Chapter 3

Biological Species as a Form of Existence, the Higher Form

Victor Prokhorovich Shcherbakov

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/53309

1. Introduction

Our major enemy is not another being but our imperfection

"Some say the world will end in fire, Some say in ice."

Robert Frost

"Artificial Intelligence description method for deliberative agents functioning on the basis of beliefs, desires and intentions as known in Artificial Intelligence, can be used successfully to describe essential aspects of cellular regulation" [1]

The Universe consists of discrete entities: elementary particles, atoms, molecules, planets, stars, galaxies. That is there are a limited number of configurations of matter that are fairly stable and lasting, the intermediate ones being volatile. The Universe is structuralized. It means that the world components and the Universe itself resist chaos. They are far from thermodynamic equilibrium. They exist. The existence is resistance to chaos. Many will agree that thermodynamic equilibrium means death for a biological entity, but it is true for any system as well. It may sound funny today that the Darwinian natural selection, acting by accumulation of tiny heritable changes, was initially supposed to produce an even continuum of the living beings. This expectation was never corroborated. The creationists still keep using the absence of this continuum as evidence against biological evolution. But the biological world follows the same global principle: organisms, populations, species are discrete stable entities, the intermediate configurations being volatile. Biological evolution cannot retain and does not retain everything that randomly emerges. The existence of the

Universe depends on the mutual affinity of its constituents, their ability to interact with each other, thus resisting the general aspiration for evenness. This is, however, only one side of the coin. The interaction should prevent the dissipation, but not more than this. Any existence implies a balance between two opposite forces – dissipating and compressing, repulsion and attraction. Too strong interaction leads to collapse, disappearance in singularity.

There are two major forms of existence: inanimate and animate. Any existence is not perpetual. The second law of thermodynamics predicts final dissipation or destruction in collapse of everything in the Universe. What is the dissipating force? Generally speaking, it is energy. Why does the Universe not dissipate immediately? The components of the Universe *interact* with each other, thus retarding the dissipation. The four fundamental physical interactions (weak and strong nuclear interactions, electromagnetic interaction, and gravitation) prevent immediate dissipation of the inanimate entities. These interactions beget numerous new forms of existence, new entities. The Universe as a whole evolves. The prebiotic evolution shares the same major principle with biological evolution [2,3,4]. Various objects continuously arising in the Universe have different longevities, from infinitesimal fractions of a second to billions of years. In the course of evolution, ephemeral forms are replaced by more lasting ones. This principle – "survival of those who survive" – sounds as a tautology, but it is *the great tautology*: Everything genuinely new emerges through this principle. "The only meaningful and objective definition of adaptation would be persistence" [5]. *Longevity is a quantitative measure of existence*. Thus, the evolution of the Universe implies the development of resistance to dissipation, to chaos, to entropy. On the other hand, the longevity implies limitation of the force of interaction, resistance to collapse, to annihilation in singularity. To exist long, the living forms of existence must be able to keep the balance of dissipation and attraction.

2. Biology is special

… "…knowledge is a natural phenomenon which originated long before humans."[6]

It gets increasingly evident that life is not a physical process. It is not just extended physics and chemistry. It is absolutely different form of existence, the higher form. The swallow, building its nest in my shed near Moscow, flies to South Africa and returns strictly to the same shed every year. I hope nobody will try to calculate the probability of such event proceeding from the physical causality and stochasticity. It is evident that swallow knows the route, there and back. Just as I know the route from my home to my work and back. And this knowledge is only a trifling part of the total knowledge any organism enjoys. This total knowledge is knowledge how to reproduce itself. I beg pardon of those who cannot stand anthropomorphisms. Human beings are biological entities and they share many defining characteristics with other living entities (and vice versa). Knowledge is one of them. *Knowledge can be defined as ability to accomplish reliably a low-probable action.* The knowledge may be

http://dx.doi.org/10.5772/53309

given quantitatively as the inverse of the probability of the action. This ability is acquired during evolution of species and ontogenesis of organism (not only in a high school). Defined this way, knowledge is linked to behavior. The behavior based on knowledge is an expedient behavior. Taking the word "behavior" in the broadest sense, we may speak about the behavior of molecules, organelles, cells, organisms, populations, and ecosystems.

The autocracy of physics ends at the border between the inanimate world and the biosphere, where the world of sense and knowledge begins, and behavior of matter becomes expedient. The words: knowledge, memory, coding, transcription, translation, function, signaling, recognition, decision-making, governing, creation, which are impossible and needless in describing inanimate nature, become not only acceptable but unavoidable in the description of living systems [4].

3. Organization as a form of existence

An organization is a complex system that can perform certain functions by virtue of its particular assemblage of parts [7]. Organized systems must be distinguished from the ordered ones. Neither system is random, but the ordered systems are generated according to a simple algorithm and therefore lack complexity, whereas the organized systems must be assembled element-by-element according to an external program or plan. Organization is complexity endowed with function. It is not random due to design or selection, rather than to the necessity of crystallographic order [8]. Living entities (cells, organisms, populations, and species), and only living entities[1], are organizations with the function of survival. Parts of the living entity may hold only particular functions.

"Life is based on semiosis, i.e., on signs and codes" [9], and it cannot be adequately described by means of physics and chemistry. Everything essential in biology is determined not by physical causality but by semantic rules and goal-directed programs. This principle operates on all levels of biological organization. Coding is not limited by the coding of polypeptide sequence by the nucleotide sequence. The entire life cycle is carried out by sequential development of the organic codes and interpretation rules for stepwise self-manufacturing of the entity. In contrast to the objects of the inanimate world that come into being as a result of stochastic interactions, the living entities and their components are *manufactured* on the basis of ontogenetic intention [10]. "All biological objects are artifacts, and … life is artifact-making" [9]. Coding and instructions involve the use of symbols, but a symbol is connected to the symbolized subject semantically, not physico-chemically. The DNA sequence cannot be deduced from the physico-chemistry of the nucleotides just as the text cannot be deduced from the alphabet. Moreover, this non-deductibility is a necessary stipulation for the capability of DNA to code genetic information. The ambition and hope of molecular biology was to explain phenomenon of life via some new sophisticated physics, in particular, via non-equilibrium thermodynamics. Inadequacy of this approach in explanation of life becomes

1 Machines may also be organizations but they are human made creatures.

more and more evident. Living entities survive not because of some special physics or chemistry but owing to their sensible behavior [4,11].

We are used to think that all the entire stuffing of the Universe is presented by two interconvertible essences: energy and substance or matter. Latterly, several bold guys [6,9,12-17] started talking about the third fundamental essence – organic information, which is neither energy nor matter. It is an attribute of life and only life. I think the term "information" may not be the most suitable one. It may be confused with the homonym used in the information theory. Shannon's information is devoid of meaning whereas the meaning is just what we are interested in in context of biology. Most importantly, "the third fundamental essence" is not just information but behavior, which includes internal and external signaling, their interpretation and implementation in the form of organization with a function of survival. I think adequate name for this third fundamental essence would be "mind". Four fundamental physical interactions prevent immediate dissipation of the inanimate world yet they cannot explain existence of living entities. The living world resists chaos by means of *behavior*. Let us define a behavior *sensible* if it is aimed at survival of the behaving entity. Inanimate evolution might be portrayed as self-construction of Nature: matter from energy; biological evolution might be portrayed as self-knowledge of nature: mind from matter [18,19]. The mind is not just epiphenomenon of life. It is *the fifth fundamental interaction* preventing the living world from dissipation and from collapse as well. Mind is a major life-specific instrument for survival. The words "mind", "knowledge", "sense" should not be taken as metaphors. They are good terms. The cells of my body know how to replicate DNA. This knowledge does not differ conceptually from my knowledge of how to read and write, being of course much more important for my survival than the literacy. The total knowledge a biological entity enjoys is the knowledge of how to reproduce itself. Not more and not less. Life is everlasting self-reproduction.

In inanimate nature, all the processes are directed from a less probable state to a more probable state: movement to equilibrium. Life is a movement to a low-probable state. It is a river flowing upward. A stone falling down from a mountain is an example of a physical process; an alpinist climbing up a mountain is an example of a biological process. It needs not only energy, but intention (will) and knowledge; it needs mind. The laws of physics are not violated during this "climbing up". Instead, they are harnessed by the goal-directed programs of life in such a way that low-probable, virtually impossible events become the most probable. Hence, life is a form of existence that differs radically from any form of inanimate existence.

A living entity may disappear for two reasons: it may die or it may change. In both cases the previous entity ceases its existence. To exist means to exist long. Biological species know how to exist long. This is a miraculous knowledge because living entities are improbably complex things. It is not complexity in itself that is miraculous but the fact that the biological complexity is *highly organized*. Complexity implies availability of a large space of the states for the system, while the term "organized" implies that only very few of the states are compatible with vitality. "For the gate is narrow and the way is hard, that leads to life". I.e., living systems are non-equilibrium, low-entropy, low-probable things. We do not say that

http://dx.doi.org/10.5772/53309

organisms violate the second law of thermodynamics. Living things are open systems, continuously sharing matter and energy with their environment. Organisms export entropy to environment, thus keeping their internal states far from equilibrium. This is a correct description of the state of affairs, though it is not an adequate explanation of biological organization. Energy is necessary but not sufficient for implementation of life. It needs knowledge. Energy in itself is a chaotic factor. To support organization, energy must be sensibly harnessed. The living entities survive due to their sensible behavior. They know the way that leads to life. By the way, the necessity of knowledge for implementation of life was already evident for the naturphilosophers of the eighteenth century [20].

4. Living entities

4.1. Prokaryotic cell

The basic form of the biological existence is a cell. Prokaryotic cell is a minimal biological entity. Though any separate thing may be named "entity" in English, it would be heuristically important to name living or biological entity only the organization with the function of survival. The components of a cell (proteins, nucleic acids, membranes, ribosomes, viruses and the like) possess only particular functions, so they are not *biological entities*. A living entity is a monad. It is specifically isolated from the environment and it is a cohesive whole; it exists in time by means of self-reproduction. I am quite aware of possible disagreements with such definition of a living entity; however, I find it not only useful but even inevitable in context of this paper. Cell is a minimal quant of Life. A living entity cannot be less than cell. The components I mentioned above are products of cellular activity. Prokaryotic cells are also the most ancient of the known forms of life. They appeared on the Earth about three billion years ago [20].

4.2. Eukaryotic cell

The eukaryotic cell is a much more complex entity. It appeared on the Earth about one billion years ago as a result of cooperation between several prokaryotic cells [22,23]. As such, they created the enormous and abundant world of unicellular eukaryotes.

4.3. Multicellular organisms

The high complexity of the eukaryotic cells enabled further cooperation and appearance of multicellular organisms. The multicellular organism is a monad. Providing it is asexual, it is substantive entity (see below) that can reproduce itself acting alone.

4.4. Biological species

It occurred that the higher multicellular organisms with large genomes and complex development fail to reproduce themselves reliably across generations. This impediment brought about further cooperation: creation of *multiorganismic entity* as a self-reproducing unit – bio-

logical species. Individual organisms comprising the species lack their status as substantive monads. The above scheme is a simplification. On the one hand, the real self-reproducing entity is a generation of interbreeding population – deme. On the other hand, there exist various forms of sexuality, not only the obligatory sexuality on which I am concentrated in this paper. Existential consequences of sexuality are most clearly expressed in the obligatory sexual forms.

4.5. Substantive and attributive existence

In accord with the above definition of living or biological entity, I am going to use here the notions of "substantive" and "attributive" existence. Substantive existence implies autonomy and self-sufficiency of the entity in its reproduction and evolution. Substantive entity is a sovereign player on the stage of life. Attributive existence implies existence as a part of a higher rank entity (host). Its survival and evolution is causally linked to survival and evolution of the host. In case of asexuality, an organism is a substantive entity, whereas a sexual individual is an attributive entity that exists as a part of a higher rank entity – deme. The attributive existence is a ubiquitous form of biological existence. For example, hepatocytes are entities that exist as an attribute of the animal organisms. They represent a class of polyphyletic entities. Hepatocytes of the different animals are much more similar to each other than, for example, to neurons or any other cells of the same organism. While demonstrating transspecific "epigenetic consanguinity", they reproduce and evolve as an attribute of the host and for the good of the host. Other good instances of the attributive existence are organelles (mitochondria, plastids). I find the concept of substantive and attributive existence useful for description and understanding of biological organization and evolution. In context of this book, it must be quite important to keep in mind that the existence of a sexual individual organism is attributive.

5. Extant and lasting forms of biological existence

As was stated above, evolution of the Universe automatically leads to replacement of ephemeral forms with more lasting ones. This result is inevitable in the ever changing world. Inanimate entities are the most probable configurations of matter at a given situation; their lasting is provided by their physical durability that is provided by the balance of dissipation and attractive power. Organisms are low-probable configurations of matter; they are physically flimsy, extremely complex, low-entropy systems. They cannot withstand entropy growth perpetually. The homeostatic mechanisms cannot be absolutely perfect. They make errors and they lose their robustness. Absolutely perfect homeostasis would require infinite energy expenses. Organisms inevitably die even in the most favorable environment, in the absence of any competition, with an abundance of energy and substance. They perish because of entropy.

It looks like organism as a form of existence reached the thermodynamic limit and is unable to further improve its homeostatic facility. The accuracy of the cell processes is tuned to the

http://dx.doi.org/10.5772/53309

point where it is optimal. Both too little and too much accuracy will adversely affect organismal vitality. The energy expenses are concentrated on fidelity of DNA reproduction. And it is really high: one incorrect nucleotide is incorporated only once in 10^8–10^{10} events. Transcription and translation proceed with a much lower fidelity, with misincorporation rates of 1 in 10^4 and 1 in 10^3–10^4, respectively [24,25]. With this error rate, significant proportion of newly made polypeptides contains amino acid substitutions [26]. And it is not the whole problem. All biopolymers and supramolecular structures are continuously damaged and the defects are accumulated with time. Accumulation of errors must have self-accelerating dynamics inevitably leading to catastrophe. Living systems bypass the catastrophe by means of reproduction. They reproduce to avoid death. Sometimes, single-cell organisms are referred to as immortal. It is misunderstanding. They also save themselves by reproduction [27]. Even for the apparently symmetrically dividing cells of Escherichia coli, it was shown that the two supposedly identical cells produced during division are functionally asymmetric. The old pole cell should be considered an aging parent repeatedly producing rejuvenated offspring [28].

A characteristic property of life is that its stability is dynamic. Living entities continuously change during lifespan. In essence, this changing is self-regeneration, self-manufacturing, self-renewal. This is the content of life. Organisms and generations of species continuously reproduce themselves through the time. They are transient, renewable forms of existence. The lasting forms of biological existence are lineages and species. An individual organism and a generation of species is a transient link in the existence of lineage or species.

The reproduction may be coupled with multiplication, with increasing the number of organisms. This expansion is an important but contingent factor of species survival. The essence of the reproduction is the replacement of an old, worn-out body by a new one. It may not and, in a standard situation, should not lead to the increasing of the number of organisms to avoid the resource exhaustion. The genuine evolutionary success is stable reproduction [4].

Why does the reproduction, a more complex phenomenon than the simple existence of the individual, prevent entropy from growing up? The point is that reproduction is always coupled with selection. Natural selection is a quality control of reproduction. Imperfect copies are rejected while novelties have a chance to be saved[2] only if they improve or at least do not essentially worsen the homeostasis. So, the outcome of natural selection is largely conservative. Life would not be possible without this conservatism. Evolutionary biologists were mostly concentrated on the generative, inventive side of evolution. But evolution is a dual phenomenon: it generates novelties and it stabilizes them. Moreover, evolution is just a by-product of reproduction, its imperfection. The changes as such are entropy-driven [29] and do not appear enigmatic. Rather they are inevitable. The true marvel is stability, the persistence, the resistance not only to destruction but to further changing as well. Note that only conservative mechanisms are related to sensible behavior (by definition). Reproduction coupled with selection is the very mechanism that is able to provide lasting existence, potential immortality of a living entity. I would like to stress that natural selection is not a special

2 This saving is memorizing new knowledge.

goal-directed mechanism invented for the lineage survival. It operates automatically by retaining those that persist and letting go off those that give up. Nevertheless, special mechanisms improving the efficiency of purifying selection are known [30-32].

Ideally, reproduction should be precise; otherwise, the goal of immortalization is not got. Template-directed synthesis was the first and major invention of nature, from which life itself started. It is clear that the precision of DNA replication must be such that most progeny received unaltered genetic information. The real fidelity of DNA replication is remarkably high [33]. For unicellular organisms, the attained fidelity of DNA replication is enough for potential immortality of the lineages. However, in multi-cellular organisms with large genomes and complex development, the number of mutations per genome per generation is unacceptably high, up to three orders of magnitude higher than, for example, in yeast [34-35]). I.e., *genomes of higher organisms are not reproduced with high fidelity*. For example, in man the number of mutations per zygote is 60 or even more. At such rate of mutation, the higher organisms must rapidly degrade because of mutational overload, i.e. because of entropy. They, however, persist. Their longevity needs explanation.

Why did the replication fidelity not evolve to a higher level? The matter is that faithful replication is a costly process. High accuracy needs too much energy. It looks like a further increase in fidelity of genome reproduction was not possible. Hence, higher organisms have to be able to fulfill ontogenesis successfully, and species must be able to persist in time despite never-ending mutational perturbations. This problem has no solution in the frame of asexual ("homeogenomic") lineages. They would rapidly degrade and become extinct or blurred out in the course of the reckless evolution.

Earlier [4], I discussed what other means, besides the high fidelity of genome replication and purifying selection, were invented by evolution to avert or evade the fatal outcome of the mutational deluge. The phenomenon of canalization or robustness [36,37] is directly related to the problem. Robustness is generally defined as a property that allows a system to maintain its functions despite external and internal perturbations. In case of biological systems, it is an ability to perform successful ontogenesis despite environmental and mutational perturbations. Robustness is the retaining of function (meaning) despite changes in structure and environmental impacts. The resources of robustness are derived from all levels of biological organization. Global degeneracy of the link between structure and function is one of the definitions of canalization: there are more genotypes than phenotypes. Function, not structure, is selected during evolution. Different genotypes may correspond to the same phenotype. This principle operates on various levels of biological organization, including operation of multiple pathways leading to the same final result. This is possible owing to the fact that biological processes are determined not by physical causality but by semantic rules and goal-directed programs. Simple organisms, reproducing their genomes with high fidelity, have rather simple semantics with relatively simple hermeneutics. The language of higher organisms is much more complex, with rich synonymy and complex, context-dependent, hermeneutics. This helps to provide resistance of development to mutational and environmental perturbations.

http://dx.doi.org/10.5772/53309

Nevertheless, we have to admit that for the higher organisms with large genomes and complex development all these salutary efforts have appeared insufficient: they fail to reproduce themselves reliably across generations. Their lasting needed another instrument. This instrument was sexual reproduction, the creation of *multiorganismic entity* as a self-reproducing unit.

For a long time, the problem of emergence and maintenance of sexual reproduction attracted little attention from evolutionists. The matter probably seemed too obvious. No one doubted Weismann's idea that sexual reproduction, creating genetic variability, produces material for natural selection and enhances the evolutionary potential of the species. A possibility of the acceleration of evolution at amphimixis was quantitatively substantiated by Fisher [23] and H.J. Muller [24]. The conception of the evolvability is still popular among population geneticists. It is frequently assumed that the capability for rapid and diverse evolution is a positive trait supported by natural selection, while a shortage of the evolutionary potential is fraught with extinction. The notion of evolvability as a selectable trait is in evident contradiction to the known efforts of evolution aimed at creating genetic stability of organisms and lineages [2-4]. It is obvious that the evolvability cannot be easily taken as a species homeostatic mechanism. Direct selection for evolvability is impossible conceptually, so the transition to sexuality needs another explanation, independent of the evolvability. Though sexual reproduction and genetic recombinations are a source of combinative variation in populations, they do not produce new alleles but only new combinations of the extant ones, which are, moreover, doomed to be destroyed in the next generation. If to think that the sexual reproduction was invented for acceleration of evolution (Lamarckian thought, by the way) than the continuous shuffling of the genomes (heedless of their merits) looks more than strange. I think we should not assume special mechanisms for the acceleration of evolution created by evolution. These would be suicidal mechanisms. A species with accelerated evolution would not exist long. All the organisms populating our earth today belong to species resistant enough to further evolution. Evolution is inevitable because the systems created by evolution for protection against evolution, species homeostasis, are not absolutely perfect, and the entropy pressure overcomes them now and then. All the species are capable of evolving just because they originated from the ancestors that were capable of evolving and inherited their imperfection, their "original sin". It is hard to avoid evolution.

6. Biological entities as self-reproducing units

There is some complication in delineating the self-reproducing unit in case of sexual reproduction. Two individuals of different sexes are enough to produce progeny. But it is known that the stable reproduction needs a rather large interbreeding population – deme. Small populations have low robustness because of inbreeding that leads to considerable homozygotization. The homozygous individuals usually have a drastically reduced vitality, and the populations they form also have low robustness because of lack of polymorphism and weak genotypic plasticity. Small population size is fraught with the risk of extinction. On the other hand, a species may consist of many demes with rare interdeme genetic exchanges because

of geographical impediments or habitual preferences. Different species have various forms of intraspecies organization and sexual relationships. So the borders of a self-reproducing unit must be of necessity fuzzy. In context of this paper, this complication seems not to be principal. All the existential advantages of sexual reproduction are fully realized on the level of deme at any form of sexual relationships. The rare interdeme genetic exchanges may complicate the picture for the evolutionary theorists but not change it principally. Though demes are not completely closed entities, they are closed enough to depend in their survival primarily on the merits of their own.

The early group selection models were flawed because they assumed that genes acted independently, whereas now it is apparent that gene interaction, and more importantly, genetically based interactions among individuals, were an important source of the response to group selection. As a result many are beginning to recognize that group selection is potentially an important force in evolution. So I will try to avoid here the painful discussion related to group selection. I limit myself by the statement that a unit of selection and a unit of substantive reproduction are strictly the same units, the same monads. The notorious replicator/interactor discrimination was invented to save the selfish gene theory which I regard as erroneous. There are two great delusions in the evolutionary theory: gene as an ideal replicator and individual organism as a quintessential unit of selection. Gene is not a substantive entity. I am not even sure that ontologically it is an entity at all because it is definitely not organization. It even lacks any defining characters of an autonomous thing. It is a product of cell activity, even if the very important product. Functionally, it is a piece of text that acquires meaning only in context of the whole organism. It is getting clear that the concept of a selfish gene is not based on real premises. The linkage "one gene - one trait - one selection vector" is not observed: one gene may affect several traits, and most traits depend on many genes [12]. On the other hand, a sexual individual is not a self-replicating entity either, so it cannot be selected as such. Organisms are unique, inimitable parts of species manufactured as piece-goods during species reproduction. The selective meaning of an individual organism is appreciated in context of population via inclusive fitness. Generation of deme is a minimal entity that reliably reproduces itself with a high fidelity (according to the Hardy-Weinberg law). Deme and species are ontologically comparable entities. They differ only in the size and degree of cohesiveness. So we may say that generation of species is a self-reproducing unit. In most contexts, I use “deme” and “species” as equivalent terms.

Thus, substantive sexual entity is a generation of deme or generation of species. The term “generation” may need some clarification. Deme (and species) is a lasting form of existence; generation is a transient (extant) form of a species existence. Now and here we deal only with generation. I think it is heuristically useful to keep in mind that actually living spatiotemporally restricted entity is a generation, not a lineage, which is in fact a historical phenomenon. A lineage could be even comprehended as existing only in our consciousness. However, there must be something more substantial, more existential in the lasing existence than our human perception of the historical reality. “The defining characteristic of a living organism is that it is the transient material support of an organization” [36]. This definition is fully applicable to a species generation as well. The material support is transient. But what

http://dx.doi.org/10.5772/53309

is lasting? According to Merser, organization is lasting. I.e., mind is lasting. The knowledge how to reproduce itself is lasting. Exactly and only this knowledge is transmitted from generation to generation. And of course, this knowledge is not just DNA sequence. Only entire substantive entity is a carrier of this total knowledge, not only genes and brains. I would like to stress that the "material support" and the mind are not separate things like the hardware and software of a computer (organism is not a Turing machine) [16]. They are aspects of the same whole [17].

A real extant population may contain organisms of different age, from new-born to mature to old individuals (overlapping generation) or it may be more or less synchronous. The lifespan of a generation is equal to the average lifespan of individual organisms that comprise the generation. The extant entity is an individual organism in case of asexuality and a generation of deme in case of sexual reproduction. When we speak that a species lives million years we may mean that an entity very similar to the extant entity lived million years ago and it is directly connected with the extant entity via sequence of reproductions.

7. Meaning of sexual reproduction

Sexual organisms are constituents of a higher rank entity – biological species. The transition to sexuality, like all other major evolutionary transitions, is cooperation. Individual organisms forfeited their ability to autonomous reproduction and autonomous evolution. They exist and evolve as a part of biological species. Their existence is attributive. The transition to sexuality is ascension to a new and a higher quality. Sexual population is a coherent system able to self-reproduction. Species reproduction should not be confused with speciation. Species reproduction is not formation of another (daughter) species. Reproduction is a way of species existence. The reproduction must be precise. In case of stably existing species, the reproduction is really precise. One generation may somewhat differ from another generation in accord with the environmental variations owing to a species' genotypic plasticity and the phenotypic plasticity of the organisms. These changes are reversible manifestations of species robustness. They are not evolutionary changes [12]. By the same token, speciation is not species reproduction, not continuation of the given species. Speciation is a macroevolutionary event that should not be confused with the reproduction. Reproduction is an essentially conservative process. Reproduction is renewal of the same whereas speciation is creation of the new. Similar to a sexual organism, a species is unique: it emerges on one occasion in the history of biosphere and never appears again. Therefore, it is not correct to regard a species as a segment of a species level lineage, as is suggested by De Queiroz [39]. There are no "species level lineages" just as there are no "organism level lineages" in case of sexuality. Lineage is a sequence of generations. In its totality, it represents species ontogenesis [12]. Speciation is not a pre-programmed stage in the species existence. Speaking metaphorically, the species is never "interested" in speciation. For the extant species, begetting a "daughter" species means begetting a competitor. Note that allopatry is a precondition for survival of a new-born species [40].

Reproduction of asexual and sexual organisms differs in many respects (Table). Asexual organism (typically it is a cell) is a self-reproductive unit by itself. Its ontogenesis is relatively simple, typically, the way from the young cell to the mature cell. The reproduction is perfect. It is precise and reliable. Prokaryotic lineages seem to exist billions of years [21]. The ordinary (i.e. reductionistic) viewpoint ascribes this stunning longevity to the high fidelity of DNA replication. According to the ontologically right (holistic) viewpoint, a prokaryotic cell *reproduces itself with a high fidelity*. The ability to replicate DNA belongs to cell, not to DNA. This comprehension is crucially important for adequate portrayal of the life phenomenon. Biological organization is hierarchical, and sensible behavior is a property of the whole system, not of its parts. Though the lifespan of an individual (the time from division to division) is short, the lineage is potentially (proper environment being provided) immortal. So, the lasting form of existence of an asexual entity is an organism level lineage, a linear sequence of individual organisms.

Feature	Individual organism	Species
Founding	By fusion if two gametes	Usually, by geographic or ecological isolation of a small group of the individuals of different sex (founder)
Probability of abortion	Low	Extremely high
Process of ontogenesis	Individual development	Microevolution
Genetic basis	Non-evolving genome	Evolving gene pool
Contents of the ontogenesis	Embodiment of the ontogenetic intention.	Creation of species robustness
Causal mode	Teleonomy. Downward causation. The final result is determined by ontogenetic intention (boundary conditions) within the limit of the norm of reaction of the genotype	Group selection The final result is not determined. The process is limited by the initial conditions (historical constrains) and by a necessity to create perfect species organization
Unit of self-reproduction	Self-reproduction is impossible	Generation of a deme
General attractor	Adult organism	Stasis (ceasing of evolution)
Ending of ontogenesis	Obligatory death (probably programmed)	Extinction. Potential immortality is not excluded

Table 1. Comparative characteristics of ontogenesis of a sexual individual and a biological species.

Many give an import to the fact that asexual organisms can exchange genetic material now and then. However, the biological sense of such exchanges is quite different. There is sex but no sexual reproduction. Asexual entities do not form biological species sensu Mayr-Dobzhansky, an entity of a higher rank. They have no need in this complication just because they

http://dx.doi.org/10.5772/53309

reproduce themselves with high fidelity acting alone. If a mutated individual survives, it initiates a new lineage that may compete with the previous lineage and may swap it.

Metaphysics of a biological species as an individual is an intricate philosophical and epistemological problem and its discussion has rather long history [12,39-55]. Here, I am interested in the ontological aspect of the problem: species as a form of existence. As the basic definition of species, I take that of Ernst Mayr [49]: "Species are groups of interbreeding natural populations that are reproductively isolated from other such groups". Both traits “interbreeding” and “reproductively isolated” are obligatory.

Many, including me, regard biological species as an ontological individual. This view was clearly formulated by Michael Ghiselin [43]. Similar to an individual organism, a species has ontogenesis: birth, infancy, adolescence, maturity, aging, and death [12]. This lasting existence is carried out as a sequence of generations. This sequence is commonly known as microevolution that may be confusing because the essence of the species ontogenesis is not an evolution. In case of success, a species’ ontogenesis culminates in stasis (i.e. cessation of evolution) that may last dozens of millions of years and more [4]. Theoretically, the potential immortality cannot be excluded. Generation of deme is a self-reproducing entity. It means that generation of deme, not the deme, is the ontological individual. So a deme is equivalent to an asexual individual organism in its role in survival and creation of the lasting entity, which is a lineage, sequential row of self-reproducing entities, sequential raw of generations of deme.

Species is organization. Bonding of the intra-species components (individual organisms) is carried out by means of behavior. I suggested the term "behavioral bond" to designate the interaction between organisms by analogy with ionic, covalent, hydrogen, etcetera bonds [12]. Behavioral bonds provide cohesiveness of species. Species-specific behavior implies operating of special connections between the individuals, which transform the species into organization with the function of survival. Primarily, these are the connections accountable for the interbreeding and reproductive isolation, which make a species a genetically closed monad. Reproductive isolation is determined by the mutual affinity of organisms. The affinity is not limited by choosing a mating partner; it includes all the intraspecies interactions as distinct from the interspecies ones. Reproductive isolation and preventing inbreeding are two opposite “forces”, analogous to the attraction and repulsion, the proper balance of which is a necessary precondition for a species existence. Both inbreeding and promiscuous sexual behavior are destructive for a species. What is “the proper balance”? What is the final state this balancing is aimed at? It is an optimal species gene pool.

Genetically, a species as a whole is a closed system. Parts of the species (groups, demes) are potentially capable for substantive existence in nature. This capability is analogous to the capability of plants and lower animals to regenerate the whole body from the parts. As such, this is not speciation. The absence of the physical skin hampers us to grasp a species as a unity. But it is only a matter of habit and imagination. Behavioral bonds are common in biology. They unite families, groups, tribes, armies, companies, states, and humankind.

The transition from genome to genetic pool is far from being the whole story. Genetic pool, similar to genome, is not a substantive entity. It is reproduced by a generation of the deme as its part, its attribute. The necessity to reproduce a genetic pool drastically changes the biological status of the individual organisms. An asexual organism is a self-sufficing sovereign player on the stage of life. It is a monad. It can reproduce itself through generations acting alone. A sexual individual is a law-obedient citizen of the multi-organismic realm. It has to cooperate. This cooperation is not limited by the finding of a sexual partner and rearing a progeny. The final goal is transmitting an *optimal gene pool*. The entire species organization, including behavior of individual organisms, is submitted to this final goal. What gene pool is optimal? The most general answer is like this: the pool which provides reliable survival of the next generation. Of course, this answer is too general. The function of survival belongs not to a gene pool but to the organization as a whole, i.e. to the generation of deme. A property characterizing perfect organization is known under the label of robustness. The robustness is defined as an ability to perform successful ontogenesis despite mutational and environmental perturbations. The resources of robustness are derived from all levels of biological organization. At the species level, the main factor creating robustness is diversity of organisms comprising the species. This factor influences species survival in two ways. Immediately, diversity of organisms is the material for creation of perfect species organization. The same diversity is the prerequisite for creation of an abundant gene pool bestowing species with genotypic plasticity. The diversity of this type is an emergent trait of a species and it must be selected. Not all diversities are of equal merit. However, it may be postulated that the absence of diversity would result in rapid extinction of the species just because such homogeny annuls all the advantages of sexual reproduction.

The above consideration makes it clear that Darwinian selection of individual organisms, the conquerors in the intraspecies competition, does not work in case of sexuality. There are a lot of objections to "the selection of the best", and this one is one more: such selection would lead to the virtual annulling of the diversity.

A crucial feature of sexual reproduction is manufacturing individual genomes by picking them over from the continuously shuffled population gene pool instead of the direct copying of the ancestor's genome. The main advantage of this way of reproduction is quite evident. Though large genomes cannot be precisely replicated, there always exists a possibility to manufacture one errorless genome from the two with errors. Moreover, degeneracy of the link structure-function implies that the functionally robust genomes may have various sequences. *I.e.*, the intrinsic property of sexual reproduction is creation of great diversity of genomes and hence individual organisms. The emergent species property that follows is the *genotypic plasticity* – the ability to change *reversibly* the population gene pool configuration in different environments. This is a powerful factor of species stability.

This is the basic level of cooperation – genetic. Though the genome of a sexual organism cannot be replicated with an adequate accuracy, a genetic pool can be reproduced with an adequate accuracy. All the well-known complications and troubles of the sexual reproduction are justified by this capacity for an accurate reproduction because only accurate reproduction provides longevity.

http://dx.doi.org/10.5772/53309

The "picking over" mechanism of genome reproduction supports the diversity of genomes and individuals. It is evident, however, that this diversity inevitably includes a high proportion of genomes (and corresponding individuals) of low vitality doomed to perdition. Unfortunately, this was interpreted in the classic Darwinism (and in Neo-Darwinism as well) in the spirit of Malthus's idea of exponential growth of populations leading to the competition for resources: struggle of everyone against everybody. The very idea of natural selection was based on the assumption that organisms produce more offspring than can survive. Organisms, therefore, have to compete with each other. This competition was construed as a moving force of biological evolution leading to continuous perfecting of the biological entities. It was stressed that a most fierce struggle must be between the individuals of the same species because they have identical needs.

This misleading interpretation begot most malignant forms of social Darwinism and, as a counterbalance, an antievolutionary attitude of many intellectual and spiritual leaders. In reality, the seemingly "extra" progeny is a compensation for the poor fidelity of genome reproduction and for random death of the organisms[3]. In both cases, the differential survival of individual organisms is not a result of competition for resources. First and foremost, they survive or die accordingly to the merits of their own, irrespective of the presence of other individuals. As a rule, they are not killed or starved to death by their fellows or rivals.

The stability of the biotic entities is determined not merely by their physical durability but by their expedient behavior especially. They are organizations with the function of survival. The Universe evolves via the interaction and cooperation of the entities, whence its complexity and hierarchical structure come from. The major transitions in biological evolution (prokaryotic cell → eukaryotic cell → multicellular organism → biological species) are the steps of cooperation. Though a complex entity consists of the other simpler ones, it is not just an aggregate of the included entities. It is a qualitatively new form of existence; it is an organization of a higher rank. Hierarchy in biology doesn't mean just complexity or heterogeneity. It implies a functional predestination of their parts for the sake of the whole. Survival of the parts crucially depends on survival of the whole. Hence, constituent entities are to be included into the higher entities only in an appropriately transformed configuration. The operating principles of the organization of the higher rank are not necessarily related to or derivable from the properties of the parts or to their internal operating principles. That is the principles organizing an upper rank are novelties. They are not necessarily predictable from the rank below. On the other hand, the organizing restrictions of the living entities, being emerged as a frozen chance, cannot be deduced from any general principle or law. They can be understood only retrospectively, in the context of their history. The above statements imply that the evolution of a higher entity cannot be adequately presented as self-sufficing evolution of its constituents. The prosperity of the whole is the vector of selection for the constituent entities.

3 At r-strategy of reproduction the random death, i.e. associated neither with competition nor with genetic defects, may be massive.

8. Altruism

Neo-Darwinism defines altruistic behavior of an individual organism as a behavior that diminishes its own fitness and enhances the fitness of other individuals. In its turn, fitness is defined as a relative fecundity of the individual. According to the same paradigm, "Evolution is based on a fierce competition between individuals and should therefore reward only selfish behavior. Every gene, every cell, and every organism should be designed to promote its own evolutionary success *at the expense of its competitors*." [56]. If so, altruism must be impossible. Altruism, however, is ubiquitous. One more inconsistency is the fact that sexual organisms cannot reproduce themselves. To cope with this snag, G.C. Williams [57] and then R. Dawkins [58] announced the gene as a unit of selection. The gene seemed to be an ideal immortal replicator. The hypothesis of kin selection [59,60] and of reciprocal altruism [61] gave a formal explanation of how evolution could favor altruism despite a fierce competition between individuals. It did not prove of course that an individual organism or a gene can really serve as a unit of selection. Most biologists, being not trained in mathematics, had been pressed to take for granted this logical trick under the label of "gene centered view". Regretfully, it got global success among population geneticists and molecular biologists and buried the holistic understanding of life and evolution for dozens of years.

Meanwhile, an altruistic behavior, which is ubiquitous among people and other animals, keeps being a headache for the evolutionary biologists. Hamiltonian pill has helped to alleviate the headache but the phenomenon remains enigmatic and gives food to unending and mostly fruitless discussions. It is really difficult not to see the numerous and various forms of cooperation, mutual aid, friendship, and love at every turn. For this, one must specially train his/her imagination in the reductionistic logics or reject the phenomenon ironically as did Michael Ghiselin [44]: "Scratch an 'altruist,' and watch a 'hypocrite' bleed". Meanwhile, the problem of origin and maintenance of altruism is just a seeming problem begotten by the gene-centered point of view and reductionistic philosophy. The reductionistic methodology is not an adequate tool for operation with the hierarchically organized world of life.

The idea of gene as a replicator is bewildering. Gene is not a living entity. It is not a self-replicator. It is replicated. It is a replica or a template. Genes are manufactured by cell, just like all the other cell constituents: RNAs, polypeptides, organelles. Only self-reproducing substantive entity can serve as a unit of selection. By this I say of course in favor of deme (or group) selection as the only meaningful level of selection for obligatory sexual organisms. Deme is the lowest substantive entity that reproduces itself with a high fidelity. Opponents of the group selection reject it as a too slow process[4]: lower-level selection easily trumped higher-level selection. First, the group selection may be rapid enough: a generation of population (the unit of reproduction) is of the same longevity as an individual organism; second (and uppermost), the lower-level selection in itself is the destructive side of the overall process. If it is not trumped by the higher-level selection, the group simply will not go through. The mechanism of species evolution (microevolution or species ontogenesis) presumes a

4 A successful species ceases to evolve [4]

group selection. Successful groups may prosper, while less successful shrink and extinct. And again, competition and struggle between the groups may play little role in their fate: they parish or prosper primarily because of their own merits, e.g. because of the prevailing of selfish or altruistic behavior of the constituent entities. For a comprehensive discussion of the problem of group selection, see [62].

The idea of multilevel selection has now received a substantial support [63]. It is a step in the right direction. However, I think that here remains some inconsistency. Given that the higher level of selection operates, the selection at the lower levels must be forbidden because it can produce nothing but casualties like a parasitic DNA or a malignant cell. The so called ultra-selfish genes are factual parasites with a net harmful effect on the host. They, along with other parasites and harmful mutations, are representatives of the destructive force of nature. Evolution in action is an unending struggle against this force. And the most productive way of this struggle is cooperation. Biological species is organization, which is the cooperation of individual organisms. A hierarchical organization presumes submitting behavior of parts in favor of the whole. Selection presumes the selection of genes but the vector of selection is "for the good of species", not "for the good of gene"! Just because a gene is not a living entity, not organization with the function of survival! It is strange for me to insist on such a self-evident statement. These two goods coincide. If they not coincide, the gene will be rejected "for the good of species". The reverse (rejection of species for the good of gene) is nonsense. For more discussion, see [12].

Once we took a population as a self-reproducing unit, once we have grasped the biological species as an individual of a higher rank, we see no enigma in altruistic behavior. It is simply inevitable. We do not wonder why cells of our body, e.g. those of skin, living only several days, do not fight for unlimited proliferation. We know very well what follows if they do. Let us define altruistic behavior as behavior of parts for survival of the whole. Sexual organism lost its status as a substantial biological entity. It places its genes into the common gene pool hereby demonstrating the hundred-per-cent altruism at the most basic genetic level. Organisms are unable to reproduce themselves. They are reproduced by species as a class of entities. So they just have to be altruistic or they will disappear along with the whole. This statement may look contra-intuitive. The vernacular understanding of altruism as disinterested aid to other organisms hampers us to see the altruism as a multifaceted biological phenomenon. Faces of the altruism are numerous and they may look unexpected. I remind that an altruistic behavior is the behavior for the good of group. It may sometimes look unfriendly, hostile, and cruel in relation to the other individuals, still being altruistic.

This nontrivial comprehension helps to interpret inter-individual relationships as largely altruistic. True selfish behavior of an individual organism would be a mistake, similar to the behavior of a cancer cell. Normal behavior of the parts is always aimed at survival of the whole. Let me present one example of apparently selfish behavior that is actually behavior for the good of group. Fighting for leadership is often presented as an example of a fierce struggle. Though the picture is slightly spoiled by the ritual character of such battles, the scene remains to be impressive. But is this fighting really selfish behavior? It is hard and dangerous. The transmitting of genes to the next generation does not look as a final cause.

Every genome is unique and it is not transmitted as a whole. The semantic content of genetic information depends on the combination of genes. But the combination is not transmitted. Meanwhile, the meaning of the fighting is quite evident. A proper leader is extremely important for survival of the group. And if we give up our human envy to leaders, we will be able to recognize that the life of leaders is fairly altruistic. It is completely devoted to the group survival and often has a sacrificial character. The essence of interindividual conflicts in population is not the fighting for power but the verifying of the relative status. The correct status is an extremely important parameter for a proper organization of the population. An individual that lost in this fighting still did not lose in life. The correct status is important for getting a *right* position. A wrong position, even if it is the higher one, would be failure for the individual and for the population. It is important and comfortable to occupy a proper position in the group.

Hence, altruism, as defined above, is not something special. The balance of two counterforces is a prerequisite of any existence. In case of species, these two forces are behavior of the parts for survival of the whole and behavior of the parts for their own survival. They are two aspects of the sensible behavior, of which a disinterested aid of one individual to another is only a particular type of altruism. Classic Darwinism proclaimed the struggle for existence. And it was implied that it is mainly the struggle between individual organisms of the same species for resources. But a lack of resources is not the common cause of organism's death. The universal enemy of life, which acts everywhere and always, is entropy. And the only force that helps to resist it is the sensible behavior.

What do we mean when we speak about the behavior of such a complex entity as a deme? The overall content of this behavior is self-reproduction. The deme is a substantive entity. Its behavior is aimed at its own survival. So it is selfish (by definition).The behavior of all its parts, including individual organisms, which is aimed at survival of the whole, is *altruistic* (by definition). The living world is organized hierarchically. Though only deme is a substantive entity, other (attributive) components may also be *relatively* autonomous in their existence. So, their behavior must be also aimed at their own survival. Moreover, the survival of the parts is absolutely necessary for survival of the whole. The behavior of the relatively autonomous entities is dual. It may look selfish and competitive in a certain respect being altruistic as a whole. This trivial consideration just shows that altruism, being complex and important phenomenon, does not look strange and enigmatic for the holistic perspective.

8.1. The faces of altruism

Suicide is the most common form of altruistic behavior. It operates on all the levels of biological organization, from molecules to organisms. One example of molecular altruism is the DNA damage repair by enzyme O^6-methylguanine-DNA methyltransferase, which transfers the methyl group of the damaged base to one of its own cysteine residues in a suicide reaction [64]. Numerous and diverse forms of cellular suicide are well known.

The evolution of the “picking over" mechanism of genome formation was necessarily coupled with the evolution of the intrinsic or internal selection. The intrinsic selection is a purifying selection. It begins to operate long before the organism is tested by the environment or

http://dx.doi.org/10.5772/53309

came across the other members of population. Moreover, it starts operating even before the appearance of the individual, during the formation of generative cells (sperm and eggs). The overwhelming majority of the generative cells and their predecessors undergo programmed death. This mass suicide is aimed at selecting robust generative cells [31,65-68]. For example, in the testis of mice, the mutation rate declines five-fold during spermatogenesis: the heavily mutated cells commit suicide. During ontogenesis of multicell organisms, cells with damaged DNA also commit suicide (apoptosis). It is really suicide, not a killing. This behavior prevents malignisation.

One more phenomenon, inconceivable from the individual-centered view, is phenoptosis, the programmed death of organisms. In the most expressive form, it occurs in salmon: death of the adult individuals after spawning. It looks probable that an aging is a slurred form of the phenoptosis. The existence of a programmed altruistic ageing and death was suggested in [69]: "The similarities between the molecular pathways that regulate ageing in yeast, worms, flies and mice, together with evidence that is consistent with programmed death in salmon and other organisms, raise the possibility that programmed ageing or death can also occur in higher eukaryotes".

The different longevity of the individual life is a manifestation of the same phenomenon. Both, mouse and man are mammals. Why does a mouse live only two years, while a man lives up to hundred years? The answer is: individual longevity must be optimal for the species survival. And this optimum is the integral constituent of the general strategy of species survival. The phenomenon of frustration may also be construed as a type of altruistic phenoptosis. From the individual point of view, frustration looks strange: it is evidently a programmed reaction to a stress, and it is definitely contra-adaptive, especially the destruction of the immune system. May be it is also a case of altruistic suicide, a form of intrinsic selection, self-elimination of the individuals with inadequate reaction to stress.

The intrinsic selection keeps operating over entire ontogenesis: in the process of fertilization, during embryo implantation, embryogenesis, at birth, during infancy, adolescence, maturity, aging. I would like to stress that this intrinsic selection, though it may look cruel and relentless, may have little relation to the competition between individual organisms. The doomed entities die primarily because of their own imperfection.

The intrinsic selection controls robustness of the individual organisms, their healthiness. This is the first, immediate quality control at the level of an individual. The final quality control is carried out at the level of generation of deme where robustness of the generation as a whole, perfection of the deme organization is checked. It is not easy to define specifically what a "good organization" is. The most evident parameters are diversity and genetic plasticity, which are crucially important for the stability of the deme reproduction. Real success is not maximal but optimal fecundity. So that even infertile individuals may occur useful for the population survival.

The general tendency in progressive evolution is diminishing fecundity. Ideally, one female should provide two healthy offspring, not less and not more. Only during a relatively short initial period of the species founding (during creation of the species robustness and territori-

al expansion), the exponential Malthusian increase of population in the number makes sense. A matured species needs stable reproduction. The principal "the more the better" stems from the capitalistic psychology that is well known to lead to economic crisis. Natural selection is wiser than the human leaders. Biological species know how to control their numerical strength and thus exist long. The numerical strength should not exceed the resources. The reproductive rate in most species had evolved through group selection to ensure populations remained below the threshold of over-exploitation of resources [70].

While the competition between asexual lineages or between different demes and species may be sometimes a real combating, such combating between the organisms of the same deme would be self-destructive. I do not discard competition, but I only think that its biological meaning should be reconsidered: it is an instrument for creating, fine-tuning and maintaining species organization, which is cooperation. A species is organized hierarchically. The hierarchy is continuously checked. This checking may look as a conflict or struggle for survival yet it is not. To make emphasis on the fierce struggle means to create the problem in theory that does not exist in reality. Scratch antagonism and you find *the good of group*. On the sidewalk under my window, I see a boy jumping on the skateboard. Very dangerous exercise! He risks breaking his neck. Why? What is he fighting with? With the desk? With the gravity? Not at all. He fights with his own imperfection, which is the major enemy of everybody.

Other forms of altruism may look much more attractive: parental care, friendship, mutual aid, and other examples of the uninterested aid. They are well-known. I only would like to raise an objection against an opinion that an altruistic individual always fails in conflicts with a selfish one. This was postulated in the ”dove-hawk model” by Price and Maynard Smith [71]. I stress that it was not based on empirical observations. It was assumed. “Selfishness beats altruism within groups. Altruistic groups beat selfish groups. Everything else is commentary” [72]. It is a good phrase in favor of group selection. But in my opinion, the authors over-appreciate the selfish individuals. Why to think that an altruist is always a looser and an egoist is always a winner? I think opposite. A weak individual just cannot afford altruistic behavior. He needs a help itself. Let me cite a rhyme by Theodor Sologub (in my word for word translation):

”It is pitch-darkness in the field.

Somebody is calling: “Help!”

– What can I do?

I am scared and petty.

I am dead tired.

– How can I help?”

---

http://dx.doi.org/10.5772/53309

Who could dare to respond to this call in the dead of night? Who will leave his warm and safe dwelling and help? Loser? By no means. Hero or Saint. They may not leave progeny of their own, yet they are certainly not losers, not weak and cowardly. Monks do not have children by definition; however, they are stably produced by the human populations during many centuries; quite similar to the stable production of, for example, hepatocytes or neurons, or worker bees though these entities never cross the frontier of generations. Altruists are stably reproduced across generations even if they happen to have no offspring of their own. It looks most probable that the altruistic/selfish phenotype of an individual is determined by numerous genes, and a population is characterized by a broad continuum of individuals, from the “pure altruistic” to the “pure selfish”. This distribution is a “species trait”. Owing to the gene pool shuffling, it is totally transmitted to the next generation, even if the extreme altruists do not produce their own offspring while extreme egoists have too little concern for their offspring. During evolution, the form of this distribution is optimized for the species survival. Of course, it is species-specific and must be coordinated with the *general strategy of species survival.* Altruists would be stably reproduced across generations even if they had no offspring of their own. But why? Normally, they have offspring. Women love heroes.

What about competition and struggle between the groups? Group is a substantive entity and its behavior is selfish. As such, this does not presume the survival at the expense of other groups of the same species. Groups also prosper or shrink in accord to the merits of their own. However, competition and struggle is possible and sometimes it may be really fierce. Unfortunately, evolution of Homo sapiens included such struggle in the most extreme forms. The history of humankind was the fighting of the tribes that often acquired a character of genocide. But this is quite another story.

Years ago, I asked once my fellow student about meaning of sexual reproduction. She was a romantic person and she quickly replied: "possibility of the love". And we both laughed at the joke. But now, being an old and wise man, I take it quite seriously. The love is a rather good term for designation of the intraspecific interactions not only between the sexual partners or the parents and children, but for intraspecific interactions in general. The sexual reproduction is a real cooperation not only at the level of gene pool, but at the level of entire inter-individual relationships. The apparent hostility and competition should not hide the basically cooperative character of intraspecific bonds that we would not expect for the asexual organisms that are self-sufficing sovereign players on the stage of life[5]. Above, I defined mind as the fifth fundamental interaction, which is life-specific. In the particular case of intraspecific bonds it could be named "love".

9. Conclusion

There are two major forms of existence: inanimate and animate. No existence is perpetual. The second law of thermodynamics predicts final dissipation of everything in the Universe.

5 Lover's tiffs end in kisses.

The Universe does not dissipate immediately because its components *interact* with each other. The Universe as a whole is an evolving entity. The four fundamental physical interactions produce numerous entities, thus retarding immediate dissipation of the Universe. Various objects in the Universe have different longevities, from infinitesimal fractions of a second to billions of years. In the course of evolution, ephemeral forms are replaced by more lasting ones. This principle – survival of those who survive – sounds as a tautology, but it is *the great tautology*: Everything genuinely new emerges through this principle. Longevity is a quantitative measure of existence. Inanimate entities are the most probable configurations of matter at a given situation; their lasting is provided by their physical durability. Organisms are low-probable configurations of matter; they are physically flimsy, extremely complex, low-entropy systems. Their existence needs a special explanation. We are used to think that all the entire stuffing of the Universe is presented by two interconvertible essences: energy and substance. Latterly, some people started talking about the third fundamental essence – organic information, which is neither energy nor matter. It is an attribute of life and only life. The term "information" may not be the most suitable one. It may be confused with the homonym used in the information theory. Shannon's information is devoid of meaning whereas the meaning is just what we are interested in in context of biology. An adequate term for the third fundamental essence would be "mind". The living world resists chaos by means of *sensible behavior*. I define a behavior *sensible* if it is aimed at survival of the behaving entity. Inanimate evolution might be portrayed as self-construction of Nature: matter from energy; biological evolution might be portrayed as self-knowledge of nature: mind from matter. The autocracy of physics ends at the border between the inanimate world and the biosphere, where the world of sense and knowledge begins. All and only the living entities are organizations with the function of survival. The longevity of a living entity is provided by self-reproduction. The sensible behavior is based on knowledge. The entire knowledge a living entity enjoys is the knowledge of how to reproduce itself. In asexual organisms, the self-reproducing entity is an individual organism. The minimal living entity is a prokaryotic cell. More complex living entities are presented by eukaryotic cells, multicell organisms and biological species. There are two different ways of reproduction: asexual and sexual. Asexual organisms (typically a prokaryotic cell) reproduce themselves with a high fidelity that is sufficient for the potential immortality of the lineage. Higher organisms are too complex to be able to reliably reproduce acting alone. They cooperate and form a higher rank multiorganismic entity – biological species. In case of asexuality, an organism is a substantive entity, whereas a sexual individual is an attributive entity that exists as a part of the higher rank entity – deme. A generation of the deme is a self-reproducing unit. A crucial feature of the sexual reproduction is the formation of genomes of individual organisms by randomly picking them over from the continuously shuffled gene pool instead of the direct replication of the ancestor's genome. This process inevitably produces individual organisms with different abilities to survive. Generally, they survive or die according to the merits of their own, irrespective of the presence of the other entities. This is a moment of purifying or intrinsic selection. Evolutionary success of a species depends on the perfection of species organization, which includes cooperative interaction between the individual organisms. This cooperation is one of the manifestations of the fifth life-specific fundamental interaction.

Author details

Victor Prokhorovich Shcherbakov

Institute of Problems of Chemical Physics, Moscow Region, Russia

References

[1] Jonker. CM., Snoep JL., Treur J., Westerhoff HV., Wijngaards WC. Putting Intentions into Cell Biochemistry: an Artificial Intelligence Perspective. Journal of Theoretical Biology 2002; 214(1) 105-134.

[2] Shcherbakov VP. Evolution as Resistance to Entropy. Evolution is Aimed at a Halt of Evolution. 2004. RIO IPChPh RAS (in Russian).

[3] Shcherbakov VP. Evolution as Resistance to Entropy. I. The Mechanisms of Species Homeostasis. Zhurnal Obshchey Biologii 2005; 66 195-211 (in Russian).

[4] Shcherbakov VP. Stasis is Inevitable Consequence of Every Successful Evolution. Biosemiotics 2012; 41-19.

[5] Wake DB., Roth G., Wake MH. On the Problem of Stasis in Organismal Evolution. Journal of Theoretical Biology 1983;101(1) 211-224.

[6] Sharov AA. Role of Utility and Inference in the Evolution of Functional Information. Biosemiotics 2009; 2 101-115.

[7] Denbigh K. A Non-conserved Function for Organized Systems. In: Kubat L. Zeman J. (eds.) Entropy and Information in Science and Philosophy. Elsevier; 1975.p83-92.

[8] Wicken JS. The Generation of Complexity in Evolution: A Thermodynamic and Information-Theoretical Discussion. Journal of Theoretical Biology 1979;77 349-365.

[9] Barbieri M. Biosemiotics: a New Understanding of Life. Naturwissenschaften 2008; DOI 10.1007/s00114-008-0368-x

[10] Shcherbakov VP. Evolution as Resistance to Entropy. II. A Conservative Role of the Sexual Reproduction.Zhurnal Obshchey Biologii 2005; 66 300-309 (in Russian).

[11] Shcherbakov V P. Biological Species is the Only Possible Form of Existence for Higher Organisms. Evolutionary Meaning of Sexual Reproduction. Biology Direct 2010; 5. http://www.biology-direct.com/content/5/1/14

[12] Noble D. The Music of Life: Biology beyond Genes. Oxford, New York: Oxford University Press; 2008.

[13] Noble D. Biophysics and Systems Biology. Philosophical Transactions of the Royal Society London A2010; 368(1914) 1125-1139; Doi: 10.1098/rsta.2009.0245

[14] Abel DL., Trevors JT. Self-Organization vs. Self-Ordering Events in Life-Origin Models. Physics of Life. Reviews 2006; 3211-228.

[15] Weber A. The Book of Desire: Toward a Biological Poetics. Biosemiotics 2011; 4(2) 149-170.

[16] Battail G. An Answer to Schrödinger's What Is Life? Biosemiotics 2011; 4(1) 55-67.

[17] Coen E. The Art of Genes: How Organisms Make Themselves. Oxford: Oxford University Press; 1999.

[18] Teilhard de Chardin P. The Phenomenon of Man. New York: Harpers & Brothers; 1959.

[19] Delbruck M. Mind from Matter? Palo Alto: Blackwell Scientific Publications, Inc.; 1986.

[20] Roe SA. Biology, Atheism, and Politics in Eighteenth Century France. In: Alexander DR., Numbers RL. (eds.) Biology and Ideology. From Descartes to Dawkins. Chicago and London: The University of Chicago Press; 2010.p36-60.

[21] Cavalier-Smith T. Cell Evolution and Earth History: Stasis and Revolution. Philosophical Transactions of the Royal Society London B2006; 361 969-1006.

[22] Margulis L. Origin of Eukaryotic Cells. New Haven: Yale University Press; 1970.

[23] Maynard Smith J, Szathmary E: The Major Transitions in Evolution. Oxford: Oxford University Press; 1995.

[24] Zaher HS., Green R. Fidelity at the Molecular Level: Lessons from Protein Synthesis. Cell 2009;136(4)746-762.

[25] Lynch M. The Cellular, Developmental and Population-Genetic Determinants of Mutation-Rate Evolution. Genetics 2008; 180(2) 933-943.

[26] Ehrenberg M., Bilgin N. Measurement of Ribosomal Accuracy and Proofreading in E. coli Burst Systems. In: Martin R. (ed.) Protein Synthesis: Methods and Protocols. Methods in Molecular Biology, V.77 1998.p 227-241.

[27] Mortimer RK., Johnston JR. Life Span of Individual Yeast cells. Nature 1959; 183 1751-1752.

[28] Stewart EJ., Madden R., Paul G., Taddei F. Aging and Death in an Organism that Reproduces byMorphologically Symmetric Division. PLoS Biology 2005; 3 e45.

[29] Brooks DR, Wiley EO. Evolution as entropy. Chicago and London: The University of Chicago Press; 1986.

[30] Lynch M., Walsh, JB. Genetics and Analysis of Quantitative Traits. Sinauer Associates Inc.; 1998

[31] Baum JS., St. George JP., McCall K. Programmed Cell Death in the Germline. Seminars in Cell & Developmental Biology 2005; 16(2) 245-259

[32] Levine AJ. p53, the Cellular Gatekeeper for Growth and Division. Cell1997; 88 323-331.

[33] Drake JW., Charlesworth B., Charlesworth D., Crow JF. Rates of spontaneous mutation. Genetics 1998; 1489(4) 1667-1686.

[34] Kondrashov AS. Modifiers of Mutation-Selection Balance: General Approach and the Evolution of Mutation Rates. Genetic Research 1995; 66(1):53-69.

[35] Sniegowski PD, Gerrish PJ, Johnson T, Shaver A. The Evolution of Mutation Rates: Separating Causes from Consequences. Bioassays 2000; 22(12)1057-1066.

[36] Schmalhausen I I. Factors of Evolution: The Theory of Stabilizing Selection. Philadelphia: Blakiston; 1949 (Reprinted Chicago: University of Chicago Press; 1987).

[37] Waddington CH. (1942). Canalization of Development and the Inheritance of Acquired Characters. Nature 150(3811) 563-565.

[38] Merser EH. The Foundations of Biological Theory. New York: Wiley-Interscience; 1981.

[39] De Queiroz K. Species Concepts and Species Delimitation. Systematic Biology 2007; 56(6)879-886.

[40] Wiley EO. On Species and Speciation with Reference to the Fishes. Fish and Fisheries 2002;3 161-170.

[41] Dobzhansky T. Speciation as a Stage in Evolutionary Divergence. American Naturalist 1940; 74(753) 312-321.

[42] Simpson GG. The Species Concept. Evolution 1951; 5(4) 285-298.

[43] Ghiselin MT. A Radical Solution of the Species Problem. Systematic Zoology 1974; 23(4)536-544.

[44] Ghiselin MT. The Economy of Nature and the Evolution of Sex. The University of California Press; 1974.

[45] Ghiselin MT. Metaphysics and the Origin of Species. Albany: State University of New York Press; 1997.

[46] Ghiselin MT. Species concepts: The basis for controversy and reconciliation. Fish and Fisheries 2002; 3 151-160.

[47] Ghiselin MT. Metaphysics and Classification: Update and Overview. Biological Theory. Summer 2009; 4 253-259.

[48] Mayr E. The Growth of Biological Thought: Diversity, Evolution, and Inheritance. Belknap Press of Harvard University Press; 1982.

[49] Mayr E. What is a Species, and What is not? Philosophy of Science 1996; 63262-277.

[50] Wiley EO. The Evolutionary Species Concept Reconsidered. Systematic Zoology 1978; 29(1) 17-26.

[51] Wiley EO. Is the Evolutionary Species Fiction? A Consideration of Classes, Individuals and Historical Entities. Systematic Zoology 1980; 29(1) 76-79.

[52] de Queiroz K. The General Lineage Concept of Species and the Defining Properties of the Species. In: Wilson RA (ed.) Species: New Interdisciplinary Essays. Cambridge, Massachusetts: MIT Press; 1999.p49-89.

[53] de Queiroz K. Species Concepts and Species Delimitation. Systematic Biology 2007;56(6)879-886.

[54] Mayden RL. On Biological Species, Species Concepts and Individuation in the Natural World. Fish and Fisheries 2002;3 171-196

[55] Wilkins JS. What is a Species? Essences and Generation. Theory in Biosciences 2010; 129141-148.

[56] Nowak MA. Five Rules for the Evolution of Cooperation. Science 2006; 314(5805) 1560-1563.

[57] Williams GC. Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought. Princeton: Princeton University Press; 1966.

[58] Dawkins R: The Selfish Gene. Oxford: Oxford University Press; 1976.

[59] Hamilton WD. The Evolution of Social Behavior I. Journal of Theoretical Biology 1964; 7(1)1-16.

[60] Hamilton WD. The Evolution of Social Behavior II. Journal of Theoretical Biology 1964; 7(1) 17-52

[61] Trivers R. The evolution of reciprocal altruism. Quarterly Review of Biology 1971; 46(1) 35-57.

[62] Wilson DS. Truth and Reconciliation for Group Selection. http://www.huffingtonpost.com/david-sloan-wilson

[63] Okasha S. Multi-Level Selection and the Major Transitions in Evolution. Philosophy of Science 2005; 721013-1028.

[64] Friedberg EC., Walker GC. Siede W. DNA Repair and Mutagenesis. Washington, DC: ASM Press; 1995.

[65] Mori C., Nakamura N., Dix DJ., Fujioka M., Nakagawa S., Shiota K., Eddy EM. Morphological Analysis of Germ Cell Apoptosis During Postnatal Testis Development in Normal and Hsp 70-2 Nockout Mice. Developmental Dynamics 1997; 208(1) 25-36.

[66] Tilly JL. Commuting the Death Sentence: How Oocytes Strive to Survive. Nature Reviews Molecular Cell Biology 2001; 2838-848.

[67] De Felici M., Klinger FC., Farini D., Scaldaferri ML., Iona S., Lobascio M. Establishment of Oocyte Population in the Fetal Ovary: Primordial Germ Cell Proliferation and Oocyte Programmed Cell Death. Reproductive Biomedicine Online 2005; 10182-191.Doi:10.1016/S1472-6483(10)60939-X.

[68] Liu Z., Lin H., Ye S., Liu Q., Meng Z., Chuan-Mao Zhang C., Yongjing Xia Y., Margoliash E., Rao Z., Liu X. Remarkably High Activities of Testicular Cytochrome c in Destroying Reactive Oxygen Species and in Triggering Apoptosis. Proceedings of the National Academy of Sciences USA 2006; 103(24) 8965-8970.

[69] Longo VD., Mitteldorf J., Skulachev VP. Programmed and Altruistic Ageing. Nature Reviews Genetics 2005; 6866-872.

[70] Wynne-Edwards VC. Animal Dispersion in Relation to Social Behavior. Edinburgh: Oliver and Boyd; 1962.

[71] Maynard Smith J., Price GR. The Logic of Animal Conflict. Nature 1973; 246 15-18.

[72] Wilson DS., Wilson EO. Rethinking the Theoretical Foundation of Sociobiology. Quarterly Review of Biology 2007; 82(4) 327-348

IntechOpen