Reflections on Four Related Miracles: Life, Memory, Consciousness, and Emotions.

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Preface

The purpose of this essay/book is to lift the veil of miracle from each of the concepts in the title, to demystify them.

The emergence of life, its evolution, and especially consciousness, fascinate us. Those are nothing short of miracles. Upon reflecting on this, you begin to believe in a superintelligence that created life, created species, and endowed life with consciousness.

In the approach that I outlined in the book *Reflections on Consciousness* and that I will briefly summarize in a separate chapter of this book, life and memory automatically create consciousness. This lifted the veil of mystery from the concept of conscious behavior. I no longer needed the superintelligence (God) hypothesis to perceive consciousness as a natural process. However, the notion of life remained a complete mystery. Here, the need for superintelligence was the only explanation.

But now I feel once again that I do not need the God hypothesis in order to explain the natural character of the process of emergence of life and its evolution. Consciousness is the leading factor in evolution and also in the emergence of life. However, not the standard understanding of consciousness, but its broader interpretation discussed in the book I mentioned, *Reflections on Consciousness*, which I will repeat in the section on consciousness.

Finally, emotions are generated by the consciousness, and we will discuss this in the Emotions section.

This is merely a very brief abstract. Even the key words such as life, consciousness, and emotions need to be defined. I will not define life as I understand this word, since in our approach we expand the framework and will work with a system that depends on a very large number of parameters and, possibly, has some additional (abstract) properties, such as certain symmetries. I will elaborate on this in the text. Besides, it is absolutely necessary that this system have a certain memory, and we will elaborate on this as well.

To start, one general but very important note. There is currently a flurry of publications devoted to consciousness, the consciousness of humans or the machines we create. For the most part, the papers on human consciousness focus on understanding how we humans think. They study neural connections and how consciousness can arise from them. I don't know anything about this and do not address this issue. I want to explain the difference between what I will discuss in this book and the entire stream of extremely important research that I mentioned.

Biomedicine differs from the exact sciences in that just when you think you've found the solution to the problem before you, this is far from the end of the solution.

In the exact sciences, we formulate and solve problems that have not yet been solved. We need to find a solution — any solution. We will work to improve this solution in the future.

On the other hand, the problems we need to solve in medicine have already been solved by Nature/God. Our task is not to find just any solution, however beautiful and elegant it may be, but to find the solution that Nature/God has already created. Therefore, having found the most elegant approach, we have to conduct experiments to check whether it is used by nature. And we are unlikely to succeed on the first try. Thus, everything will go in the garbage, and the work will have to start all over again. However, the veil of mystery around the phenomenon being studied will have already fallen, even if the solution found does not correspond to the true solution found by nature. And this is precisely our goal.

In the previous book, which we have already mentioned twice, we discussed the equivalent of consciousness that automatically arises in structures that depend on a very large number of parameters (degrees of freedom) and have a fairly large memory. However, I have not yet said what we mean when we talk about "consciousness." Since the standard perception of consciousness is associated with a person or, under a more liberal interpretation, with a living being, I will note at once that I do not intend to discuss in this part of the text what life is and how it should be defined. It is sufficient for me to recognize that it is a highly complex system that depends on a very large number of parameters and has memory. No precise definition will influence subsequent reflections. But we will begin our discussion of consciousness by recognizing that it accompanies at least some living systems, and most likely all.

Again, in that same book, *Reflections on Consciousness*, I give several examples of consciousness in various living beings. In birds, it is a completely human-like consciousness that we can understand. In singlecelled organisms and trees, the consciousness is completely incomprehensible to us, but it is consciousness nonetheless. My other book, *Life = Consciousness*, is devoted entirely to examples of consciousness in various animal species and other living things.

In order to sense and understand the approach I discuss in this book and my preceding book on consciousness, it is absolutely necessary, as a first step, to accept that consciousness is a phenomenon far more widespread than just human consciousness. At the same time, for many people, the perception of consciousness as something possessed only by humans is a near-religious belief. For this reason, I will repeat in the Side Story section one specific event that occurred with me and my family. In this story, the bird — an Australian magpie — demonstrated a level of conscious behavior that even I would not have believed possible. But this happened with me, before my eyes.

In the section on consciousness, I will reintroduce the schematic model, based on known (but non-trivial) mathematical observations, that successfully simulates some of the incredible properties of consciousness.

In the next following first chapter of this book, I will give several examples to show how truly unusual and completely unintuitive the behavior can be of systems with a very large degree of freedom. These examples are elementary to understand, although they are given on mathematical objects and represent precise facts.

Very Large Dimensions Surprise Us

I have already stated on several occasions earlier that some facts about very large dimensions are surprising. They are not at all intuitive, and when we hear about them for the first time, they are hard to believe. They are the result of mathematical calculations, and not of a priori intuition. And we, mathematicians, found these calculations surprising at first. However, many of them can be produced by any student who has completed a course in analysis in mathematics.

I am going to give a few such examples. The first few of these will not be directly relevant to the purpose of this book. I present them simply so that the reader gets used to the fact that in large dimensions phenomena can occur that we do not expect at all. Everything I will talk about here is the result of mathematical calculations, and, I repeat, these calculations are simple enough that any qualified mathematician can verify them without references.

A little bit of terminology and notation.

x or x(i) denote numbers, positive or negative, which sometimes include their index i, as in x(i). An array of numbers **x** = (x(1), x(2), ..., x(n)) is called a vector, and we emphasize the count of these numbers with an n-dimensional vector. We write {**x** = (x(1), x(2)) | |x(i)| $\leq$ 1 for i = 1,2} for the entire set of vectors **x** such that the following condition is satisfied: module |x(i)| is less than or equal to one. This is a square, which we call a 2-dimensional cube. If i = 1, 2, 3 — that is, if the dimension of the vector was three — then it would be an ordinary cube, a three-dimensional cube. Similarly, we will talk about an n-dimensional cube when the vector **x** consists of n numbers.

We will talk about the volume of cubes, and we will use the word “volume” for all dimensions n. Therefore, the volume of a two-dimensional cube is its area, and it is equal to four. The volume of a three-dimensional cube is equal to eight, and the volume of an n-dimensional cube = 2^n (2 to the power of n).

Let us now inscribe a unit ball into the cube. In the two-dimensional case, this will be a circle inside a square. In three dimensions, it will be a ball inside a cube. And so on — an n-dimensional ball inside an n-dimensional cube.

How much space does a ball take up inside a cube if n is very large? Answer: almost none. For example, let n = 15. Let's take a random point inside a 15-dimensional cube. What is the probability that it will also be inside the ball? This probability will be less than 1 in 64,000. This means that you can bet with an easy mind $10,000 that you didn't hit the inside of the ball.

Is this intuitive? Following the intuition based on the dimension of three, when we see a ball inside a cube, we would not guess this. I will add that if you took n equal to twenty, then you could easily bet even one million dollars that a random point would not fall inside the ball.

How does the volume of a ball of radius one change with increasing dimension n?

For n = 2 (circle), it is π, approximately 3.142,
for n = 3 (ball), it is 4/3 π, approximately 4.189,
for n = 4, approximately 4.935, and
for n = 5, approximately 5.264.

Enough to get an intuitive sense, wouldn't you say? The volume of the ball increases five times in a row. For any physicist, this is sufficient to assert that this will continue. However, going forward, at large dimensions n, the volume begins to drop. At n = 15, it is already 0.381, and then rapidly, exponentially, it approaches zero.

In the next example I will talk about the surface of a ball — that is, a sphere. We denote it S^n, for an n-dimensional sphere. This means that the vector **x**, consisting of an array of numbers x(i), i = 1, …, n, belongs to this sphere — that is, the sum of all numbers $x(i)^2$ is equal to 1.

A function f(**x**) is given on a sphere if for any point **x** on the sphere a number f(**x**) is given. We want to consider functions that are not too bad, and therefore, for example, we will limit ourselves to the conditions that for any two points **x** and **y** on the sphere, the values of the function f(**x**) and f(**y**) do not differ by more than 10 times the distance between points **x** and **y**. (We call such functions Lip functions with a constant of 10.)

And now we are ready to conduct a game that I think will surprise you. Let's take n to be a large number, although it doesn't need to be too large, for example, 100. Write down for yourself any such function. I don't need to know what function you choose, any function. Now take a random point **x** on the sphere. You will tell me the value of f(**x**). I couldn't know what it is. I don't know what your function is.

Now take another random vector **y**. You don't need to tell me the value of f(**y**). I will tell you that value with an accuracy of four decimal places (that is, if it were, say, 4.56783, then I would tell you 4.5678). How will I know the value? Well, simply because with a probability almost equal to one (that is, almost certainly), this new value will be the same as the old value to the first four decimal places.

It is a mathematical theorem, a completely unintuitive one, that such a function with a probability very close to one takes nearly the same value. The function looks like and behaves like a nearly constant function. And even if you want to deceive me and change this function, but not too much, this value will remain the same. The property of taking the same value is extremely stable for such functions. Of course, I must specify what type of changes are permissible. By the way, the same is true for, say, 20 functions simultaneously.

This last example, this property of functions on the sphere, is called *concentration of measure*. This property is typical for systems of very large dimensions. It is central to our mathematical model of consciousness, which is described in detail in the book *Reflections on Consciousness*.

In order to keep it precise and elementary, this chapter is written for special, relatively simple objects — those are cubes, balls, and spheres. However, we know that analogous statements are true for a huge number of various objects of very large dimensions. We could say that this kind of behavior, the examples of which I gave above, is typical. Going forward, when describing the objects that we study, we assume that they have the same properties.

A Note About Memory

It is clear that any definition of a living system would state that it depends on a huge number of parameters and has memory. Naturally, the memory's capacity can vary and can start with something very small. I will now give you one example.

Scientists have recently discovered that molecules and cells can "remember" which substances they interacted with and how. The "memory" of molecules influences their future behavior. I'd like to note that, generally speaking, there is nothing surprising about this. I will give a simple example using our common human concepts. For example, a certain "something" must enter a door that turns out to be locked with a simple hook. After some random movements, the hook is unlocked (or ripped off), and the door can be entered. Next time it will be easier to enter the door, since the hook is already unlocked. In other terms, we can say that the door "remembers" that it had been entered, and now it is easier to enter it.

By the way, here is a specific example of such molecules. New research has discovered the molecule that stores long-term memories — it's called calcium/calmodulin dependent protein kinase, or CaMKII for short. Calmodulin is a small (16.7 kDa), highly conserved protein that binds to a wide variety of target proteins and mediates many important physiological processes, such as inflammation, metabolism, apoptosis, smooth muscle contraction, intracellular movement, short-term and long-term memory, and the immune response.

Brief Synopsis on Consciousness

The central notion in our approach is the concept of consciousness, which we studied in the book *Reflections on Consciousness*. I will briefly reiterate the main propositions that we have reached and which we will use below.

Let me recall that in the study of “consciousness,” we actually discussed conscious actions. And we needed to define what a conscious action is. What I mean by a conscious action is an action that entails a clear previously established goal that this action should achieve — a plan of action is conceived in advance, and the action follows this previously conceived plan. Consciousness in my understanding consists of all conscious actions that a given living being (or our abstract system) is able to perform.

Let me note that one may categorize “understanding” and emergence of “knowledge” as conscious actions (it starts with a decision to learn, to understand, and a plan as to how we suppose to achieve it). In the category of “conscious actions” I also include “conscious reading of the situation.”

Naturally, depending on this multitude of conscious actions, we can talk about different levels of consciousness, from very rudimental, elementary forms, to highly advanced ones. I repeat once again that our definitions and reasoning can be applied to many systems that have a very large number of parameters and have memory.

Presumably, each task assigned to a certain system (say, a living organism) can be described by some function, not yet known to us today, which depends, naturally, on a very large number of parameters. And if the model example of concentration, as we discussed in the section The Mathematical Model of Consciousness of the book *Reflections on Consciousness* is also valid in this case, we get behavior close to a fixed pattern.

I call this the system’s conscious response. This reaction does not change when a small number of parameters are changed. Consciousness must be stable. And conservative. When we come back to approximately the same situation, we should demonstrate the same reaction. Repeating a reaction allows one to remember which decision is correct and select the best decision. However, completely identical situations do not arise, and it is necessary to implement the same action plan in situations that are close but not identical. And the concept of “closeness” is not a common one. It completely ignores changes, even very significant ones, but in a small number of variables.

I have already noted that this behavior of systems that depend on a very large number of variables can be considered typical. And this is our basic assumption about the objects we are considering. We believe that the systems we are considering have this property.

In the section Memory and Consciousness of the same book, I called the entire set of functions derived from one function f using a large set of perturbations that we discussed there, a “capsule of consciousness.” These “permissible” perturbations preserve the average values of the functions and the outcome of a conscious action that was programmed based on a given function.

Each of them is a family, a very large family of functions that also exhibit the same element of consciousness. We expect to see this property in our understanding of consciousness, as a manifestation of consciousness (the same reaction in similar but not necessarily identical situations). The implementation of the plan (the value of the function) can lead to a good or very good outcome, but can also lead to a bad one.

All this is registered by our memory, and the plan is written into memory with a fitting estimate (reflected in the system in question, such as an organism, as emotions — but we will talk about this later). The entire capsule of this plan is recorded in memory, and this capsule of consciousness transforms into a part of our consciousness. From now on, in other situations that are only similar to the one in which the plan was developed, we will “consciously” choose this plan (if it worked well).

The central role in our model should be played by the aggregation of all capsules derived from functions describing one specific array of conscious actions of our system, which I will call a “super-capsule.” And, in actuality, the entire super-capsule of the plan of action is recorded in memory, and this super-capsule of consciousness transforms to become part of our consciousness.

Consciousness as a whole is the aggregation of a huge number of conscious actions that a given subject (say, a living being) possesses. Consciousness gradually emerges with the increase in the number of parameters on which this system depends.

However, we discussed in the section Some Conclusions of the same book that the starting point for the emergence of consciousness may be an individual being, such as, say, an ant or a bee, and as their numbers increase, slowly and gradually there arises the consciousness of the corresponding communities consisting of a very large number of individual members. This, of course, can also be applied to a huge set of identical molecules in any chemical solution, or to cells, plants, animals, and even humans.

Let us use the term “hamula” to define a very large group of subjects united by some fixed property or certain affiliation, but not yet large enough for the emergence of full-fledged consciousness. For example, fans of some highly popular football club are already a hamula with a certain set of well-defined conscious forms of behavior. However, as it grows, a hamula can progress to the stage of a super-hamula — a new organism with its own stabilized consciousness.

This is a situation where the existence (and life) of an individual member may be completely subordinate to the group consciousness and is no longer viable individually (again, as examples, ants or bees). At the level of living beings, such a super-hamula, or a set of such super-hamulas, transforms into a species or, more often, into subspecies (a subset of species inhabiting, for example, a certain large territory). And the consciousness of these super-hamulas transforms into the consciousness of the species/subspecies.

The individual members of these super-hamulas were originally subordinated to certain rules of behavior. This was their individual consciousness. But now that they have grown into a super-hamula, all these rules may disappear. They may be now subordinated to a new consciousness, which, by the way, they do not control.

In the case of living beings, more often than not, the individual consciousness is preserved. However, in addition to the individual consciousness, there arises the consciousness of the species — even though individual beings may not be aware that their certain actions are a consequence of the consciousness of the species.

Multi-Tiered Consciousness

In actuality, the structure of consciousness can be extremely complex, especially in an already highly developed consciousness. It can consist of many tiers. The first, basic tier is the personal consciousness of the individual. The next tier above it is the consciousness of the hamula to which he belongs (for example, the football club he supports or the university where he studies or works). There can be several such hamulas, each with their own independent influence on our consciousness.

Going up, the next level of control over our consciousness is that of a super-hamula, which, in a sense, is independent of the first tier. For example, the city where this individual lives and the consciousness of the residents of this city (which I call for short the consciousness of the city). There are cities with very strong internal influence. For example, ask an Odessa native about the city of his childhood.

And then you might have the state, religion, ethnic origin, nationality, etc. For instance, the consciousness of an African American in the U.S. or a Jew in Russia. For animals, this may be the pack to which they belong, and at the next level, a geographic area where they share common challenges and interests. Of course, the more developed the species in question, the more diverse and branched are these multi-tiered structures of consciousness.

The influence on us of these different tiers of consciousness can be measured by the extent to which we are prepared or not prepared to do things that we know how to do. For example, can I walk naked down a crowded street? The answer is no, I can't, even though I know how to undress. The social consciousness imposes an absolute prohibition on such behavior for me. The challenge of studying consciousness in the case of developed consciousness lies precisely in separating the first tier of the individual's consciousness from the subsequent levels.

Our morality is also the creation of our consciousness, all of its tiers. First, the very understanding of what is moral or immoral, and to what extent. And second, whether or not we want to follow the principles of morality that we ourselves have defined, or whether we are willing to deviate from those principles, and to what extent. The same applies to weaker forms of behavior known as behavioral norms.

What I am about to propose are merely conjectures, but not too complex of a study could either confirm and refine them, or refute them.

I think that the first tier of consciousness, the consciousness of the individual, together with the highest tier, the consciousness of the subspecies to which the individual belongs, determines the basic moral principles. And the willingness to follow them is determined by the consciousness coming from the hamulas to which the individual belongs. The same applies to behavioral norms, albeit in a weaker form.

Evolution, Selection, Mutation

We now move on to the discussion of evolution.

According to Darwin, evolution begins with random mutations of representatives of a given species and subsequent natural selection of the best adapted representatives for the given environment in which this species is living at a given time. This formulation does not define what a "random mutation" is. Also, some imagination is required to accept the notions of "natural selection" and "best adapted." However, I will ignore them and focus on discussing the concept of mutations.

The understanding of mutations has changed over time, and, at present, we understand mutation as some (random?) changes in the structures of DNA and RNA.

Although the idea of natural selection is undoubtedly extremely sensible, and this phenomenon has its place in the process of evolution, the idea of random mutations that lead to a purposeful change in a species is, unfortunately, absurd. This species needs to acquire new properties for survival and adaptation over a relatively short period of time, such as several tens or, at most, hundreds of years. However, we will now carry out a simple calculation, from which it will follow that this is impossible to accomplish through random mutations even over billions of years.

I will give below an example of the evolution from one ancestor of two modern animals, the okapi and the giraffe, to illustrate how impossible it is for random genetic mutations to lead to the corresponding result. But to start, I want to share some useful information about the sizes of genes, genomes, and nucleotides, and, while on the subject, to introduce the reader to the terminology.

Some Useful Information on Ability to Mutate and the Size of Nucleotides, Genes, and Genomes

The information I chose to provide below is mostly applicable to humans. Some other examples will also be mentioned.

The Human Genome Project (HGP) estimated that humans have between 20,000 and 25,000 genes. They are distributed between (typically) 23 pairs of chromosomes, or 46 chromosomes in total. Chromosomes are made up of long strands of DNA, which contains all of the body's genes.

The HGP findings suggested that all humans are 99.9% genetically identical, and only 0.1% of genetic variations are responsible for the phenotypic differences, such as physical traits (e.g., height, intelligence, hair, and eye color) or disease susceptibility, among individuals in populations.

Fun fact: Humans are closer to cats than dogs. According to a study, cats and humans share 90% of their genetic material, whereas the genetic similarity between dogs and humans is 84%. Chimpanzees are the closest relative of humans. Humans and chimps have DNA that is 95% percent similar, and 99% of our DNA coding sequences are the same as well. However, humans have 23 pairs of chromosomes in their DNA, while chimps only have 22.

A ***nucleotide*** is the basic building block of nucleic acids (i.e., DNA and RNA). The nuclear genome (of a human) comprises approximately 3,200,000,000 nucleotides of DNA, divided into 24 linear molecules, the shortest being 50,000,000 nucleotides in length, and the longest 260,000,000 nucleotides, each contained in a different chromosome. The rate of nucleotide substitutions is estimated to be one in 10^8 per generation, implying that around **30 nucleotide mutations** would be expected in each human gamete of around 3 billion nucleotides. (A gamete is a reproductive cell of an animal or plant.)

A single gene for mammals is often more than 10,000 nucleotides long, and genes that span 100,000 nucleotides are not uncommon. The human genome is said to contain 3 billion nucleotide pairs, even though most human cells contain 6 billion nucleotide pairs. DNA is a double helix: Each nucleotide on a strand of DNA has a complementary nucleotide on the other strand.

The average gene size in humans is 10–15 kbp (kilobase pairs, which is a unit of length of nucleic acids equal to 1,000 base pairs) (Strachan and Read, 1999). The median gene size in humans is 24 kbp (Fuchs et al., 2014).

Genes of a Cell

All the self-reproducing cellular organisms so far examined have DNA as the genome. However, many RNA viruses exist, and there is a widespread view that an RNA world existed before the present DNA world.

Aquatic and host-associated microbial genomes present on average the smallest estimated genome sizes (3.1 and 3.0 Mbp, respectively). These are followed by terrestrial microbial genomes (average 3.7 Mbp), and genomes from isolated microorganisms (average 4.3 Mbp).

Gene flow, called also gene migration, is the transfer of genetic material from one population to another. Gene flow, the mixing of genetic information, maintains consistency within a species. When gene flow is restricted, species can diverge, leading to new species. This process, called speciation, contributes to biodiversity.

And Now, Mutations

Mutations can be caused by environmental factors called mutagens. Mutagens include radiation, chemicals, and infectious agents. Some mutations occur spontaneously without outside influence.

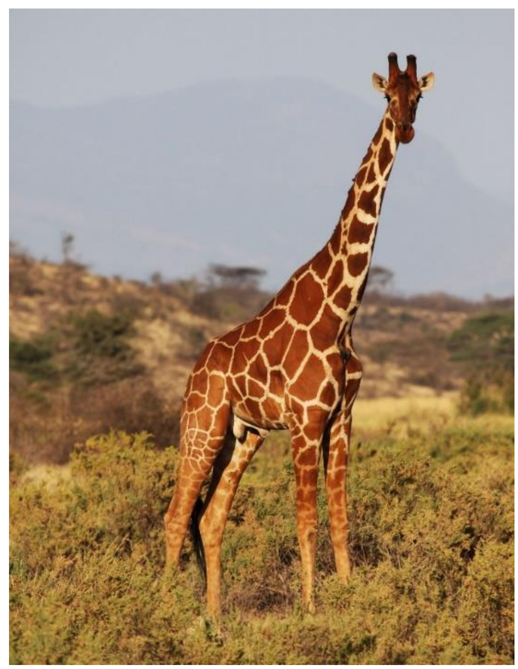
We have already noted above that in a genome of 3 billion nucleotides, an average of **30 nucleotide mutations** occur in each human gamete. That is, this the expected number of mutations in each generation. On average, the size of one gene corresponds to 20,000 nucleotides. Thus, in one specific gene that we dream about mutating, the mutation will occur with a probability of one in 5,000.

You might think that this is not such a small number. However, who said that a mutation will lead in the direction that we need? Also, is one mutation in the gene enough to bring about positive change in the entire genome, or perhaps it takes several mutations? We cannot perform an exact calculation here, but we could conjecture that this number will drop — at the very least, down to one in 1 billion (for example, if two nucleotides must change in one gene, then the probability becomes one in 25 million).

Of course, we must remember that the number of individual organisms is also very large, and therefore, perhaps, the corresponding correct mutation will occur in one of them. But even this will not help. Gene flow (gene migration) will remove this new information from the population, maintaining genetic consistency within the same species.

This is precisely the part where I'm going to introduce some revisions. But first, let us consider one example.

Who was the ancestor of the giraffe, and how could the giraffe descend from this ancestor? It is considered common knowledge that the following two modern animals descended from the same ancestor: the okapi and the giraffe.



Okapi, or okapi Джонстона

The body length of an okapi is about 2.1 meters, the tail is 30–40 cm, and the height at the withers is up to 1.2 meters. For a giraffe, the leg length is around 180 cm, the height is up to 6.1 meters, and about 1/3 of its length is the neck. It is important to note that the number of vertebrae in the neck of a giraffe is the same as in the neck of an okapi and almost all other mammals, including humans. The number of vertebrae is seven.

One of the most famous explanations for why giraffes have such a long neck was proposed by the prominent French naturalist Jean-Baptiste Lamarck — he believed that their necks were stretched from constant efforts to reach the leaves in the treetops. Darwin shared the same opinion. Of course, they lived long before the emergence of genetic theory.

And now think about how the seven vertebrae of the giraffe's ancestor are simultaneously stretched under the influence of mutations. And this happens in a fairly short period of time, since the food needs to be reached now — well, let's say, within several decades during which the tree crown grows higher and higher. This cannot wait thousands of years.

One final note. The criticism above is somewhat mitigated by the following fact. There are genes that promote mutation. One of the most promising genes in that regard is ACTN3, which has commonly been referred to as "a gene for speed." (The ACTN3 gene is only carried by a small portion of the population — in Europe, only 18% (from Wikipedia).)

Evolution

However, evolution is an observable fact, and there must be some factor directing it. I believe that this is the work of consciousness. **However, not individual consciousness, but the consciousness of the species.**

Consciousness controls our behavior, our habits. It limits our so-called free will and, perhaps, completely deprives us of that free will in any serious matters (we discuss this in the side story, "Does Freedom of Choice (Free Will) Exist?" from the same book I mentioned a few times before).

We also have many auxiliary consciousnesses associated, say, with affinity for certain clubs, people, or political views. This also causes the extreme difficulty we experience in changing these habits. (For example, is it easy for football fans to change the club that they have supported for many years, or to change political allegiances?)

Can consciousness "act" to improve a living organism?

It would be the result not of the individual consciousness of one organism (or a more abstract system) but the result of the consciousness of the entire given species, which is a super-hamula of all families of genetically near-identical organisms (consciousness of the species). As a simple example, it may act through changing the sexual attractiveness (attraction) of individual organisms (to steer it in the direction of the selection gradient).

This possibility was confirmed by a Penn State anthropologist, David A. Puts (2010), who found that male physical competition, not attraction, was central in winning mates among human ancestors. We have also observed shifts in men's sexual attractiveness during the nineteenth and twentieth centuries from physical strength to intellectual prowess. Another example is the emergence of incredible proliferation of self-sacrifice during wars of survival. This is also the impact of the collective consciousness of the respective super-hamulas.

To summarize our approach to evolution:

The consciousness of a given species, or of a large part thereof (subspecies), observes and controls a certain part of our behavior, our consciousness. In the event of significant changes in the environment or any other threats to the given subgroup of the species, the consciousness of the species predetermines the direction of mutations and selection, the selection of the individuals most useful for preserving the species. This is selection directed by consciousness.

First Steps of Evolution and Emergence of Life

Scientists speculate that under the influence of solar radiation, powerful electrical discharges (lightning) and volcanic eruptions in the atmosphere of the ancient Earth 4–4.5 billion years ago, the simplest organic compounds necessary for the emergence of life may have arisen from inorganic substances. (I don't see any miracle in this conjecture.) Recently, some scientists have narrowed in on the hypothesis that life originated near a deep-sea hydrothermal vent.

At the very beginning of this chapter, we talked about memory. We noted that currently there are molecules that are known to remember things. Of course, their memory is extremely limited. But to continue, we don't need it to be large. The sizes, known to us, of such molecules are also not that small. For example, the size of the Calmodulin is 16.7 kDa.

So let us consider such a molecule, which we will call X. It is fairly large and has memory. Therefore, the theory of consciousness that we outlined above is applicable to this molecule. Its conscious actions are absolutely elementary and perhaps consist of only one action — bonding with another molecule. However, there is a huge number of such molecules. They are all around. And, as such, they form a super-hamula **X**, as we also explained above.

This super-hamula also acquires its own consciousness — that is, a certain influence on the actions of type X molecules. And, if the molecules bonded to another molecule are more stable, then this influence will be precisely the drive for this molecule to bond with another molecule of the same type.

And thus, if this promotes greater stability and better survival of these molecules, then the result will be a huge number of type X dimers (i.e., two identical molecules linked together). And a new **X+X** super-hamula appeared, with its own consciousness of the new super-hamula. It is no miracle that the process will continue over time, forming large groups of mutually bonded molecules of the same type, and possibly not of the exact same type.

Such a process will lead us to a large number of multi-molecular structures. These clusters of specialized, cooperating cells eventually became the first animals. Some evidence suggests they evolved around 800 million years ago. Sponges were among the earliest animals. They are multicellular organisms that have bodies full of pores and channels allowing water to circulate through them, consisting of jelly-like mesohyl sandwiched between two thin layers of cells.

Sponges have unspecialized cells that can transform into other types and that often migrate between the main cell layers and the mesohyl in the process. Sponges do not have complex nervous, digestive, or circulatory systems. Instead, most rely on maintaining a constant water flow through their bodies to obtain food and oxygen and to remove waste.

The process of evolution has begun. It is not a fast one. Comparing the data on the emergence of the molecules I described in the beginning, with the data on the emergence of the first signs of life, shows that this process took more than half a billion years. But the veil of miracle has been lifted from this process (for me).

A Few Additional Facts

The first chemical traces of life, approximately 3.5 billion years old, were discovered in the rocks of Australia (Pilbara). Organic carbon was later discovered in rocks dating back 4.1 billion years.

Life originated in the ancient ocean, apparently about 3.7 billion years ago. At that time, there were only algae, but they could already synthesize oxygen from energy. Perhaps life originated precisely in hot springs, where there were many nutrients, including nucleotides.

Living organisms first emerged in the Archean era. Those were heterotrophs — that is, they used for food pre-made organic compounds that they found in the primordial soup. The first species of living organisms were anaerobic bacteria.

The first multicellular organisms emerged on Earth about 650 million years ago. That is, after another 3 billion years had passed. Experts also determined that the place where they first appeared was Australia. These living organisms came about thanks to the emergence of plankton and the onset of cooler climate. Paleontologists call this phenomenon the "Algae Revolution."

The first recorded complex life forms appear around 560 million years ago, though they were very different than the creatures we are familiar with today. Many were soft-bodied, with only a few tube-like creatures having a stiff outer sheath. Between 390 and 360 million years ago, the descendants of these organisms began to live in shallower waters, and eventually moved to land.

The next leap in the development of evolution occurred another half a billion years after the appearance of the first multicellular organisms, 170 million years ago (according to scientists from the University of Plymouth).

Before this, the main role in the existence of ecosystems was played by abiotic factors — the chemical composition of water and the climate. However, in the middle of the Jurassic Period, plankton began to actively reproduce in the World Ocean, releasing calcium carbonate. This compound was then deposited as sediment (from *Nature Geoscience*). Scientists concluded that this process allowed the chemical composition of the ocean to stabilize and provided the conditions for a very wide variety of species to thrive.

Emotions

What role do emotions play in our discussion on Consciousness?

Before starting this discussion, we need to understand what the subject of our discussion is, what we are talking about, what an Emotion is. Each of us feels and understands when our reaction is, in a certain sense, an emotional one, but this is not at all easy to define exactly, and there is much confusion in the debates on this matter. I will quote Google:

"Emotions are conscious mental reactions (such as anger or fear) subjectively experienced as strong feelings usually directed toward a specific object and typically accompanied by physiological and behavioral changes in the body." (Is this clear?)

I would not dwell on this definition. There are many others. In our text, my goal is different. I want to understand why life (and consciousness) needs emotions (and does it?). If they are necessary, what is their role? I will provide a definition of emotions that relates to our discussion of consciousness.

But here, I want to discuss the range of our, human emotions — to list them. Again, it turns out that this isn't so simple. There is a concept of Basic Emotions. Even though many psychologists have accepted the theory of basic emotions, there is no consensus about the precise number of basic emotions. This number varies from four to eight in different studies, but I have also seen the number 12.

Psychologist Robert Plutchik believed that humans ordinarily experience eight primary emotions, which are wired into our brain at birth. These primary emotions include Anger, Fear, Sadness, Joy, Disgust, Surprise, Trust, and Anticipation.

However, scientists have now found that the number of all emotions is as many as 27:

Admiration, Adoration, Aesthetic Appreciation, Amusement, Anxiety, Awe, Awkwardness, Boredom, Calmness, Confusion, Craving, Disgust, Pain, Entrancement, Envy, Excitement, Fear, Horror, Interest, Joy, Nostalgia, Romance, Sadness, Satisfaction, Sexual Desire, Sympathy, and Triumph.

Then again, in other studies, researchers have identified 24 different categories of emotion. I have seen two different such lists, which do not coincide. Here is one of them:

Adoration, Amusement, Anger, Awe, Confusion, Contempt, Contentment, Desire, Disappointment, Disgust, Distress, Ecstasy, Elation, Embarrassment, Fear, Interest, Pain, Realization, Relief, Sadness, Surprise (negative), Surprise (positive), Sympathy, and Triumph.

Of course, all of these lists repeat the same items, although sometimes the same emotion is called by different names. Incidentally, Plutchik believed that in total, humans can experience over 34,000 unique emotions.

All of these categories of emotions are useful to keep in mind when we discuss the concept that parallels the categories of emotions in our model of consciousness.

By the way, do we live any single moment without experiencing some emotion? Is it possible? Being in the state of calm (which is also an emotion) is the answer, when you think you don't have any emotion.

So how does the concept of emotions appear in our scheme of consciousness and conscious actions? We evaluated each conscious action by some function (a function unknown to us, but existing in our scheme). The result could be good or very good, but it could also be bad or very bad. The level of success or failure of our action is assessed by the strength of our emotions. This is where emotions come into play. How else could we know how good or bad the result is? Emotions are the evaluative function of our consciousness. It is also a form in which consciousness stimulates our actions.

However, there are great many different emotions. Each of these emotions reflects a certain area for which our consciousness has assumed responsibility. Of course, these areas can overlap, and in some cases, the picture of emotions can be very complex.

To Summarize

I will briefly repeat what I see as a single step of evolution.

Let us consider a certain thriving species. Each individual member of the species has its own consciousness, responsible for the success and survival of that individual member within the species. But there also exists a consciousness of the species (or perhaps just a super-hamula), responsible for the success and survival of the species or a subspecies (or super-hamula) that is distinct in some way. In a certain sense, it **dominates** the consciousness of an individual member.

Some changes occur in the external environment, and the species must begin to adapt to the changing conditions. The consciousness of the species springs into action and directs the evolution of the individual members. Their tastes change, their mating partners change, and perhaps more serious changes occur. The actions of the consciousness of the species raise the level of consciousness of individual members, which means that the level of consciousness of the species also rises automatically. Of course, all this can happen only with part of the species, with a subspecies inhabiting a different environment than the rest of this species, or even with some kind of a super-hamula.

This process began about 4.5 billion years ago, when, under the influence of powerful electrical discharges and volcanic eruptions, or possibly in deep-sea hydrothermal vents, organic compounds emerged, molecules that have memory and depend on a sufficiently large number of parameters for the emergence of elementary signs of consciousness.

At present, we are observing the current, most recent stage of this development, where the consciousness of humanity creates before our eyes an artificial intelligence that has incredible memory and covers the entire planet — perhaps the next step in the evolution of consciousness.

Side story.

Example of Consciousness in Animal World

There is a widely held view that consciousness is a trait of humans, but not of animals. From everything I described above, it is obvious how much I disagree with this belief. My understanding is that all living things have consciousness. I have described examples of conscious behavior not only in the animal world, but also in the world of cells and in the world of trees. I devoted my book *Life = Consciousness* to this subject, but also described some examples in the preceding book, *Reflections on Consciousness*. Here I will repeat only one example of undoubtedly conscious behavior in a bird. I am unable to understand how one can deny consciousness in what you are about to read.

We will talk now about a very intelligent bird, the Australian magpie. We were renting a small house on the outskirts of Canberra. There were always birds in the small area in front of the entrance. Of course, our children, nine-year-old Anat and 11-year-old Emanuel, fed the birds a little. There was even some kind of a small feeder on the ground a couple of meters from the entrance. We had been living there for a while, and the birds were also used to us, although they scattered when we walked past them.

Once, fairly early in the morning, there was a small knock on the door. We were all downstairs already, not far from the entrance. Luda went to open the door. Our front door opened into an entrance hall, about two by two meters, which led into the living room through an open entryway. Luda opened

Australian Magpie

the door and saw no one. She then looked down and saw a bird standing by theentrance! It was the bird who knocked on the door! We were all nearby but standing in the living room. Luda moved away. And the bird slowly, in no haste, came in and made a circle around the entrance hall. It was obvious that the bird was terribly nervous. It even relieved itself a little on the floor along the way, out of fear. But it made this journey and went back to the porch. None of us moved.The bird breathed a sigh of relief (this was my interpretation, but it was an obvious one). It then glanced at us again and jumped off the porch. The feat was over. It went to the feeder. And we realized that it showed all the birds that were watching from all sides that this was its place now. The bird claimed it and was now the master. And from that point on, all the other birds waited for it to finish its meal and move away from the feeder. And then the other birds could eat too.

Once again, we see a clearly set goal, a complex and risky plan, and its rigorous implementation. What can we learn from this story about this civilization, the civilization of Australian magpies?