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FORMULATION OF THE DEFINITION OF LIFE USING THE ARIZ 85C METHODOLOGY

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Abstract: *In the paper the ARIZ 85C method was used to solve the epistemological problem - how to create a generally accepted definition of life. Following the ARIZ 85C logics step by step the definition of life based on the phenomenon of the local entropy reduction was created. The unusual method of investigation matters of biology by epistemological and TRIZ tools has created a large amount of ideas for possible future research.*
Key words: *ARIZ 85C, definition of life, reduction of entropy, epistemology.*

1. INTRODUCTION

The ARIZ 85C is an extremely powerful tool for solving complex technological problems. We wanted to prove that TRIZ tools can be used not only to solve technological problems, but also to solve any other difficulties encountered in the cognitive process. In 2018, we explored the possibilities of applying the TRIZ method in the creation of scientific inventions [1]. This work is dedicated to testing whether the TRIZ method can be successfully applied in solving epistemological problems. To do this, we practically applied ARIZ 85C logics to solve a specific epistemological problem - to create a definition of life. Our choice was based on the following reasons:

• The phenomenon of life is intuitive and easy to understand for any person;

• Despite this intuitive intelligibility, scientists and philosophers have not yet succeeded in creating a generally accepted definition of life;

• Great intellectual efforts have been made so far in creating the definition of life, thus accumulating a large amount of information that can be applied creatively;

• Unlike the traditional epistemological problems, which are very different from the field of TRIZ applications - technology, manifestations of the phenomenon of life are much similar to technological problems. This fact facilitated the application of solutions by analogy.

• We have noticed the interest of other TRIZ enthusiasts to combine research in biology and philosophy [2].

With respect to the TRIZ methodology, it can be said that we used a traditional tool (ARIZ 85C) to solve a non-traditional problem. In order to avoid methodological inaccuracies in this process, throughout our work, we tried to follow the methodology developed by G. Altshuller [3] as accurately as possible, observing his recommendations literally point by point. In order to make the course of author of this work more understandable to the reader, the judgments are based on analogies with the examples given by Altshuller.

Although, in some cases, the tools designed to solve technological problems did not meet the needs of the epistemological research, we managed to apply the method successfully until the problem to create a definition of life was solved. Therefore, we hypothesize that the ARIZ 85C method can be used not only for solving technological problems, but also in other fields of cognitive interest.

2. GLOSSARY

Before we turn to the analysis of a specific definition of the life phenomenon, we need to describe in a few words our general understanding of what a definition is, the process of creating a definition, and other concepts that will be used in a specific way in this work.

The definition is an explanation of how the phenomenon under study should be perceived in terms of the structure of existing views. Several approaches are possible to link the phenomenon to be defined with already recognizable concepts:

• It is possible to list from what components the subject of the definition is created (built);

• The processes by which the phenomenon works can be explained;

• It can be explained where and how the phenomenon has originated;

• An analogy can be established with similar phenomena, indicating correspondences and inconsistencies;

• It is possible to show the connection of a particular phenomenon with other already studied phenomena by means of logical tools and he mathematical apparatus.

The structure of all definitions includes the concept or word that is described - **the definiendum** and the words and concepts that describe it – **the definiens**. Because the structure of the definition corresponds to the structure of a logical judgment, we will replace unusual Latin words with the more common logical terms. Instead of the definendum, the term **definition subject (subject)** will be used, but instead of definiens, we will use the term **predicate**.

In a mundane sense, people use **informal (intuitive) definitions** that resemble narratives, usually with easy-to-understand analogies with already known and understandable phenomena. Such an approach, trying to intuitively understand the essence of things, usually makes it easier to understand and describe the real nature of things, or to create **a real definition**.

Scientists try to describe the phenomenon under study by **formal definitions** that include strictly formalized concepts and categories, preferably linking them with mathematical relations. Scientists and philosophers rely on scientific paradigms to create a structure of formal definitions in which each definition is linked to other ones. **Paradigm** is a distinct set of concepts or thought patterns, including theories, research methods, postulates, and standards, that constitutes legitimate contributions to a field. A scientific-formal approach usually facilitates the creation of a **nominal definition** that explains what the word to be defined means, often without going into its essence.

An interesting reality that, to some extent, explains the difficulties in defining the phenomenon of life is the fact that, in English, the same word “life”, in different contexts, denotes at least three different concepts. In definitions, these three terms are often used without explaining exactly which concept the author defines. For instance:

•“*Death is the permanent termination of all biological functions that sustain an organism, and as such it notes the end of its* ***life***” [4] (life as a period of time between birth and death);

•”*Thermodynamically,* ***life*** *has been described as an open system which makes use of gradients in its surroundings to create imperfect copies of itself*“[5] (life as an organism, system);

•“***Life*** *is a characteristic distinguishing physical entities having biological processes (such as signalling and self-sustaining processes) from those that do not* “ [4] (life as a characteristic, property).

In the following description of this document, each term is described by a different English word:

• **Lifetime** is the period of time between the birth and death;

• **A living organism**, or **living system**, is something intuitively and fundamentally different from an inanimate object;

• The property that distinguishes a living organism from an inanimate object is **life**.

The last term is also the one for which we are trying to find a correct definition in this study.

3. APPLYING THE LOGICAL STRUCTURE OF THE ARIZ 85C METHODOLOGY FOR THE EPISTEMOLOGICAL RESEARCH

3.1 Analyzing the Problem (ARIZ 85C PART 1)

Formulate the mini-problem (ARIZ 85C 1.1). Scientists and philosophers have sought to describe the concept of life through nominal and formal definitions, using existing scientific paradigms as predicates for these definitions. At the same time, all people (including scientists themselves) have a real (intuitive) understanding of what life is.

It has not yet been possible to establish a formal definition of the phenomenon of life that would be unequivocally accepted among the scientific community (it would be nominal) and be suitable for use by the general public (it would be real). Any attempt to create and bring such a definition to date has been opposed by two forces: 1) other scientific authorities that criticize the definition from the scientific-formal point of view, and 2) the resistance of a potential everyday user to the definition as overly complex, long and difficult to remember.

The epistemological problem of creating a definition of the phenomenon of life is an attempt to resolve the contradiction between the nominal definition of life and the formal definition on the one hand and the real definition and intuitive understanding on the other. It includes the following components:

•A strong intuitive understanding of what object is alive and what is not. Practically, every person has such an intuitive understanding.

•Existing nominal definitions of life and their predicates - well-known concepts and popular scientific paradigms, with the help of which the authors have tried to create a generally acceptable definition of life.

•Similarities, analogies, inductive and deductive judgments, and other techniques that link the subject of definitions with predicates.

• Intolerance by scientific authorities of (in their view) incomplete or unjustified definitions. Criticism of both the predicates with scientific paradigms and concepts that are intuitive, but are not scientifically sound.

• Everyday people's misunderstanding of (and therefore often intolerance towards) complex and incomprehensible predicates of definition.

To explain the course of further thoughts, let us remember that, in the example given by Altshuller [3], the technical system includes a radio telescope antenna, radio waves, lightning discharges and lightning conductors. The antenna has to receive radio waves, but the lightning conductors has to protect the antenna from lightning discharges during a thunderstorm. The problem is that lightning conductors shield weak radio waves, both during calm weather and during storms, the many lightning conductors placed around the antenna securely protect it, but, at the same time, they interfere with radio reception.

Paradoxically, in the problem of creating a definition of life, it is possible to find quite direct analogies with the example of radio telescope. Instead of a radio telescope antenna, we can imagine a real definition of the phenomenon of life. For the definition of life to be universally accepted, it must be able to perceive "weak radio waves" - an intuitive understanding of the phenomenon of life.

At the same time, it should be consistent with the nominal and formal scientific interpretation, that is, the subject of the definition and the predicates should be connected by strong logical links, and predicates of the definition should be based on generally accepted scientific paradigms.

The process of creating a definition that combines real and nominal definitions is hampered by "lightning" in the form of criticism from scientific authorities. The definition based on scientific paradigms are similar to lightning conductors - they eliminate the anger of authorities because they are difficult to question. At the same time, they hinder the transformation of an intuitive (real) definition into a generally

accepted nominal and formal definition of life, because they are difficult to understand and remember.

From the list of components of the problem, two epistemological contradictions (EP) can be deduced, which are somewhat analogous to the technical contradictions (TP) given in Altshuller's example:

EP 1: If many predicates based on scientific paradigms are used to create a real definition of the phenomenon of life, they protect the definition from the scientific criticism, but they do not allow an intuitive understanding of what life is.

EP 2: If the definition proposed uses only few or no scientifically based concepts and is limited to the use of some intuitive predicates, such a definition is usually easy to understand and remember, but it will be subjected to a significant criticism from leading scientists.

To explain the epistemological contradictions, we can give the following examples.

EP 1. Currently, one of the most popular definitions of living organisms is: "living organisms are open systems that maintain homeostasis, are composed of cells, have a life cycle, undergo metabolism, can grow, adapt to their environment, respond to stimuli, reproduce and evolve" [6]. Due to the many scientific terms and theories used in the definition, it is very difficult to criticize or question it from the scientific point of view. However, it is difficult to imagine that such a long, complex and difficult-to-keep-in-mind definition could gain popularity on the everyday (intuitive) level.

EP 2. For millennia, a simple understanding of life has been the presence of a soul in the body. The general intuitive and also theological understanding was that, if an organism is alive, it is inhabited by a soul; if the soul leaves the body, it is considered dead. This is a very simple definition (just one predicate), based on an intuitive and widely recognizable concept of soul. Although mystical and completely incomprehensible, the concept of soul was extremely strongly established in the human consciousness through the church. Beginning with the Renaissance, scientists and philosophers have been questioning the concept of soul because of its uncertainty and inexplicability.

Thus, the definition of life, which is formed by the predicate of soul, has received considerable criticism from scientists, using rational arguments, and is not employed today to form a nominal definition of life. Summarizing the analysis of the problem so far, we can formulate a mini-problem:

by introducing minimal changes in the system, it is necessary to create an easy-to-understand nominal definition of life that would reflect the real (intuitive) understanding of the phenomenon of life and could not cause the criticism of the scientific authorities.

Define the conflicting elements. Identify and write down the conflicting pair: a product and a tool (ARIZ 85C 1.2) The product that needs to be improved is the real definition of life. This definition has not yet been formalized; it currently exists only on the intuitive level and is expressed through the (informal) methods of intuitive definition. The current nominal definitions of the phenomenon of life need to be improved so that they could formally describe what is meant by the term 'life', and this verbal description would be fully in line with the real (intuitive) understanding of it.

There are tools for creating definitions in a direct contact with the product. They are the epistemological means and methods by which definitions are formed and modified, for example: 1) the description of the subject of definition; 2) selection of the definition predicates; 3) techniques that interconnect the subject of definition and predicates, such as logical constructions and analogies.

Although in different ways, these tools and techniques are characteristic of both the real understanding of the phenomenon of life and the nominal definitions.

Thus, our problem has to consider one product (the real definition of life phenomenon) and two tools. These tools are: 1) the intuitive method for creating a definition; 2) the scientifically rational method. The intuitive method uses more widely accepted and socially recognizable predicates, and their connection with the phenomenon of life is often realized with the help of similarities or analogies. In the scientific-rational method, scientifically widely accepted

paradigms are chosen as the predicates of definition, and the connection with the subject of definition is ensured by rational causal relations, logical outputs, and deductive and inductive conclusions. Both of these tools help one to transform and improve the product, but they affect each other and interfere with each other.

Describe graphic models for epistemological contradictions (ARIZ 85C 1.3).

EP 1. If many widely accepted scientific concepts are used in the definition of life, then such a definition is justified in the nominal sense, it is difficult to criticize it (a positive effect), but these scientific constructions hinder the manifestation of intuitive understanding (a harmful effect).

EP 2. If the definition of life is formulated by the intuitive method, it is possible to create a real definition that is easy to understand, easy to remember and is widely accepted (a positive impact). The criticism of scientific authorities undermines confidence in such a definition (harmful effects).

Select a graphic model for a further analysis (ARIZ 85C 1.4) At this point, the ARIZ 85C method requires the selection of the Main Manufacturing Process (MMP). In the example with a radio telescope, the reception of radio signals is assumed as the MMP (no lightning protection).

In creating a definition of life, the MMP is the creation of a nominal definition of life that corresponds to the real essence of the concept of life. Such a definition should be generally acceptable, intuitive, easy to understand and safe from the scientific criticism. Therefore, the second of the two graphics should be considered as the main one, which focuses on the MMP. Namely, the tool to be used in the further research should be such that it ensures the creation of the definition, but not the elimination of criticism.

Describe the problem model (ARIZ 85C 1.6) The problem model is an abstraction in which only two elements forming a conflicting pair are artificially selected from all the elements of the system. The problem model includes:

•a conflicting pair;

•description (definition) of the intensified conflict;

•description of a new element X - what such an element should do (provide, maintain, develop, prevent, improve) to solve the problem.

In Altshuller's explanation, the lightning and lightning conductors were chosen as the conflicting pair. The radio telescope antenna and radio waves were ignored at the time the problem model was created. In this case the element X was something that could prevent the harmful effects - shielding the radio waves while providing a beneficial effect – the protection from lightning discharge.

By analogy, in our investigation the conflicting pair would be predicates and critiques of existing nominal definitions. The real definition itself and the intuitive understanding which it should demonstrate would be subordinated to an analysis of the conflicting pair, or even completely ignored, at this point of the epistemological study. It would be necessary to find an element X that would successfully replace the predicates of existing definitions and not be questioned or criticized by scientific authorities.

Most likely, such an element would be a description of the life phenomenon that would correspond to the intuitive understanding of the life process, but would not contradict the existing scientific paradigms. Such an element X does not necessarily have to be something completely new and unknown - it can as well be an existing modification of a definition predicate or an unexpected combination.

Apply the inventive standards (ARIZ 85C 1.7) To solve the problem model, the ARIZ 85C at this point calls for the application of invention standards. Technological problem solvers at this moment of research have a wonderful opportunity to apply the invention standards identified by G. Altshuller, that is, phenomena of the physical world, which, when reviewed and creatively applied, usually manage to find a solution to the mystery of the element X.

Unfortunately, in the field of epistemology, no one has compiled and systematized such

inventive standards that could facilitate process of finding of element X; therefore, the further direction of our research will follow the second recommended direction of ARIZ 85C – an in-depth analysis of the problem model.

3.2 Analyzing the Problem Model (ARIZ 85C PART 2)

Define the Substance-Field Resources (SFR) (ARIZ 85C 2.3.) By analyzing any technological problem, it can be reduced to the elements of the material world that make up the technological system, namely, the matter and field. The epistemological problem, in turn, must be solved with the help of the concepts involved in the problem and the consideration of the mechanisms inherent in functioning of the human mind, which connect these concepts with each other - logical constructions, application of analogies and the like. In the analysis of the object of our research - the phenomenon of life, it is necessary to apply the concepts that have appeared in many attempts to create a nominal definition of life.

We tried to create such a base of terms (predicates), or SFR in the epistemological sense.

The most complete such analysis, which analyzed 123 definitions of life and identified 100 predicates, was published in 2012 by Trifonov [7].

We used this list of predicates as the basis for our SFR, supplemented by a number of predicates from other sources that we consider relevant, such as terms related to biological information, the origin of life, life-boundary cases, and alternative theories that explain the phenomenon of life.

Due to the limited scope of this scientific work, we will present only the stopping points.

3.3 Define the Ideal Final Result (IFR) and Physical Contradiction (PhC) (ARIZ 85C PART 3)

Formulate IFR (ARIZ 85C 3.1.) An ideal end result of this research would be the identification of an element X that could unambiguously describe the phenomenon of life. This quality would be logically and formally connected with the regularities of the material world already discovered and described. Thus, the existing intuitive and realistic understanding of what is the phenomenon of life would be aligned with existing scientific paradigms, avoiding the scientific criticism.

Intensify the definition of IFR-1 (ARIZ 85C 3.2.) Ideally, it would be possible to describe the phenomenon of life not only qualitatively, but also quantitatively - to measure it with the help of a parameter that could be derived from the currently known parameters.

People evaluate the liveliness of objects in an intuitive sense. For example, it can be said about a puppy: "He/she has a huge vitality", but old people often complain that their vitality begins to fade away.

Until now, the quantification of liveliness has always taken place at the level of intuitive understanding only through the concepts of "more" and "less".

Quantifying the vitality of a system (organism) would be the creation of a completely new concept, which at least initially, will collide with the psychological inertia and, consequently, with the criticism from opponents.

Identify the Physical contradiction for the Macro-level (ARIZ 85C 3.3.) According to the ARIZ 85C methodology, at this point in the study, it is necessary to identify the unresolved physical contradiction that hinders the achievement of the ideal end result. In an epistemological analysis, we will analyze the main contradiction between the intuitively strictly understood (obvious) processes in a living system and the (unsuccessful) attempts to explain these processes from the viewpoint of paradigms of the classical physics.

In the everyday sense, every person experience that all material (inanimate) things, both in nature and in daily life, degrade over time. In turn, those systems that have a living phenomenon not only retain their form, but also evolve. This phenomenon is particularly noticeable when comparing two very similar systems, such as the incubation process of a fertilized and an unfertilized egg. In the egg, where there is no phenomenon of life, the complex molecules present are broken down, but in the fertilized egg there is a surprising internal arrangement of the system.

This apparent physical contradiction is at the heart of the understanding of the phenomenon of life. It is intuitively and socially accepted, and therefore there is an intuitive definition of life. Scientifically, there is still no good explanation for this phenomenon, so there is no good nominal definition yet

Identify the Physical contradiction for the Microlevel (ARIZ 85C 3.4.) By solving the question of why the microscopic components of a living organism behave differently depending on whether or not it contains a living element (or element X), it is very likely that we will resolve the epistemological contradiction between the real and nominal definitions of life. Namely, by introducing the element X, which could explain the unusual phenomena of life at both macro- and microlevels, it would be possible to improve the real (intuitive) definition in such a way that it corresponds to both the intuitive understanding and scientific notions. Surprisingly, the exploratory journey from purely epistemological problems has led us to the classical ARIZ 85C area, namely to the analysis and explanation of physical and chemical processes at the microlevel.

Analyzing the epistemological resources at our disposal (definitions of the phenomenon of life to date), we are faced with at least three obvious contradictions:

•Scientists are trying to base the targeted metabolic processes, such as growth or healing, on the classical laws of chemical reaction kinetics - an analysis of the thermal motion of molecules and the probability of their collision, although it is obvious that many life processes involved in the transfer and reactions of substances, like growing or healing, are directed and are not accidental;

•The only form of energy transfer in living organisms is through the ATF / ADF pair. This mechanism is explained from the physicochemical point of view; however, the targeted delivery of ATF directly to the body's site required and the subsequent return of the ADF and phosphoric acid molecule to the "charging site" cannot be explained by the chaotic movement of these molecules due to heat motion. In this movement, there clearly is an organizing element under the influence of which the chemical energy is transferred.

•Many chemical processes in a living organism seem to be contrary to the laws of thermodynamics. All reactions of the synthesis of complex compounds take place not in the direction of reduction Gibbs free energy; but on the contrary – the energy is purposefully supplied to these processes.

The intuitive feeling is that these processes are carried out by the will of an "invisible chemist". The existing explanation of these processes tries to circumvent the problem by involving DNA and RNA information transfer mechanisms in it. As far as the structure of the synthesized molecules is concerned, the DNA / RNA argument is good, but it does not explain the incomprehensible desire of reactions to perform a process contrary to the laws of thermodynamics, namely, by arbitrarily attracting external energy and information.

All the processes considered can be generalized by describing the phenomenon of life as a process with a decrease in entropy.

However, reasons why entropy (system disorder) decreases locally in the presence of a life phenomenon is not yet explained satisfactorily. Thus, at the microlevel, we can describe the problem as follows: although all particles in a living system should obey the classical laws of physics and chemistry, they largely move and react against these laws.

Formulate IFR-2 (ARIZ 85C 3.4.) The ideal end result of epistemological conflict, IFR - 2, would be an explanation, consistent with both the laws of physics and the intuitive perception of why and to what extent living system microparticles, which should obey classical laws of physics and chemistry, move and react against them.

3.4 Mobilizing and using Substance-Field Resources (SFR) (ARIZ 85C PART 4)

Take a "step back" from the IFR (ARIZ 85C 4.2.) According to the ideal final solution IFR - 1 proposed, the property X must describe all known life forms and their manifestations. Let us take a step back from the requirement to

describe all known life forms with the help of a thought experiment about what features could characterize the hitherto unknown life forms. When NASA was preparing for an expedition to Mars in the early 1960s to try to identify life forms there, they approached the English chemist James E.

Lovelock and asked him a TRIZ-style question: “What if Martian or other life didn’t look or act anything like terrestrial life? Could it still be detected?” Lovelock approached these questions by considering the concept of “entropy”. A sure sign of life on Mars, Lovelock realized, would be a reduction in local entropy. [8].

Indeed, on reflection on all known manifestations of life, we can see that they are all characterized by a phenomenon of reduction in local entropy.

The idea that the mystery of the phenomenon of life could be explained by the factor of reduction in local entropy has been popular since Ernest Schrodinger published his book "What is life?" in 1944 [9]. In the following analysis, we will try to find out whether the factor of negative entropy alone can be a sufficient condition for defining the phenomenon of life.

Using a combination of substance resources(ARIZ 85C 4.3.) We find out that combining different terms in trying to create a necessary and sufficient definition, for example, from a list compiled by Trifonov [7], is a purely sophistical exercise.

Numerous combinations of predicates are possible, and for each of such combination, it can be proved that either it does not contain all the predicates necessary for describing the phenomenon of life, or it is possible to find a nonliving system to which all the predicates mentioned in the list correspond.

Moreover, in an attempt to combine as many life properties as possible in one definition, it was only made longer and more complex. Therefore, we immediately applied the next methodological method of problem solving.

Using "voids" (ARIZ 85C 4.4.). Epistemologically, this method would be attempt to decide which predicates can be completely discarded from the possible meaningful definition of life.

This was one of the most creative and challenging parts of our work, as we had to overcome psychological inertia many times, examining, for example, whether it was possible to abandon concepts such as the cell, DNA, evolution, organism, when defining the phenomenon of life.

To understand which of the predictions of life definitions (SFR) to date should be discarded, we needed to review more than 100 concepts (predicates of existing definitions).

To intensify this work, we grouped all the predicates into nine groups according to their conceptual features, and tried to understand whether a good definition could be such that, in principle, does not include any element from that particular group, i.e., would it be possible if one or more of these groups were to be abandoned altogether?

• The physicochemical structure of a living system. These aspects mainly characterize a living organism (system) rather than a living phenomenon (process). We presumed that if a sufficiently general concept of the life phenomenon could be developed, it is possible that the specific manifestations of the structure of the organism could be excluded from such a concept.

• Physicochemical processes, self-organization phenomenon; aspects of energy, matter and information flow, changes in thermodynamic states. The processes that take place in a living organism are the very essence of the phenomenon of life, therefore, they certainly cannot be excluded from a further analysis.

• The relationship of the living system with the environment. The phenomenon of reduction of local entropy includes both the concept of the system itself (in which entropy decreases) and the concept of environment (against which this change in entropy is observed), so the concept of environment cannot be excluded from the understanding of the life phenomenon

• A living system as a subsystem (i.e. species). We concluded that by analyzing the nature of a particular living organism, it is possible to abstract from the supersystems to which it belongs.

• A living organism as a supersystem of subsystems such as organs and cells. Similar to the argument mentioned in the first paragraph, when looking at the life process in a sufficiently generalized way, it would be possible to disregard exactly what subsystems (elements) it consists of.

• Aspects related to the emergence (birth) and cessation (death) of a living system (organism). By analyzing the life processes of a particular living organism, during it's lifetime we can abstract from the analysis of how it originated or how it will cease to exist.

However, the fact that any living organism experiences both the moment of emergence (birth) and the moment of termination (death) is so general that it cannot be ignored. A good definition of the phenomenon of life should at least give an indication of how to explain this phenomenon.

• Reproductive phenomenon, information transfer to offspring. The standpoint that there is a connection between the ability to reproduce and the phenomenon of life is, in our view, a misunderstanding. Indeed, it cannot be said, for example, that a mule or a sterilized pet is not alive simply because they are unable to reproduce.

Therefore, the ability to reproduce should be completely excluded from any predicates in the definition of the phenomenon of life. On the other hand, it is an undeniable fact that, without exception, all living beings have originated from other living beings. This truth is so absolute that a good definition of life should include at least an implicit explanation of it.

• The debate over the origin of life is somewhat reminiscent of the proof of God's existence with the root cause argument. Namely, if each living organism originated from another living organism, from what did the first living organism originate? Although it is possible to abstract from this question by analyzing and describing a particular living organism, a good definition of life should include at least an implicit reference to how to deal with this casus.

• Special theories (such as teleology, vitalism) can be ignored in the course of creating of creating the definition except for the fact that they might be an interesting source to look for analogies or unexpected solutions.

Finally, we selected five predicates that, in our opinion, are necessary and sufficient to describe any form of life, both that occurs on Earth and theoretically undiscovered forms of life. They are: negative change of entropy, open system, flow of matter, flow of energy, flow of information. Summarizing these predicates in the form of a definition, we obtained the following formulations:

• Life is a fundamental feature of the structure of the world, that manifests itself in a local negative change in entropy.

• A living system is an open system in which the reduction of entropy is ensured as a result of the flow of matter, energy and information.

• Lifetime is the period of time during which an open system has life.

Using derived resources (ARIZ 85C 4.5.) The expression "negative change in entropy" includes the idea of change in entropy per time, in other words, it is the time derivative of the entropy - time relation S(t). Accordingly, we can introduce the notion of lifeness (L) that describes quantitative presence of life in the system at any point in time:

$$L = \partial S / \partial t$$

Due to the fact that the goal of our research work - to create a quantifiable definition of life has been achieved, we can move on to the seventh chapter of ARIZ 85C.

3.5 Analyzing the Method of Resolving the Physical Contradiction (ARIZ 85C PART 7)

Preliminary estimation of the solution concept. (ARIZ 85C 7.2.) To evaluate the solution of the problem, Altshuller proposes to answer four control questions:

Does the solution concept provide the main requirement of IFR-1 (the element without complicating the system…)?

The element X that could unambiguously describe the phenomenon of life and would be logically and formally connected with the regularities of the material world already discovered and described, was found – it is decreasing of the entropy over time.

The solution proposed also satisfies intensified IFR-1, as the change in entropy over time can be quantified.

Thus, the existing intuitive and realistic understanding of the phenomenon of life is aligned with existing scientific paradigms, avoiding (hopefully) the scientific criticism.

Which Epistemological Contradiction (if any) is resolved by the solution concept? We believe that definition proposed resolves both EP's.

Also, just five predicates based on scientific paradigms are used, they are generally accepted terms and should protect the definition from the scientific criticism.

At the same time, all the predicates used are also understandable in everyday language, so the definition is easy to understand and remember.

The only term that might be unfamiliar to the average user is entropy, but it can be correctly explained by using the analogous word "order".

Does the new system contain at least one easily controlled element? Which element? How is it controlled? Although the concept of entropy is widely used in both thermodynamics and information science, there is currently no clear view on how entropy can be measured and controlled directly.

However, many theoretical and practical studies, such as the relation of entropy with information and energy, are likely to create new opportunities and challenges in life science as well.

Does the solution concept found for the "single-cycle" Problem Model fit the real conditions, multi-cycle conditions? In the case of epidemiological research, such an issue would be more relevant to the necessity and sufficiency aspects of the definition established.

We performed a large amount of research to compare our definition with existing definitions of life and to check if our definition is general enough.

In parallel, we tried to find any manifestations of the material world that could be described by the proposed definition, but which would not correspond to an intuitive understanding of the process of life.

The results of this intensive research cannot be presented in detail within the framework of this scientific work, rather it would be another scientific article. However, in short, we managed to find only a few discrepancies that could be the subject of further research.

4. CONCLUSION AND OUTLOOK

Within the framework of our scientific work, we have proved that the TRIZ and ARIZ 85C can be successfully used not only in solving technological problems, but also epistemological ones. By consistently applying the logics of the ARIZ 85C, we were able to offer a solution to the significant and hitherto unresolved epistemological conflict - the existence of many scientific definitions of life that are inconsistent with the general, intuitive understanding of the concept of life.

In another words, we have proposed a definition of life phenomenon which combines real and nominal definitions of life. This allowed us to conclude that the ARIZ 85 C is suitable not only for solving technological and inventive problem but is a much more general "problem solving tool".

It is not improbable that by accurately describing the mini-problem, finding the conflicting pair and applying other ARIZ 85C methodological recommendations, it is possible to solve problems in other fields of cognitive interest, for instance, philosophy, economics and politics. This, in our opinion, is an extremely interesting direction of further research.

At the same time, the very intensive acquaintance with the phenomenon of life and the creation of a new definition of life encourage us to think about further research in this field.

The explanation that the phenomenon of life is a local decrease in entropy is broader than the biological explanation of life.

In the ontological sense, a living (biological) organism thus manifests only one of the subsystems of the concept of a "living system", or

speaking in TRIZ terminology, the epistemological conflict of creating a definition of life was resolved by shifting the problem of explanation the phenomenon of life to the supersystem.

Therefore, further research is needed on systems that are not biological organisms but show a local decrease in entropy.

These can be, for example: an anthill, an industrial robot or any big city. This type of analysis leads us to the beliefs that are characteristic of autopoiesis representatives.

The approach that identifies the phenomenon of life with the phenomenon of negative change in entropy requires a more detailed explanation of how the concept of entropy is understood and how it is related to the matter, energy and information - the three substances that circulate in each living system.

For instance, interesting direction for future research is related to the entropy and information relationships in processes of life and possible quantitative measurement of entropy changes.

Finally, we must acknowledge the logical consistency: if the phenomenon of life can be considered a "deviation" from the second law of thermodynamics, it is likely that this "deviation" is as general as the law itself.

This, in turn, means that the phenomenon of life in its most general form did not arise in unexplained conditions on Earth 4,5 billion years ago [6], but at the same time as the world order itself. Undoubtedly, such a hypothesis opens the door to the widest range of future research in both science and philosophy.

5. REFERENCES

[1] Schollmeyer J., Tamuzs V., *Discovery on Purpose? Toward the unification of Paradigm Theory and the Theory of Inventive Problem Solving (TRIZ)*, Cavallucci D, De Guio R, Koziolek S (eds) Automated Invention for Smart Industries. Springer, Strasbourg, pp 94 – 109, (2018)

[2] Vincent J., Cavallucci D., *Development of an Ontology of Biomimetics Based on Altsuller's Matrix*, Cavallucci D, De Guio R, Koziolek S (eds) Automated Invention for Smart Industries. Springer, Strasbourg, pp 14 – 25, (2018)

[3] Altshuller G., *Algorithm of Inventive Problem Solving*, http://www.evolocus.com/Textbooks/ariz85c.pdf

[4] Vandenberghe L., *The Significance of Humans in the Universe: The Purpose and Meaning of Life*, Bloomington, USA, (2019)

[5] Holley D., *General Biology I: Molecules, Cells and Genes*, Indianapolis, USA, (2017).

[6] *Life*, Wikipedia, https://en.wikipedia.org/wiki/Life

[7] Trifonov E.N., *Vocabulary of Definitions of Life Suggests a Definition*, J Biomol Struct Dyn 29, pp 259-266, DOI: 10.1080/073911011010524992, (2011)

[8] Tobin A.J., Dusheck J., *Asking about Life. Brooks/Cole – Thomson Learning*, Belmont, USA, (2005)

[9] Schrödinger E., *What is Life – the Physical Aspect of the Living Cell*, Cambridge University Press. ISBN 978-0-521-42708-1, (1944)

Formularea definiției vieții folosind metodologia ARIZ 85C

Rezumat: În lucrare a fost utilizată metoda ARIZ 85C pentru a rezolva problema epistemologică - cum să creăm o definiție general acceptată a vieții. În urma logicii ARIZ 85C, a fost creată definiția vieții bazată pe fenomenul reducerii entropiei locale. Metoda neobișnuită de investigare a problemelor biologice prin instrumente epistemologice și TRIZ a creat o mare cantitate de idei pentru posibile cercetări viitoare.

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