

Information entropy which accompanies acts of information transfer to the new generations has regularly contributed its share to the general entropy expenditures required for maintaining of the non equilibrium state and falls on the scale which has a positive sign (i.e. towards the equilibrium state). These rare fluctuations transfer the system in an unsteadiness state only for a short time and it is accompanied with the birth of a new information motive. The information entropy which accompanies this simple event can in no way influence the general entropy balance in a separate cell. But it is summed with the whole array of similar events on an evolutionary time scale and assures us that the Second law of thermodynamics is adhered to.

We would like to discuss the idea that in living systems there is the phenomenon of *disproportionation of entropy in time*. It should be understood as a kind of conjugation of positive entropy events in the genetic material of cells of past generations with the formation of highly organized structures in modern organisms; and this conjugation can be considered a way of implementation of the Second law of thermodynamics in uninterrupted living systems with a very long life time. Of course, we are aware of the fact that the information entropy which was produced in the genomes of past generations in no way can be taken to the entropy balance of current cell. This would contradict the principle of obligatory physical conjugation between two processes going on in the thermodynamically opposite directions. The proposed term "disproportionation of entropy in time" is intended to emphasize that genetic information physically transmitted in generations was created and improved during the evolution in really existing genetic information systems which experience continuous entropy pressure transforming these systems into unstable state.

Summing up, we note again that the two faces of entropy correspond with two fundamentally different periods of biological systems existence. Production of the thermodynamic entropy in the metabolic system provides maintenance of steady state and reproduction of already existing information. This is evolution towards the most probable state in periods of ontogenesis. Production of the information entropy in the genetic system accompanies the transformation of a system into unstable state and is a condition for the generation of new information. These events correspond with the evolution of the system to a less probable state which is formed from the unlikely events

(mutations) in the genetic information system, and it becomes possible only with the participation of selection in the process of phylogenesis and memorization of the selected sequence (information motives).

5. Concluding remarks

Consistent consideration of the spontaneous formation as of the simple inanimate objects and of the primary pre-biological systems and cells allows defining information in general. *It can be considered as a factor contributing to the achievement of one of the unlikely and stable combinations of the elements of the system.* With regard to genetic systems, *information* can be defined even more specifically: *it is memory about the realized acts of choices of the next monomer, which (memory) is recorded in the polynucleotide sequence of monomers. Information emerges in the system together with the formation (and reproduction) of the polynucleotide and determines through the encoding system the sequence of choices in respect of elementary events that form another structure — polypeptide.* In other words — it is the *memory* of the sequence of the choices made in the structure of source, transferred and implemented in the functional structure of the recipient. In this definition, we want to avoid worldview collisions and don't reduce the meaning of the term "information" either to the observed *new physical entity* [4], or to an *intangible substance* [15, 12, 21], concluded in a linear sequences of monomers in the nucleic acids. The term "memory," to which we reduce information, rather testifies that it is merely an abstraction (concept), born of the human brain, and is a means of describing the alleged non-material relationships between interacting material structures.

The main conclusion of the presented review is that the information occurs *simultaneously* with the formation of the primary physical and chemical systems in a series of physical structures. In the first stage the organic molecules of increasing complexity arise spontaneously. The sequence of elementary acts of synthesis is formally recorded in the structure of these molecules. But this memory (structural information) is not *operational*. It cannot be used for their self-reproduction, or otherwise transferred and translated into the structure of other molecules.

In the second stage a new class of *non-regular polymers* constructed from 4 types of nucleotides emerges spontaneously. It was the world of RNA molecules that possess two key features — complementary reproduction capability and catalytic activity of a fairly broad spectrum. The second stage can be considered the beginning of the information age.

Here all elements of the intra-molecular information process are present — the event of non-random selection of the next monomer in the synthesized molecule, and the transfer of the order of the nucleotides to the newly synthesized complementary replica.

In the third stage the simplest recoding device emerged in which the code principle of conjugation of two basic processes of living systems has been implemented — the generation and storage of information (genome) and functional activity of recipients (proteome). The *prescriptive* symbolic information emerged. Describing these material structures, we can see that a certain entity that we call information is connected with them; and we face a question that is not easy to answer. Is information an objective reality, the new entity (physical or non-physical), existing independently from the human mind [4, 12]? Or is it only an abstraction (concept) that occurs in the human brain, which man uses to describe real events in living systems [6; 26]? The second assertion is captivating in its simplicity and is not contrary to the Occam's principle (Occam's razor).

However, if looking at the subject from a different angle, one finds a very important property of information. This is the *long-range action* in space [11] and in time [21], and the closely associated with this property anti-entropic organization of the local regions of space. Long-range action of information contained in the common organic molecules in polymers as pre-biotic systems is equal to zero. But at self-reproduction of the primary nucleotide sequences via the mechanism of complementary recognition of purines (A, G) and pyrimidines (T, C) there is some intra-molecular long-range action. The next step in the evolution of the properties of the information was made when symbolic information emerged as a result of molecular semiosis. Now, long-range action has spread from molecules-sources to molecules-recipients of information (proteins). This is an intracellular long-range action. The emergence of multicellularity increased the long-range action of genetic information to the size of the organisms. And the long-range action of information produced in the neural networks of the human brain is limited only to the achievable power of the signal-transmitting source.

Noticeable evolutionary correlation between the increasing complexity of living things and the accompanying volumes of information does not always appear clearly, and the above question thus remains open. Apparently, the meaning of the phenomenon of information is just as mysterious as the understanding of how the purely material flows of nerve impulses in neural networks give rise to human consciousness, which is a clearly immaterial entity.

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