Concepts as Building Blocks of Information
and The Structure of Consciousness.

Boris Rusakov
(Rusakov@xpertnetinc.com)

Abstract.
We show that information, in contrast to the common belief, is not contained in a signal external to consciousness, but is a product of consciousness itself and is a set of concepts. The external signal serves as a trigger for the response of the nervous system. The response is subsequently analyzed by consciousness for its conceptual content. Information is a result of this analysis and can be considered a vector of concepts, i.e. conceptogram, of a signal for a specific consciousness at a specific moment. A concept is a sensory and visual image of a certain biochemical profile of the human nervous system, which is created and developed throughout one’s lifetime. It is an elementary building block of both human consciousness and information. In particular, 'I' ('self') is one of the concepts. The creation of a particular concept is a phase transition. The Concept Module, or ability to generate concepts, is unique to humans. We offer scenarios for how this ability could have been acquired by our predecessors. It is suggested that the animal's brain, being a processor of visual signals that converts them into internal images, has developed this ability as a result of “guessing” or imagining details that are missing in the actual visible picture. We will also discuss some other issues related to consciousness that may be of interest to both Human and Artificial Intelligence research.

Introduction: Concepts.
Looking at an oak, birch, pine or willow, an animal does not try to understand what is common between them. It does not decide to call them all trees and does not look for what could be other trees. Humans do. You may correctly point out that, firstly, it is because animals do not have language. Secondly, they do not analyze, systemize, extract common properties, or look for reasons and explanation. But why do we do that while they do not? When did it start? Below, I hope I will answer these and some other questions.

The tree in this example is a concept. A concept is an abstract property common to different observables (values), their common classifier, common description, and common feature. The crucial property of a concept is its independence from the specific object from which we single it out, its portability to other objects. We even apply it to completely unrelated subjects. Recall “tree of life”, “family tree”, “tree-like diagram”, etc. In mathematics we would say that the concept is a vector, i.e. a collection of values, or components. In the example above, oak, birch, pine, and willow, are specific values of the concept of a tree. Oak, pine and the rest of them are concepts as well, since they are generalizations of their own sub-categories, such as red oak, white oak, poison oak, etc. Everything our consciousness operates with is a concept. Any word corresponds to a concept. Any action, verb, phrase, logical operation, or mathematical construct denotes a concept as well. To sit, to drink, to
think, to imagine are concepts. A concept is an abstraction created by our consciousness. Any concept at the same time could be a value of another concept as we just saw. Conceptualization is an abstract thinking. Concepts do not exist in nature. They are only in the human mind, and are acquired in the process of learning. Moreover, even in the human mind, they do not appear at birth.

Biologically, each concept is a unique combination of senses, a sensory image of corresponding unique biochemical profile, or state, or excitation, in the individual’s nervous system. And this is how it is stored in the nervous system. It is also a visual image. Concepts change with time as our experience and education change. Some of them become more sophisticated. Others become obsolete and fade because of their irrelevance. Many concepts have disappeared as contradictory to science. Many were dismissed as inadequate. And certainly we acquire new concepts. This is not easy to do. To acquire a new concept we need to train our brain to sense it, to relate it to other concepts we previously acquired, to accommodate it into existing system of concepts, i.e. into consciousness.

Another important property of the concept is that it cannot exist without notation. Any new concept at the time of its birth (or conception) must be denoted. The notation could be a picture, a sign, a sound, a meme, a gesture, or a word or phrase. The notation is what allows us to transfer a concept from one object to another. In our civilization the main instrument of notation is language. Without a language designation, i.e. word or phrase, the concept does not exist. The word or phrase denoting the concept is its integral part. I am far from claiming that absence of language automatically indicates absence of concepts. As mentioned above, there are other ways of notation that can be used. However, language is the most versatile and dynamic one, and we are very lucky to have it.

Since every nervous system evolves over time and since there are no two identical nervous systems it is impossible that the same concept is felt identically by two different people or even by the same person at different moments in time. This is yet another reason why two people perceive same “Information” differently.

The privacy of consciousness is a direct result of this uniqueness. Only the owner knows about his or her feelings and sensations. We cannot read another person’s thoughts. We cannot even determine whether we see a color in the same way. While it is easy for us to establish that a color-blind person is such, since he does not distinguish one color from another, we cannot find out how exactly another person, who is not color-blind, sees (or better say feels) a specific color. If I see (feel) the color blue the way you see (feel) green and vice versa, there is no way for us or anyone else to determine it.

Even when something hurts, your doctor doesn't “see” the pain. That is why he asks you to describe it. The only things your doctor can see, using any of the most advanced tools, is where you have inflammation, and what parameters are abnormal. From his experience with other patients he may be able to assume you have a pain, but he cannot be sure that you have it. It is equally impossible to “see” any other of your sensations and the consciousness as a whole.

It is still a subject of debate whether our senses are real physical phenomena or just pure imagination existing only in our consciousness, just like concepts. I am not going to debate it here. I can only claim that every concept being a product of our imagination has a very real sensory, and thus biochemical, portrait in our nervous system.
Side note on Memory. Recall a situation that probably happened to everyone, when you forgot a word or someone's name, and are painfully trying to recall it. In order to recall it you are scrolling through suggestions brought up by your mind and dismiss them one by one. You know exactly when it is not it, unless it is it. When the suggestion is close you hesitate for a few seconds, but then decide that it is not it. Indeed, when it is it, you would not hesitate, you would know it immediately and unmistakably. But how do you know that, if you forgot it? Answer: It is because your body remembers the exact sensations in which it was tabulated. When the sensation is not exactly the same, you know it, even if it is very close. Thus, memory of any concept, any word, is a unique sensation corresponding to it. Our nervous system remembers a chemical portrait of the whole concept. We may forget its verbal notation, i.e. the word associated with it, but the chemical portrait is still there and comes up when we recall the notation.

In addition to the privacy of consciousness, another reason why it is so hard to study is our language that we use to deceive ourselves and others in everything related to consciousness. When we say “I”, “I think”, “thought”, “soul”, etc, we think we know what we are talking about, but we don’t. How exactly do we think? We don’t know. Then how can we claim we do something that we cannot even remotely describe how it’s done? These are the concepts created by our consciousness to avoid understanding of what is really going on in it. The first step in gaining this understanding is therefore to expose the deception and to dismantle the illusion of consciousness being something fundamentally mysterious.

Despite the deception, the achievements of human intelligence deserve our admiration. Thanks to them we have our cities, roads, books, atomic energy, ships, cars, planes, etc. Actually, it is not despite the deception, it is because of it. By the way, this echoes what Harari described in his book [1]. It is amazing how well it works, that we can successfully use our consciousness without caring at all about what it is and what happens in it. So we will assume that so far it has been a deception for the good. Except that not all achievements of the human mind were peaceful.

Concepts and Information.

As our consciousness convinced us, it processes information coming from outside. Such processing is its main function. Below we will show that this is not true, and that in fact information does not come from outside, but is a product of consciousness itself. Regardless of where it comes from, it is obvious that until we gain a clear understanding of what information really is we will not be able to understand what consciousness is.

Despite the roaring development of Information Technology, Artificial Intelligence, as well as all the sciences related to the study of consciousness, brain, and neural networks, there is no consistent definition of the main subject of all of these sciences, which is information. Nevertheless, all of us constantly use this word, and intuitively somehow understand its meaning, although it varies depending on the application area.

For the beginning let us try to understand where information is produced and/or contained.
We are accustomed to think that information is contained in a received message, in a newspaper, in a file, in a photograph, i.e. in the outside world, and is independent of the recipient. Every day and minute we reinforce this delusion with the help of our language: “I received (obtained) information”, “I was given information”, “The message contains important information”, “The book contains a lot of useful information”, and so on and so forth.

Now imagine this whole outside world without recipients of information. What is the meaning of all of these messages, files, photos, if no one can ever see, decode, or understand them, and how do they differ from other artifacts of inanimate nature? The answer is none, zero, in no way, they do not, and there is no information in them. The encoded message that is never going to be decoded contains no information. On the contrary, if someone convinces us that those breathtaking shapes of Arizona Monuments are actually a coded birth certificate of John Smith from Alpha Centauri, we will rush to decode them. But if there is no receiver, then even a real birth certificate of a real John Smith from Kentucky carries no more information than the curves of the mountains. If no one is there who knows what it is and how to decode it, it's just an artifact of inanimate nature. It is no better than peculiar shapes of some mountains.

Therefore: for information to exist there must be a recipient who has a concept of such information, who knows (or at least can assume) what it is, or what it is about, how to decode it, and has concepts of its components. In the example above, the concepts are birth, date, name, gender, encoding method, and many others. If you don’t know what birth is, have no concept of date, of names, or simply cannot read, then the birth certificate bears no information for you. In addition, these concepts are functions of culture, language and time. For example, in some cultures, at certain times, a birth certificate contained ethnic and religious affiliation of each of the newborn’s parents. In other cultures, a birth certificate contains height and weight of the newborn.

We know very well that two people talking to each other in a foreign language unknown to us are sharing information with each other, while for us their conversation is a noise. Sometimes we don't even understand our own language. Go to a seminar of theoretical physics or mathematics at the university if you are not physicist or mathematician. You will see people who speak your language, and exchange apparently valuable information, but you get nothing of it. This is a shock I experienced when I first attended such a seminar as a third-year student. You seem to understand all the words, but cannot even grasp the meaning of what is being said. So it's not just the language. It is a lack of relevant concepts.

The phrase “That’s not what I said” (or “That’s not what I meant to say”) sounds familiar to everybody. You thought you encoded certain information in a message, but the message produced very different information within the recipient. “If you said the same thing with a different tone I would understand it” – also sounds familiar. Thus, even the tone in which it is said carries a lot of value and can change the result to completely opposite. Needless to say that written messages are often even worse, and understood by our recipients not as we intended.

If you spent most of your life in a city, or your native place is located among forests, I guarantee you will be lost if you find yourself in the polar snowy desert. However, a local guide, having a quick glance at what looks to you an impenetrable white plain, would instantly determine your location and
a way out. For him, the slightest curves of snow hills carry a lot of information, while for you they mean nothing and you do not even see them. Your mind is not used to it, while his mind deals with it all the time.

Thus, the information for one recipient may not be information for another. One can continue indefinitely and recall countless examples in which the same “information received”, or rather the same signal, or message, produces completely different information in different people, and even in the same person at different times.

Therefore, if we attempt to define information as something contained in a signal, we have to admit that the signal contains an infinite number of “informations” at the same time. Thus, it is clear that to define information as something that exists outside a recipient is just as meaningless as to claim that any cubic centimeter of space contains all the information about the entire Universe and every piece of it, you just need to be able to extract it from there. In a sense, of course, this is true. But in order to extract the same recipient is needed.

The claim that information cannot be defined as something objectively existing has nothing to do with solipsism. We do not deny the existence of an objective reality outside our consciousness. But information about this reality, unlike reality itself, requires the presence of a “recipient of information” for whom this “information” makes sense. That's why I put quotation marks here, because I claim that there is no “information” outside the “recipient”.

The only role of an external signal is that by interacting with sensors of the recipient it can trigger a response within recipient that is interpreted by the recipient as certain information. But again, it may not trigger it at all as we saw in the examples above, as well as the triggering may produce no information, as we saw in these same examples.

Moreover, the information may be produced even without external signal. For example, you expected an event that did not happen, or the signal you expected did not come. Is it information? No doubt. I guarantee that if the sun does not rise tomorrow, this will cause a tremendous flurry of news, literally a bombshell of information. One can certainly say that absence of information is information about its absence, thus confirming once again that information is a product of consciousness as only consciousness can interpret absence of information as information about its absence. No external signal is needed.

Not only is information a product of consciousness but the very ability to produce it is a sign of consciousness. To produce information from a signal the receiver has to be 1) teachable (able to learn) and 2) able to conceptualize, to interpret. The first is the common property of all animals while the second is unique to humans.

We know perfectly well that the same external signal or message that we receive during our life produces more and more information in our minds over time, whereas in early childhood they did not produce any. What happened? We have learned. The signal received for the first time did not “give” us any information. But we remembered it, and the next time it turned out that the same signal
produces information, and the further, the more. If we were not able to learn, each new reception of a signal would have the same effect as the first time, and this would not change throughout our life.

The ability to learn implies the presence of memory, the ability to recognize, as well as the ability to correct, improve one's reaction to the subsequent receipt of the same signal. All animals possess this ability to varying degrees.

But for the production of information, learning alone is not enough. You also need the ability to conceptualize and interpret the received signal.

From observing animals, it would appear that they also have concepts. By the dog's reaction to other dogs, to its owner, to cats, one could assume that it has the corresponding concepts such as ‘dog’, ‘cat’, ‘owner’, ‘friend of the owner’, ‘stranger’, and etc. But this is only the appearance. What we see as a dog's reaction is just a result of its trainability. Animals cannot extract a concept from an object and apply it to a different object, in a different situation. For example, you can teach your dog to give you a paw, but it would not give a paw to another dog. It is we who interpret reactions of the dog as a sign of the dog having concepts, which is another illusion of our human consciousness.

Returning to information, we now understand that it is produced by our consciousness as a reaction to the signal received. The signal can be either external or internal, i.e. generated by the nervous system itself. The information is a result of analysis by consciousness of conceptual content of the response. By analysis we mean decomposition of the response into conceptual components. Thus, consciousness is an analyzer of conceptual content of a signal, and the information is the conceptual content, or conceptogram of a signal.

Just as a medical laboratory analyzes your blood sample to produce the values of various components (concepts), such as the level of glucose, the level of red cells, the level of cholesterol, etc., so the consciousness decomposes the signal (more precisely, its response to it) into all possible known to it today (and in the future they will be different and there will be many more) concepts and their values. At the same time, the rest of the body perceives these results through tabulated sensations (each concept has its own sensory template).

In our everyday language, information is the interpretation by the human mind of the meaning of a received signal.

Here, once again, we imply that: 1) the “received” signal means our brain’s response to either an external or internal signal, 2) “meaning” is a set of concepts invented by us with the values assigned to them by us in this case, and 3) “Interpretation” is the process of decomposing into concepts and assigning values. At the same time, it is clear that in another consciousness, or in our own consciousness at another time, the result of “interpretation” or “meaning” will be different.

It is hard to imagine how many concepts we have not yet come up with and, accordingly, how much new information people of the future will find in the same signal. Most likely they will assume that we knew nothing, or were mistaken in everything.
Our “I” (Self) is just another concept that we identify with a mysterious owner and controller of our consciousness. But in fact it does not even exist. Imagine a theater without a director and without a script. It’s just actors and spectators. The actors do whatever they want in order to please the audience and to gain as much applause as possible. As a result, depending on actors’ talent and on spectators’ taste, there will be some kind of action, sometimes good, sometimes not. It gets even more interesting if actors and spectators are same people. As well, we can add next layer of spectators watching the original spectators and applauding them, and so on. The action may become even more interesting. But in any case, an outside observer would never guess that there is simply no director and script behind all this. This analogy is very close to what happens in our consciousness. Our “I” being this inner producer, even though absent as an entity, is still there as a concept of “would-be” producer. In daily life “I” allows us to bypass complicated details of what is going on in the brain. Try to remove the word “I” from your speech and you will see what a nightmare it saves us from. This is equally applicable to all other concepts related to it, such as “I think”. It is clear that each of our actions, each word, logical construct, is a concept.

The presence of an apparatus of concepts (or module of concepts) means abstract thinking, the ability to separate a property from an object and treat it as a separate entity. A direct consequence of abstract thinking is associative thinking. This is the reverse operation, when thinking of one phenomenon leads by one of its concepts to unrelated phenomenon that incidentally has the same common index (a concept).

For animals, the received signal has only one meaning - the reaction to it. Because animals are trainable, the reaction can improve over time. But it does not produce a concept. Animals do not systemize signals, do not analyze the “meaning” of the signal as we do, identifying various concepts. If the reaction of an animal to a signal can be treated as information, it is the most primitive particular case of it, a zero-dimensional information, or scalar of information.

Consciousness as an inner vision.

Thus, the human brain, or the nervous system generally, is a generator and processor of information. This is an extension of the ancient animal function of the brain - observation, reconnaissance, scouting, and response to change.

The task is to observe, detect and react, thus providing the rest of the body with the response to observed events. While eyes are our visual sensors, the brain is the internal display organ. All its output is visual, including information and thoughts. Any information, any thought is an image, a picture, a clip. Even sound information is instantly translated into a picture. Pictures are constantly compared with the existing templates. But while animal’s brain function is limited to this task, a human’s one has “internal” vision, which apparently came into existence due to excess of biomaterial needed just for external observation. As a result, it has extended its function to guessing, imagining “missing” parts in order to “complete” the picture, i.e. inventing what is not there, speculating, deceiving and lying (on purpose or not), coming up with theories and explanations, thus eventually producing concepts and information.
In both the human and animal brain, there is a constant flurry of work on the exchange of signals between neurons. The main goal of this work is to display a picture of the “seen” and provide the body with a reaction to it. I put quotation marks because it doesn’t matter whether the signal originally came from outside via external sensors (vision, hearing, smell, touch), or was generated by the brain itself. For as long as a brain is alive this work does not stop, even in a dream or a coma. The only thing that separates the human consciousness from the animal one is abstract thinking, i.e. interpretation of pictures as information.

The electrochemical processes, the excitations of various parts of the brain, are observed and well studied by researchers of the brain and experts in mapping the brain, see for example [2]. But at the same time, the pictures that appear in the brain as a result of the sensation of these signals by the body cannot be seen, since an outside observer does not and cannot know, what sensations this or that signal causes in a particular individual. It depends on the individual’s history, experience, education etc. Nor is it possible to directly see the interpretation pictures they evoke. Therefore, it is not surprising that researchers who study the work of the brain attribute a certain mystery to consciousness, as if it is something intangible, not directly connected to brain, or even if connected, then in some superficial way.

Cinema is the best illustration of how it works. When we watch a movie in the cinema we know very well it is just a flat screen that reflects lights coming from the projector. So, what causes us to fear that train coming at us, or lose our breath as if we really jump from that plane, or see and feel ourselves as if we are really in the middle of that epic battle, or love scene? What on that flat screen causes us to laugh, cry, scream, hate etc, as if it is real? The sequence of images imitating the motion triggers exactly the same sensations that would be triggered by the real events. The latter then “completes the picture” by triggering all the rest of the sensations corresponding to the real events that are in turn reflected in the brain’s internal screen as a result. Thus, the cinema screen creates an illusion in our consciousness that we are witnessing or participating in real events because it creates exactly same sensations the real events would create. Consciousness is this never ending movie, where “I” is associated with the spectator. In addition, it is a multi-screen performance with hundreds of sub-screens that run various fluxes of consciousness, or channels, such as memories, history, news, daily events, business, science etc.

The precise definition of Consciousness is somewhat evading because there is no generally adopted understanding of what exactly it refers to, in contrast to the case of Information. For example “being conscious” is equivalent to “being awake, or alert, or aware”, and thus refers to the owner’s condition of alert, as opposite, for example, to sleep. On the other hand, when one says that a thought is a product of consciousness there is no reference to the owner’s condition at all. The thought could be as well produced in a sleep. Nevertheless, it is still a sensation. It is similar to concepts that form the consciousness, and are based on sensations.

We tend to define **Consciousness as a sensation of the brain’s work**, where the sensation is felt by the whole body. According to this definition it is neither illusion [3] nor mystery [4]. One can say that it is as much of an illusion as any image we see and as real as pain that we feel. While a train running at us from the cinema screen is an illusion, the fear it causes is not.
While our brain is constantly at work, the feeling of this work is very limited and changing. It expands at certain times and shrinks at others. It is almost absent when we sleep. It can start thinking its own thoughts, and it does not know how the thinking is done.

Consciousness, as already mentioned, is essentially inner vision. Besides converting an “external” picture into an internal one, it “guesses” the details that are not in the external picture, it imagines, invents everything, and certainly lies. Surprisingly, our language, deceiving us in almost everything, sometimes yet adequately describes processes in the mind. Expressions such as “look at the root cause”, “see the difference”, “I see” (I understand), political “views”, “foresight”, “observation”, etc use the terminology of optical vision although they refer to consciousness.

It is also understandable why it is so easy to deceive us. Our consciousness itself will gladly buy everything offered just to fill an empty space. We must know everything, understand everything. A false model, information, or concept, is better for us than their absence. This is what magicians and illusionists, swindlers and politicians, kings and dictators, preachers and fake news journalists, and other “kind” people actively use. Likewise, the simple concept is more readily acquired than the complicated one, and more fiercely protected from extinction. The concept of God that was invented by ancient people as a simple universal explanation of unknown is still around and keeps adapting to modern science. The Socialist concept despite its immorality and criminality, and despite the heinous crimes it has caused in our recent history, is still around, due to its simplicity (take away and split) as compared to the complicated idea of personal liberty and private property rights.

We could stop here since we answered what consciousness and information are in terms of sensation-based concepts. Nevertheless, there are a few important yet unresolved questions that we can now address. One of them is the origin of human intelligence, abstract thinking, logic and logical constructions.

Since consciousness is a feeling of the work of the brain, or the nervous system in general, we have to conclude that it is present in all living beings possessing a nervous system. By observing dogs, it is easy to see that they not only feel pain and joy, but they are also no strangers to more refined feelings such as resentment, jealousy, sadness, boredom, and even love (at least for the owner).

What distinguishes a human from an animal? The answer is the apparatus (module) of concepts, or what we call the human mind, intelligence. Below we speculate on how our animal ancestor might have acquired this ability.

The origin of intelligence as a phase transition.

Why is it so difficult for us to learn, to perceive, and especially to create new knowledge? Because it requires the creation of new concepts in the mind. Even mastering the simplest concepts is not easy for a child. It is almost obvious that the creation of each new concept is an extremely energy-consuming operation. In the language of physics, this is a phase transition.

At the biological level, the creation of a new concept requires breaking the existing adjacency matrix of human connectome to insert a new “member” and establish new connections. This must be an
extremely painful operation equivalent to surgery. Even though there are no pain receptors in the brain, it somehow must know about it and resist it with full force. Moreover, the more radical the new concept is, the more painful and energy-consuming is its creation.

This is the reason why many students prefer mindless memorization to conceptual learning, and why many people stop learning altogether at some point in their lives. Of course, there is a big difference between mastering everyday concepts and scientific ones. Despite the huge initial energy consumption, mastering the apparatus of concepts is energetically beneficial over a long period of time, both for an individual and for the species as a whole, since it greatly facilitates the acquisition of knowledge in the future, facilitates the transfer of knowledge and allows predicting and forecasting.

My hypothesis is that intelligence, i.e. module of concepts, has emerged in the chaotic mind of our animal ancestor as a result of a phase transition. The transition is from the chaotic state of memorization and accumulation of facts (accumulative, animal phase) to the ordered state of generation of concepts (models, theories, systematic knowledge), to the ability to systematize, generalize, analyze, and predict (conceptual, human phase). In other words, the concepts created the human.

The accumulative phase can be also thought of as the experience phase, since accumulation of facts and accumulation of experience are the same. The conceptual phase is also an intellectual phase. In other words, the work of human consciousness is a conversion of experience into conceptual knowledge. In physics we would call it phenomenology, or experimental phase, and theory. Each such conversion corresponds to a leap of intellect.

We also note that the accumulation of experience occurs gradually, while intellect, on the contrary, changes abruptly.

This leap occurs at the moment when a new concept, a model, appears in consciousness. And then all the random “facts” fall into place, like spins in the Ising model. The newly created model immediately allows predicting, and depending on the result, it either confirms or disproves the model. This situation is familiar to every researcher, as well as to those students who were lucky enough to receive a systemic education and one by one realize the models in which the learned “facts” fit. If such realization does not occur, then such an “education” is a scam. It is just a mindless accumulation of facts. Such “knowledge” in our time can be replaced by Google and does not contribute to the increase of the intellect.

Similar to an individual transition, the realization of a concept, a model, by a group of people is also a phase transition, though of a collective “mind”. In order for the phase transition of one to become the phase transition of the entire community, it is necessary that the same phase transition occurs in the heads of all members. A collective phase transition requires considerable intellectual work by others, although to a lesser extent than by the “discoverer”. The work of secondary members (colleagues who read the article of the “discoverer”, then students, schoolchildren, if the result has become part of the curriculum) is facilitated by the fact that they know the result in advance. But nevertheless they must do some intellectual work in order to realize this result, to master it in their mind. At the end the
discovery becomes “their own”. Sometimes this leads to (unintentional) scientific theft, when, as a result of such work, a person forgets that he received the idea from someone else, and did not come up with it on his own.

The emergence of intelligence.

Extrapolating into the ancient past, it would be logical to assume that the emergence of the first concept, i.e. the very origin of the human intelligence was the same phase transition like all the others that we regularly make in our own brain (for those who does), or collectively, as a community.

Today, we do not know what served as the biological cause for such a transition, since the science is not there yet. But I would venture to suggest that it was the surplus of biomaterial, i.e. neurons, that did not have enough roles for active participation in the process of external observation, so they turned to creating their own roles of “guessing”, “completing” the details that are missing in the picture observed by their fellow partners, to looking for something that is not there, or even simply lying without malicious intent in order to “justify” their existence. In other words, too many actors for too little roles pushed the actors to create their own roles in the whole spectacle.

Besides the biological conditions for such a transition, there need to be a trigger for it, or, in the language of physics of phase transitions, an external field. The trigger can be any strong emotion or a random event. We can only speculate what exactly the first concept was, and whether it resulted in the emergence of the very apparatus of concepts. Therefore, there are endless opportunities for speculations.

Hypothesis 1. The evolutionary emergence of intelligence – observation and guessing.

As already mentioned, our brain, being a visual organ, is constantly working on generating pictures of what we see. It is easy to understand that the desire to recognize what is seen leads to guessing, coming up with details not actually seen in the real picture. You saw ears flickering in the grass and your imagination instantly draws one of the familiar concepts (tiger? wolf?), especially when it could be a danger. This is how concepts (“threat”, “danger”) and abstract thinking (inventing missing details) appear. The discovery of what you saw (or thought that you saw) has to be immediately reported to your herd in order to warn about the danger. The more details seen, the more reliable is the guess. Incidentally, humans are perhaps the only creatures that can instantly increase their viewing height by standing up from a sitting position and thereby see more details and verify the guess. Hence the need for upright walking may arise.

This would give a jump start to the appearance of the module of concepts, which could take millions of years to develop into a property that became a stable and inheritable part of the nervous system.

Hypothesis 2. The revolutionary emergence of intelligence – fear and weapon.

The previous hypothesis came straight from our newly gained understanding of the role of concepts, and what consciousness is. But we can also employ some facts we know from anthropology. For example, the fact that the first humans made weapons and tools, while animals do not make them. Therefore, it would be logical to assume that either weapons or tools were the first concepts. There are two considerations that could be helpful. The first is that one of our strongest emotions, if not the
strongest, is fear. And the second is that inventing a new concept is not just difficult, it is also scary. Fear sometimes makes us think and look for an escape from a dangerous situation threatening our life or life of a loved one. It also helps to overcome other less significant fears. For example fear for life may help overcome fear of pain.

And what can you think of under the fear, especially in a situation of immediate threat? Weapon!

This is not just about the use of weapon, but about the emergence of the concept of weapon, i.e. the property that can be transferred to other objects. Monkeys, according to various sources, can also use a stick as a weapon, and not just as a tool for knocking down bananas. And not just a stick. It is alleged that monkeys also use stone throwing as a weapon. But unlike ancient human, they do not make a spear from a stick, which they then carry with them almost all the time, to equalize their chances in confrontation with a lion.

For this to happen, something extraordinary had to take place that caused our ancestor to invent weapons and thereby make a phase transition in his brain, thus becoming first human. For example, the fear of imminent death in the paws and teeth of a powerful predator suddenly ended by a well-used stick with a sharp end that miraculously killed the attacker. The tremendous change of emotion from the mortal fear to the joy of salvation is quite capable of making the monkey realize (and remember) that such a stick can save him next time too. Therefore, the stick must be carefully selected, sharpened and always carried, which all together constitute the concept of weapon.

In addition, and which is no less important, this is accompanied by the emergence of the first logical operator (the identity operator), the operator of identifying a new concept, in this case ‘weapons’ as a means of defense (and, of course, attacks):

$$\text{Stick} = \text{weapon} \quad (1)$$

This gives an incentive to look for other useful concepts, by means of identifying various objects as ‘tools’.

Yet another important consequence of (1) is the causal connection between the demise of the attacker and the lucky (correct) use of the weapon. For the human this connection is obvious, but for the animal it is highly non-trivial.

I dare to claim that discovery (1) is more revolutionary and fundamental than Einstein’s $E = mc^2$. Not only because of its immediate practical value but first of all because it made a revolutionary change in the brain of our ancestor, and in fact converted him into a modern thinking human. It became the beginning of creation of the module of concepts, of the apparatus of formal logic, and prompted the next generations to look for connections between seemingly unrelated concepts.

From the point of view of the survival of the species, this is followed by 1) the need to free hands, and thus become bipedal, 2) the ability to move out of the jungle to the plain, where bipedal walking allows one to see further, and where the tail becomes an atavism, 3) the need to think about improving weapons and inventing new ones, thus turning brain into the main weapon.
In this scenario, the fear and invention of weapons turned the monkey into a human, and radically changed its appearance and status in the animal world. It made him a bipedal, large-headed, tailless, armed creature, the strongest in the animal kingdom, and lifted him to the top of the food chain. The intelligence defeated strength and even experience!

Once again, this is just one of many possible hypotheses. I was not there. The only plausible claim to my view is that the emergence of intelligence, i.e. concept module, is the result of a phase transition. From the moment of the first such invention to the beginning of a regular (i.e. purposeful) manufacturing of tools and weapons could have passed hundreds of thousands of years. In addition, this new skill still had to be consistently transferred. In the absence of a full-fledged language and since people lived in relatively small groups, this was not easy.

As we very well know, the module of concepts is inherited by human children. They do not have actual concepts but they do have an immediate ability to acquire them, unlike animals that cannot be taught any concept at all. I therefore tend to think that scenario 1 was prevailing for millions of years, preceding scenario 2 that either occurred or not only long time after that.

There is no doubt that the emergence of the module of concepts created a significant need for language, since each new concept requires notation, tabulation, indexing. With the growing number and complexity of concepts, more and more complex sounds are required to tabulate them. This is how language was born. At the same time, it allows to transfer knowledge, to train offspring, to unite larger groups, and therefore organize collective protection, hunting, and raising children. It frees females, elders, and tool makers. Communities are emerging. For a further history of the Sapiens, one can read Harari [1]. Our goal is different. It is to understand the functionality of consciousness and its various aspects.

A side note on the claim (also supported by Harari [1]) that the reasons for the disproportionately large human brain and bipedalism remain a mystery and are not explained by evolution. As we just have shown, it is perfectly explained by interchanging the cause and effect. Then the rapid growth of the brain and bipedal posture are results of the emergence of human intelligence, and not vice versa.

The emergence of spoken language finally consolidated this transition and allowed a human to become a social creature, customarily called Homo Sapiens while the correct name would be Homo Dolosus (lying, deceiving man).

From this moment on, evolutionary development, which works on the scale of millions of years, can be considered complete. A chain of revolutions has begun. On a historical scale, two million years passed from the emergence of the first logical operator in the pre-human brain that identified a stick as a spear, to the identification of energy as a mass and to the creation of an atomic bomb is an instant. In what follows, humans will be modifying themselves (and the rest of the animal world) [5], unless, of course, we destroy ourselves with our own inventions.

So, I hope we understood how intelligence has emerged. Undoubtedly, some animals behave as if they also have certain intelligence. They have models of behavior developed over millions years. But
it is also obvious that these models appeared not as a result of intelligence, but as a result of accumulated experience and natural selection. The species whose behavioral models do not meet the tasks of the survival in given conditions die out.

Perhaps, in absence of a full-fledged language, cave paintings were one of the first mechanisms by which ancient people communicated concepts to each other and to future generations.

One could challenge me that attributing intelligence to the creature that anthropologists portray as a rather scary ape with a hand axe or spear in its hand may sound quite strange. Nevertheless, the spear is unmistakably a sign of intelligence, however strange it sounds. Besides, a few million years is quite a long time, and it would be useful for us today not to forget who we are, despite our slightly more decent appearance.

Recently, I learned from Sasha Gorsky that a study conducted by him and co-authors [6] indicates that the human brain is constantly in a near-critical state, i.e. near the phase transition. This indirectly confirms the hypothesis that the emergence of a concept (and this is what our consciousness is constantly busy with, or at least is going to do) is a phase transition.

Conclusions:

1. The fundamental building block of human consciousness is a concept. Biologically it is a sensation (combination of sensations) developed and learned by an individual’s nervous system as an image of underlying bio-chemical profile.
2. Information is a product of consciousness and is a concept diagram of a signal, i.e. what we call the interpretation or meaning of the signal.
3. The production of information requires learning and conceptualization.
4. The emergence of a new concept is a phase transition.
5. Emergence of the module of concepts became the birth of the human and information.
6. Language emerged and developed as a result of the emergence of conceptual thinking, as the need to label a huge number of new concepts.
7. Consciousness is both a sensation of the brain’s work and inner vision.
8. Memory is the association of sensations with a certain image, thought, or concept.

Acknowledgements.

I am grateful to late Professor N.N. Meiman with whom I shared an office in 1991-1993 at Tel Aviv University and had numerous conversations about many aspects of the scientific mind, and the peculiarity of scientific ways. His observations came from years of collaboration and friendship with many famous physicists and gave me invaluable insights for this writing. I am grateful to Lev Neyman for discussions during this research and for reading the manuscript and making insightful comments. I am grateful to Professor Vitaly Polunovsky for enlightening me on certain aspects of modern genetics and for discussions of various issues related to this writing. I am extremely grateful to Kevin McKinney for critically reading the manuscript and making many useful comments.
Bibliography:

[1] Yuval Harari, “Homo Sapiens. A Brief History of Humankind”, 2015

[2] Rita Carter, Mapping of mind, 2010

[3] Daniel Dennett, The Illusion of Consciousness, talk 2007, Consciousness Explained, book, 1992, and talks by D. Dennett.

[4] Chalmers, D. J. 1995. Facing up to the problem of Consciousness. Journal of Consciousness Studies 2: 200-19

[5] Yuval Harari, “Homo Deus. A Brief History of Tomorrow”, 2016

[6] K. Anokhin, V. Avetisov, A. Gorsky, S. Nechaev, N. Pospelov, and O. Valba Spectral peculiarity and criticality of the human connectome, Physics of Life Reviews Volume 31, December 2019, Pages 240-256.