Book title: "**More Info on Information: From Information to Artificial Intelligence**"

Author: Tinko Stoyanov

Published as a Kindle e-book on Amazon.com in 2021

"There is nothing permanent except change."

– Heraclitus

Part 1: Information

As noted in the introduction, this book focuses on the role and impact of information in people's daily lives. It has influenced us in our past, guided us into the present, and will strengthen its role in our lives in the future. Information is an important factor for the state of individuals and our entire society inhabiting the space and time (space-time continuum) of our universe. I.e. it is connected with "*life, the universe, and everything*" else, as we will see later in the text of the book.

I am not able to find a more brilliant answer than "*42*" to "*the ultimate question*" set by Douglas Adams in his book *Life, the Universe and Everything* which is a part of his magnificent *The Hitchhiker's Guide to the Galaxy*, but in this and the following chapters, I will just try to present my view on the links between information, life, the universe, and intelligence (as a substantial component of everything).

The content of **Part 1**, collectively referred to as "**Information**", is presented in three thematically divided (and related) chapters focused on some basic topics about information. These topics are:

Chapter 1.1 Information and Universe–the chapter is dedicated to the "physical" nature of information from a "universe-centered" point of view. I hope this doesn't sound too ambitious.

Chapter 1.2 Information and Life–this chapter discusses the role of information in the emergence and evolution of living organisms. In it, dear Reader, you will find some new (I hope) ideas on the topic.

Chapter 1.3 Information and People–This chapter presents our (human-centered) view of information and its impact on our development as individuals and society. Usually, we do not appreciate enough the role of information, both in our hectic daily life and for our (as we hope prosperous) future.

The purpose of presenting information in this way, in three consecutive and related chapters, is to describe its three manifestations–physical, biological (biochemical), and social as indispensable components in human life. From a human-centered point of view, we will try to answer two major questions:

- How has information affected (and is influencing) our evolution?
- How does it affect our actions (reactions) at any given moment in the time?

Naturally, it will be done in connection with the other two components – knowledge and intellect/intelligence. On this basis, we will trace its role in the personal development of each individual and, accordingly, for the evolution of society.

I hope that the information presented in the book will fulfill its task– clarifying what information is and its role for us humans, and not contribute to further confusion on the subject. If this happens, I recommend you, dear Reader, to continue to the next chapters, as the explanations on these issues continue there (from my point of view, of course). If you still decide that you need additional information on the topics presented in this chapter, then there are many additional sources where you can look for more information on them.

As we know, any scientific research is based on certain (pre-selected) approaches, ideas (concepts), methodologies, theories (most of them, actually, still hypotheses), and various scientific tools to prove one or another statement or belief of the author or the researcher. In this chain of "scientific toolsets", the choice of the right research approach is usually decisive for the other components used in it. So let us briefly dwell here on the approach I have chosen in my research.

As I already explained in the introduction to this book, its goal is to point out the interconnections, interdependencies, and interaction of all the components in the chain of information-knowledge-intellect/intelligence. Later in the text of the following chapters, and the book as a whole, this chain is analyzed from a systems thinking point of view. Naturally, here a question arises: Why "systems thinking"?

To explain my choice of the systems-centered approach, it is good to look around us. Everything in nature that we will notice (using our natural sensors or artificial monitoring tools created by us) can be categorized as a "system". The only exceptions are the so-called "elementary particles", which science has so far defined as "indivisible", although often new studies in "depth" show that they are not so "elementary", but consist of other

smaller ones (“more elementary”) particles. Everything else can be defined as “system”, a term which in itself is not sufficiently defined if we do not indicate to which specific natural object it refers. However the general definition of the term “system” defines it as a set of interconnected and interacting components.

Let us look around us now. What will we see (notice)? Let's start with the universe that created us and that we inhabit, albeit for now only one microscopic corner of it, which we call Earth. As we know from the science called cosmology, the universe is a natural system composed of countless material and energy objects of different sizes–galaxies, stars, planets, comets, and many other cosmic objects. Astronomers' observations show that galaxies are systems made up of stars, planets, and so on. The stars, in turn, form star systems together with the planets orbiting them (those that have planets as satellites). Many planets have their natural satellites (other smaller planets) with which they form planetary systems, etc.

Let us now look at our planet, which we often call “Mother Earth”. There is a gas shell (atmosphere) around its solid core, with which it forms an ecosystem. In this ecosystem was born and exists life, including various groups of living beings (including us) forming biosystems. We, humans, are members of a biosystem that has gone further in its development and created a social system. According to the science of medicine, the human body consists of many functional systems–motor, circulatory, nervous, etc. In this book, the most interesting for us will be the so-called central nervous system and rather the results of its “higher” mental functions. If we continue, all the way down, to the lowest level in this system we will reach its separate unit–the nerve cell (neuron). But like any other cell in living organisms, it is also a system of connected and interacting components of

living matter (bio-chemicals). We can continue our “quest” inside a neuron until we reach the truly “elementary” particles from which, as stated earlier, the universe is built. Thus the circle (system) called the Universe closes.

From what has been said so far, it is clear that every object in our surrounding environment, if it is not an elementary particle, can be considered a system of interconnected and interacting components that form it. In this case, the systems approach (and thinking) allows us to see the “big picture”–the overall structure of the system, its components, its relationships, and the processes that take place in it. Going into the depth of this construction (the structure of the system) and using the methods of logical analysis and some theories, tested by practice, any experienced researcher can study in detail how this system is structured and how it works. Of course, the results of the study depend on the purpose of the study, the relevant “point of view” and the depth (scale) of decomposition in the analysis of the structure, its components, and the processes that take place in them and the system as a whole.

My main “assistants” in the study of the topic of information (nature and its role in life and us humans) were such tried and tested theories as Systems Theory, Information Theory (formerly called Communication Theory), Management Theory, a component of the science of Cybernetics, and some other scientific disciplines and theories related to the topics of the present research. All of them are to some extent related to the study of the structure and functioning of systems (natural or designed and created by us humans), so the choice of a systems approach to the study of the chain information–knowledge–intellect/intelligence, for me as a researcher was logical.

It is no coincidence that the information is placed at the beginning of the above-mentioned chain and it is, therefore, appropriate to start with it. This is due to its role as an “engine” (driving force) in this chain.

In everyday life, we often hear the word “information” and many related concepts and expressions. We take them for granted and as a given. But if we think about it and ask ourselves: “What exactly is information?” our answer to this question will not probably be so unambiguous. If we decide to clarify the issue and look for more information about the information in various sources, we will most likely come across many definitions and explanations on the topic. Most probably some of them we cannot very easily understand if we are not well-prepared readers (e.g. having a firm background in "Information theory" presented by various authors). Naturally, all this information about the information can confuse us, instead of clarifying the topic.

With this book, I join those authors who have written on this topic (each, of course, from their point of view) and I believe that a little more information about the information is unlikely to harm anyone, especially those who are interested in it professionally or they just want to expand their knowledge on the subject. I hope this additional information about information will tell you how big the role of information is for us humans. In fact (without exaggeration) it is not only a “change” but also “moves” everything living in nature. An interesting (and bold) statement, isn't it? We will clarify it further in the text of this book.

Chapter 1.1: Information and Universe

This topic is as “big” as the universe itself. Nevertheless, let us try to “embrace” it because of its role in “Life, the Universe and Everything”. Dear Reader, I hope you remember the “ultimate question” asked by Douglas Adams in The Hitchhiker’s Guide to the Galaxy. By the way, this question still awaits its answer.

Modern physics states that if we have complete information about a system (e.g. the universe), we can predict its future (development) and there is no information loss in the process. Trying to resolve the black hole information paradox, physicists tell us also that information in the universe is neither created nor destroyed–information throughout the universe simply persists. So, maybe the information is the “fifth” element in our universe (according to ancient and medieval science there is such called “ether”) and if we have complete information about the universe we will know “everything” about it. But this task is impossible to complete as we will need at least a second universe to be used as media for recording all the information collected from “our” universe. Even probably a bigger one as we have to record the moves made by all the particles building the universe in an approximately 13.8 billion years-long period. We may also need even bigger “multiverse” media to record such “big information” (some usually spell it “big data”).

So, that is why let us focus on more practical topics. In this chapter, dear Reader, I will present you with another view on information and its role in the universe. It is mine and I leave the decision to you to accept it or not.

The Universe

The universe is the place and source of everything we (humans) perceive and experience. But when we start thinking about it, the first thing that comes to mind is that there are a lot of theories about its origin, composition, size, and sure the end of it.

After several thousand years of observations and research, scientists have created an impressive “big” picture of this stuff–the origin, “history” (evolution), and nature of “our” universe. However, we still don't know “everything” about it. Many open questions remain in the fields of physics, cosmology, and life science, as it is the most important “thing” to us–the only truly intelligent “creatures”, we know to exist in the universe so far.
And today, fortunately (or unfortunately), there are so many theories about the origin and future of the universe that prove one thing only–we still do not know much about the beginning and the end of it. But for the goal of this book, let us stick to the commonly accepted theories (or beliefs) of the universe’s past and future.

According to modern cosmology (the science that studies cosmological models related to the origin and evolution of the universe), our universe is built on four basic components: space, time (today both “blended” into a single entity called space-time), matter, and energy. In Albert Einstein's special and general theories of relativity, the interrelations of these components are best presented in his famous equation of mass-energy equivalence $E = m.c^2$ (dear Reader, please don't worry–this is the only equation I use in this book). In plain words, it means “energy equals mass multiplied by the speed of light squared”. It shows that energy (E) and mass (m) are interchangeable and they are different forms of the same entity–

matter. The speed of light in a vacuum (space not containing matter), commonly denoted (c), is a universal physical constant and in this equation interrelates space and time as it is measured in meters per second. It equals 299 792 458 m/s (meters per second) according to the International System of Units. But in my view, there is another "ultimate" question about the speed of light in a vacuum. How the scientist managed to measure it this much "precisely", as there is no such a "pure" vacuum anywhere in space? There are always present electromagnetic force fields, cosmic rays, atoms, molecules, and elementary particles even in the intergalactic space otherwise we will not be able to "see" the stars, galaxies, and other cosmic objects and events. But this question is not a subject of this book and it is better to pretend it doesn't exist (for now).

In cosmology, the "Big Bang" theory still offers the most comprehensive explanation for a broad range of observed phenomena in the universe. But today, many new theories are challenging it. So, the understanding of the origin, evolution, and fate (the end) of the universe is still the most important question we should answer.

Further, in the text of this book, I will "stick" to the Big Bang theory as the most commonly accepted cosmological model of the observable universe, despite I also have some doubts about it. But as this book is not devoted to cosmology, I will not discuss these topics here. I will do this in my next book.

Sure, there are more theories on what the basis of the universe is. A "more modern" variant of cosmology is quantum cosmology (applying the quantum theory to the universe) and it "spawns" many new theories about the basics of the universe. One of those theories–a more radical one, suggests that information is the most basic element of the universe. The

prominent physicist John Archibald Wheeler, who coined the terms “black hole” and “wormhole”, stated that everything in the universe is particles, fields, and information. Recently, a group of physicists stated, according to their research, that the universe (including us–the humans) is a projection caught inside a giant hologram. Now a hotly discussed topic among cosmologists is that the universe may be a “computer simulation”. Seriously! And where is that “computer” located if “our” universe is just a “simulation”? Probably, it is in another “parallel” universe. And that computer might be like the “Deep Thought” computer (remember *The Hitchhiker’s Guide to the Galaxy* by Douglas Adams) or someone even “bigger” than it. But that “bigger” computer was the Earth demolished by the Vogons. And the Earth is a “mostly harmless” (according to the “Guide”) planet in “our” universe. So, it seems logic has no place in this “advanced” computer simulation idea.

Remarkable, what kind of “wild” ideas scientists’ brains can give birth to! But this is a topic for another discussion/book.

Despite, I like always to read about new ideas in science and technology, I am very skeptical about such “hard-to-prove” statements. Based on the logic and reality (the “ultimate measure” of all ideas and theories), I cannot accept that a hologram (let’s say my hologram) falling onto a “holographic” ground will fill the pain exactly as I will if I fall onto a real (not a holographic) ground. By definition, a hologram is a photographic recording of a light field. So, here are two simple questions: Where all those (real) things/objects are located and “arranged” to be photographed and recorded? And where and who is the photographer? I am waiting for the answer (if possible), please.

A new theory, presented recently by its authors, proposes a new fundamental idea that energy always “flows” through all regions of space and time. It says that fragments of energy (not waves or particles) may be the fundamental building blocks of the universe. If this theory is the “right” one (it should still be proved), then my idea/view that information is any “change” in the universe's energy field (please, refer to it below) is also correct. This means that the information always co-exists with the basic fabric of the universe – the energy. So, information is also everywhere around us. The “art” is to perceive and interpret it correctly.

By the way, new theories about the origin of “our” universe are “popping” all the time in the scientific “space-time”. Now, the “Big Bounce” theory is fighting for the leadership position of the “champion” of the cosmologists–the Big Bang theory. Other contestants, such as the Multiverse theory and the like, are also fighting for the “gold medal”. So, we may expect that soon life may be declared not to exist at all, just a kind of a “virtual” thing hanging on the wall of a black hole. (So that, cheers!)
Sometimes, the new ideas are really “wild” and thus hard to be understood and accepted. Nonetheless, I will be happy if those are proven by their authors (or other researchers) “true” and working.

As we said above in the text, according to cosmology, the universe contains energy, matter, forces, force fields, particle fluxes called cosmic radiation, and various other (so-called by scientists) “dark and black” things. Those are very popular among cosmologists. But in reality, so far no one of them knows exactly what they represent and whether they exist in the universe at all or simply fills the gaps in the knowledge of researchers on this stuff. And there are probably many other “things” and perhaps other universes that we have yet to discover if they exist (or don't exist). And all

this is “placed” in space and time, which, according to scientists, is a whole “thing”–space-time (that no one still knows what it is exactly). But these are also questions for another book.

In this “basic” construction of our universe (space-time and energy-matter), however, nothing is mentioned about information. Is there one in nature, and if so, what is its essence, and perhaps more importantly, what is its role/place in the universe? We humans often (sometimes too often) mention the word “information” in our daily lives. So, this means there is such a “thing”. Then what is it? Moreover, we say that we live in the “Information Age”. Every day we read, watch, and listen to programs of “information” agencies. We use information technology products and services everywhere, without which we can no longer imagine our daily lives and professional activities.

Objects, Systems, and Processes

Today, the Big Bang theory is the prevailing cosmological description of the origin and evolution of our universe. As already said, according to it, the universe is built by matter-energy (two states of the same “stuff”) “floating” freely in space-time (space and time “fused” together) which is expanding endlessly (probably). And the expansion is accelerating (because of the “dark” energy in the universe, despite nobody knowing what it is).

If we look “deep” into the matter-energy by using “tools” like the Large Hadron Collider (as the physicists do), we will see at the far end (into the matter) something the physicists call “elementary particles”. “Elementary” because, so far, the physicists cannot go deeper inside those particles and thus assume them as whole and indivisible. These elementary particles build more complex particles, such as atoms, molecules, and all the

nonliving and living matter, including us–actually “everything” around us in the universe.

If we look “deep” into space-time, what exactly the astronomers (cosmologists) do by using tools like various kinds of telescopes, we can reach as far as approximately 13.8 billion years (in depth in time) to the far end of the universe (according to the Big Bang theory). Currently, the “size” of the universe is estimated to be 93 billion light-years in diameter.

So, we can consider the universe as a “system” built by an innumerable quantity of elementary particles. All those elementary particles build endless cosmological “subsystems” placed in the universe–galaxies, nebulae, stars, planets, satellites (moons), asteroids, comets, etc. formations we call cosmic “objects” regardless of their actual size.

So, for the goal of this book, we will assume as “objects” any indivisible parts/components that form larger divisible constructions we will call “systems”. Here both terms (object and system) are “conditional” and depend on the position of the “observer” and the scope of the observation. In our everyday language, we usually call both “things”, a term that can mean everything if not specified.

If we look at our solar “system”, we can assume our planet Earth is an indivisible part–an “object” of it. The Earth and all the other planets orbiting around our star – the Sun, moons orbiting around the planets, asteroids, comets, and other cosmic objects build our solar system. But if we look at the Earth, it is a complex “system” itself encompassing numerous “subsystems”, such as to–ecosystem (sustaining life), the human social system, etc.

Here we must mention also that each of us stays at the very center of his/her “own” universe. Let’s look around us now. What do we see? In general, we’ll see an innumerable quantity of things. And of course, we do not see even more because they are very small or very far from us. But let's try to classify those we see. If we try to simplify this classification as much as possible, it will be reduced to two groups–material "things" in the visible space around us and changes that take place in/with them, if we have enough time to observe them. Let us call material “things” by the general term “objects”, and the changes taking place in those–“processes”. This will make it easier to classify the things we observe around us.

Objects are made of matter (living or nonliving) and each of them occupies a certain volume in space. Each of them has its characteristics (parameters) and properties (qualities). Observing them we will find that they change over time as a result of ongoing processes in them or with them. The observation time must be commensurate with the speed of the ongoing processes. In both extreme cases–in very fast or slow processes compared to our own “time scale”, it is most likely that we will not be able to notice (catch) the changes that occur in them. It is most likely, in this case, to accept them as static, i.e. immutable over time. But this is a delusion for our senses, which are simply unable to detect changes that are incommensurable with the speed of our internal biological processes. Let us recall the famous phrase of the ancient Greek philosopher Heraclitus (epigraph to this chapter)–“Everything flows, everything changes.” Change is everywhere and in everything. I.e. in nature (the universe), all objects are dynamic (they change over time). To observe these very small objects (for example, the so-called “elementary” particles) and for those that are huge compared to us (planets, stars, galaxies, etc.), but are also huge distances from us (“light”

years), humanity has invented and built special monitoring tools (particle accelerators, microscopes, telescopes, etc.), through which it manages to observe and monitor (and record) the processes taking place in them.

Now we come to the “ultimate” question in this chapter.

What is Information?

Let us now try to answer this “ultimate” question which is building the foundations (and the title) of this book.

Please, dear Reader, don't get me wrong, that there isn't enough information about information, including many definitions of its nature. Today, there are probably as many definitions of information as the number of authors who have written on the subject, not to mention those who have just copied what has already been written by others. We also know that there is even an “Information theory” beginning with Claude Shannon's famous 1948 publication “A Mathematical Theory of Communication” (now he is known as “the father of information theory”). There are countless scientific (and not-so-scientific) articles, books, and other publications on many issues related to information. They all reflect the specific views of their authors on this complex topic.

But in addition to what has already been written and said on the subject, there are always many additional questions, in my opinion not well clarified (and answered), which are related to the nature and role of information in the universe and especially for us humans. Here are some of the many:

What is the nature of the information? Is there a connection between matter-energy (aren't they, according to modern science, a whole like space-time) and information? If so, what is it?

And then, some more questions (and answers) to the questions above begin to come into the mind by itself: Isn't the reaction to information the “boundary” between living and non-living matter? Doesn’t it play a decisive role in the origin and evolution of the living matter? If a piece of nonliving matter starts reacting “purposefully” to the incoming information from the surrounding environment, doesn’t this mean it is “alive” already?
In my opinion, the answer is “yes”, no matter how “heretical” this idea may sound to supporters of the Genesis creation narrative, and very likely to some scientists seeking the answer to the question about the origins of life (abiogenesis).

In the next chapter titled “Information and Life” I will try to justify this idea, but if this has already been done by someone before me, then (as I already mentioned in the Introduction) with me their number becomes +1.

Here I want to clarify the question that may arise in some of the readers, why and how I had to create my definition of information that reflects my view of it. I emphasize “my view” because years ago, when this topic began to interest me more deeply, I searched for more information about it and came across many existing already definitions of what information is. Some of those were more or less acceptable, others superficial, and still others inadequate (sorry for the expression). As an engineer by education, I worked for some research and design (R&D) organizations, where following the “standards” was mandatory. I found it difficult to choose which of the many definitions I read about information was the “standard” one (i.e. generally accepted) to accept and use further in

my research. There were so many definitions, and none of them satisfied me completely. Then accidentally, a “deliverance” came from this difficult situation. As I already mentioned above in the text, a researcher from the University of Caracas, Venezuela, “discovered” 90+ different definitions of the term “definition”. So, I was greatly relieved to realize that I did not have to follow anyone's definition of “information”, and that I could create my “own” one that meets my research goals. So below is my definition of information, and I want to point out right away that anyone who doesn't like it can ignore it.

Here is my definition, which I accept as “working” for the goals of this book:

Information is any change in the state of the objects or energy of the environment that can be perceived by a living organism. In short, any change generates information.

Here, of course, I exclude “imaginary” changes in our mind, such as our opinions, etc. “products” of our mental activities until they make any changes in the “real” world.

Several important conclusions follow from this definition:

- Information (the change) is strongly related to all four components that build the universe–matter, energy, space, and time (space-time).

- Energy reflects all the changes in material objects and energy fields and transmits (communicates) the information in time and space.

- Information is generated everywhere in the universe where there is energy (no matter “bright” or “dark”) because it reflects the changes that take place in the energy field (in space-time).

- The information must be accepted and registered (on any medium) to confirm its existence. If there is no “eyewitness” and no registration, the fact of its existence cannot be confirmed. (In such a case, we come to the ancient unsolvable paradox about the falling tree in the forest whether it made a noise if we do not have a witness to the event and hence a corresponding record proving it.)

- Information has meaning (and significance) only for living organisms because only they have a “sense” of time (can “feel” the change in their time scale). After all, information is the change registered in time. i.e. it is the result of an ongoing or past process of change over time.

- Information can also be perceived and registered through artificially created means (so far used only by living beings) to serve their purposes.

- Information, regardless of its existence in the universe, has no “meaning” (does not play any role) for the nonliving matter.

Here are a few more (necessary) explanations for this definition: Everything that exists in the universe–matter, energy, and force fields, through the changes taking place in them, is related to the information that these changes generate in time and space (where all those objects and energy exist). Here I mean real (physical) objects, not imaginary ones (let’s say generated by our human imagination).

Thus, this definition clarifies the relationship between matter-energy and space-time with the information that is missing as a component in Einstein's equation ($E = m.c^2$), which gives the relationship between these four basic components of the universe. This definition will further serve the purposes of this book to explain the key role of information in the evolution

of living matter and one of the main results (products) of this process–intellect and intelligence.

To the reader, this definition and the related explanations may seem a bit long and complicated, but when we try to define complex objects or processes, their definitions are usually long, complex, and sometimes more difficult to understand (the latter depends on our background on the topic). And one more explanation for the readers–later in the text we will talk about information from the point of view of "classical" information theory, not from the "quantum" information theory (which in my view, still should be proved). Let's focus on conventional concepts and principles well "working" today. Despite, such sciences as today's neuroscience and quantum physics trying hard to "build bridges", all the promising ideas and concepts are still in their "cradle" phase. So, probably, it is better to postpone any implications of quantum information to the development of intelligence when any proven theories mature.

So, here's a little more information about my understanding of information:

- Information is generated everywhere in the universe where processes (changes in the state of objects) take place over time.

- If there is no change, then is no information generated. Here, however, we must make one clarification–it all depends on the time scale of the observer of the change. Very fast or very slow processes compared to their time scale can go unnoticed (undetected) and, accordingly, the information they have generated.

Information exists everywhere in the universe where there is time and change (ongoing processes over time). With this statement, I answer the

question of what happens to information when matter and energy in the universe are sucked in so-called “black holes”. If time stops “flowing” in the black hole (this statement of cosmologists is subject to proof, but so far I do not see how this can be proved experimentally, and not just with “curly” equations “generated” by us humans), then the information ceases to exist in these “indeterminate” objects, which for our convenience we call “black holes”. If there is no change (in time), there is no information.

Although information is everywhere in the universe, it does not play any role in the existence of nonliving matter, which obeys natural forces and “laws” only. According to the above-cited equation of Albert Einstein and some of the latest theories of modern physics and considering the universe as a system of interconnected and interacting objects and processes in it, matter is related to energy, and under certain conditions both pass from one form to another one, thus generating information.

In turn, the information about everything that happens in the universe, (generated by the processes that take place with and within the objects in it), has meaning and is “vital” only for living matter in its struggle for survival through adaptation to the environment and reproduction. This “meaning” is related to its ability to “sense” time (a major component in any change) More information on the role of information on the origin and evolution of living matter in the diversity of organisms (at least on Earth) is available in the next section of this chapter.

In my approach to the main topic of this book on the relationship between “information–knowledge–intellect/intelligence", I combine two of the main components in any physical system–information and energy. Dear Reader, please recall my definition of the information above, in which energy and information are related.

As an example, we can look at the electromagnetic spectrum and "focus" on that part of it that we call "visible light", because according to modern theories, it is the carrier of most of the information that we humans perceive (and we are not the only). And we will "see" that light (as a modulated electromagnetic radiation/energy) is the carrier and the information at the same time. In the same way, light has another "dual" property–the photon is a wave and particle. Very "strange", isn't it?

My definition of the information above provides answers to the following few basic questions related to it. Here are these questions and their answers:

- What is the information? Object or process?

From the above definition, it follows that information is a phenomenon related to the change in the state of the observed objects or processes. Here we will not go into philosophizing about whether there has been a change, i.e. information if we have not observed them.

Abstracting from the specific physical or chemical nature of the objects and processes we observe, when we start talking about any change (i.e. shape, position, movement, dynamics, composition, etc.), we have "involved" here a universal component quantity of measurements–time. This is the time of observation and the time during which the change in the observed object or process is detected. If such a change has occurred and been detected, it means that we have generated information. The object and/or the process of change in it have become a generator of information–i.e. something that "produces" information. If there is no change, i.e. the object and/or the process are static, so we will not have any information generated. From here, however, follows an important conclusion–the

observation time must be compatible with the dynamics of change, i.e. to be measured with the same time "scale". There are very fast or very slow processes that are not compatible with the "human" time scale of sensory perceptions. In such cases, we have to use artificially created devices/means for monitoring and measuring, which have compatible time scales and dynamic characteristics with the observed objects or processes.

- What is the nature of the information? Is it tangible or intangible (imaginary)?

I ask this question because lately, many publications are questioning reality (the physical world around us) stating that it is just produced by our imagination. Another very strange statement isn't it? We should ask somebody, who is near those authors, to hit them with a baseball bat. I think they immediately will change their mind about reality and imagination.

We humans can only observe material objects or processes related to them. Even if they are "pure" energy (i.e. energy processes), as we know from modern physics, energy and matter are connected. Therefore, the "real" information for us is "natural", i.e. material in nature, but it is also an "intangible asset", as the accountants like to call such "objects". Therefore, it must be recorded (fixed) on some kind of "material" medium with two main purposes:

- First, to prove, if necessary, that such information has been generated and that it exists (its natural aspect) and

- Secondly, so that it can be used at any time when it is needed (its application aspect).

Here, of course, there is a question of the appropriate choice of media, recording, and reading (visualizing) devices, but it is not the subject of

this book. The reader can find information about existing technologies for writing and reading the information (in analog or digital form) in numerous publications devoted to this topic.

However, in the case of “pure” mental processes, such as those of us humans, we can also generate mental/imaginary information in “immaterial” form - thoughts. Here it is as if we are one step ahead of Mother Nature. But is that so? First, this information is generated by processes taking place in the human brain, which cannot but be a material object (and it is/should be alive). And secondly, to have some effect, i.e. for its existence to be noticed, this information, “internal” for the individual who created/generated it, must be “visualized” (demonstrated) in some way–visually with movements (gestures) or verbally (with words). I.e. here again we rely on Mother Nature since we are her “material” creations. In some cases, the “imaginary” information can be used for “internal use” only by the individual generator of such kind of information. In such a case no external expression (demonstration) is needed. But in the case of a communication process, e.g. for its transmission to other individuals receiving that piece of information, it should be demonstrated somehow. In both cases, we are talking about specific types of mental activity. The first one is not a subject of this publication.

If we can go “back in time” (what we still cannot do today), we will discover that the idea of “change” as the only “constant” thing in life, was born millennia ago. According to Heraclitus credited with the phrase “Everything flows” and referenced by Plato as “All entities move and nothing remains still” (both of them philosophers of ancient Greece), we will witness that everything in life is changing (sometimes “in the blink of an eye”). Unfortunately, some very important things in our everyday life change too

slowly. Among those are the ways we humans build knowledge that we use in our everyday lives and transfer it to the new generations. We will focus our attention on this topic in the next chapter.

Changes in and with objects (and processes) occur as a result of the four “invisible” fundamental forces of physics (gravitational, electromagnetic, and strong and weak interactions) and also mechanical and chemical interactions whose effects we can observe directly in everyday life. All four components of the universe (matter, energy, space, and time) are “involved” in the construction of objects and the changes (processes) that take place in and with them. Today, physicists are persistently talking about the possible presence of a “fifth” natural force, which, if confirmed, will radically change our current understanding of the structure of matter (and energy) in the universe. Future research in this direction will show whether this statement is true.

As observers, we are constantly “immersed” in space, “traveling” with time (so far only from the present to the future), and are subject to the influence of objects and energy permeating the universe. Thus, in addition to being observers of these objects and processes, we are both objects and participants in the processes. And we respond, adapt, and evolve thanks to the information those cosmic processes generate and are perceived by us.

Information in the Universe

Dear Reader, here you may also ask: But what about the black hole information paradox?

Since the topic of information is one of the main ones in this book, here are some ideas on the subject. Lately, he has often been debated in

many publications devoted to this topic, reflecting the different opinions of researchers. According to the views of some cosmologists, who are working to solve the black hole information paradox, information in the universe is neither created nor destroyed. It simply persists throughout the universe and this means also in space-time.

But since, in my opinion, no one knows for sure exactly what happens to matter, energy, space, and time in the “black hole” after going through the so-called “event horizon”, everything written on the subject is only assumptions of the authors (sometimes “solidly” presented with mathematics incomprehensible to non-specialist readers). There are different views, but the “theories” that “explain” what will happen in black holes are still just mathematical descriptions of models without practical evidence (for obvious reasons). If in those the state of the four components that make up the universe (matter, energy, space, and time) is “indefinite”, a state we call “gravitational singularity”, then the state of the information that describes them must be indefinite. There simply cannot be a “description” of something indefinite. This follows from the definition of information given above in the text of this section, which reflects the change in the state of material objects and energy fields over time (and of course in space). If there is no time (for example, it does not “flow” in the black hole), then information is not generated in it and its existence is also uncertain. As a “pure” physical phenomenon, it is also “frozen” (at the particular moment when it has crossed the “event horizon”) synchronously with the “stopped” time. Whether or not there is a question that needs to be proven. Probably, the first “eyewitness” could tell us if he/she was lucky enough to go through a black hole. By the way, there are also “theories” that “allow” this possibility. As you can see, the universe and cosmology are “fertile ground”

on which many theories (like weeds) “flourish”. Recently, many new theories have been published that the “black hole–information” paradox has been solved. I want to reiterate that these statements only reflect the opinions of their authors. Dear Reader, the decision of which statements to accept as acceptable is yours alone.

The difference between my view and that of physicists is based on the difference in our definitions of information. Their definition serves their view of information in the universe, which seems to me “a little” strange, especially as we “look” at the world through the epigraph to this chapter–"There is nothing permanent except change" by Heraclitus. Yes, any “fluctuation” in the universe is an instance of change and this means generated information. Let those who disagree try to challenge it.

But let's end with the question of the physical nature of information in the universe and move on to a more specific topic–information and life (in the Universe), which is the subject of the next chapter.

Chapter 1.2: Information and Life

In this chapter, we will consider the role of information about the origin of life and its evolution leading to the emergence of intellect (and intelligence). Many of the topics that will be covered are still being debated by scholars, who to this day have not reached a consensus on the majority of them. Therefore, dear Reader, the author has allowed himself to express here some of his “unusual” views on these issues. As always, the decision to accept them or not is yours personally.

Life

When it comes to life, three topics are the most important – its origin, attributes, and evolution.

The origin of life on Earth is still “misty” to us because it started more than 3.5 billion years ago in the “mist of time” without any “eyewitnesses” to tell us how it started exactly. Those distant days in the time of the yearly Earth formation haven’t left any pieces of evidence about the outcomes of all those “natural” bio-laboratory experiments leading to the birth of life on our planet. This lack of trusted evidence (e.g. enough fossil markers) doesn’t let the scientists, who study this process, re-create the “big picture” of how life started, when, and where. Therefore they still produce their research outcomes by “indirect” inferences steaming from a huge variety of ideas, concepts, hypotheses, and theories. And all of those need to be proved. The result is we still don’t know much about the abiogenesis on Earth and if there is life also anywhere in the universe.

Even today, scientists' efforts to solve this great mystery still do not provide an unambiguous answer to this perhaps unique phenomenon in our

universe. More recent research has suggested that life probably existed on Earth at least 4.1 billion years ago, which means “very soon” after the Earth formed about 4.5 billion years ago. Science makes clear that life arose as a result of the evolution of matter under the influence of energy in time and space, but this general concept does not give us an answer as to how this specifically happened. Perhaps it is no less important for us to know why i.e. “The meaning of life” (not only in the meaning presented by the British comedian troupe Monty Python). As both of the above questions do not yet have unambiguous answers, it is better to leave them to the researchers for the time being until they reach a single solution (common answers). But below in the text, I try to give advice (hint) on a possible direction of their search. Of course, if they accept it.

To define a material structure (system) as “alive”, we must first examine its functions, i.e. to determine its characteristics/attributes. Unfortunately, as in many other fields of science, there is much disagreement on this issue. Some publications indicate that there are over 100 definitions of the term “life”. As you can see–nothing new under the Sun! If the reader remembers, I started with the fact that more than 95 definitions of the term “definition” have been found. That is why here I will try to give my views on this issue. Maybe these will sound too “unorthodox” according to many professional scholars but in research, the final results very often depend on the point of view. By the way, this is known as the “observer effect” in physics (especially in quantum mechanics).

Since there is no unequivocal definition of life (on a cosmic scale), the most current definitions of it are descriptive. So, life is usually defined (described) by its attributes. Life science (biology) teaches us that life is a (living) matter that shows certain attributes, such as:

- Organization–every living organism should be structurally composed of one or more cells (the basic units of life).

- Growth–any growing organism increases in size (in all of its parts), rather than simply accumulates (suitable) matter from the external environment.

- Homeostasis–every living organism regulates its internal environment to maintain a constant (living) state.

- Metabolism–every living organism transforms energy by converting chemicals and energy into cellular components and decomposes organic matter. All living organisms require energy to maintain internal organization (homeostasis) and to produce other phenomena associated with life.

- Adaptation is the ability of every living organism to change over time in response to changes in the environment. This ability is fundamental to the process we call “evolution” of life and is determined by the organism’s heredity (genes), diet, and external factors (habitat).

- Responsiveness is the ability of every living organism to respond to stimuli. A response can take many forms and have various aims.

From the descriptions above, we can see that the last three attributes are directly related to information, and the first three are indirectly related to it. For reasons inexplicable to me, in most publications available to me on the topic of “life attributes” (I immediately want to note that I probably haven't read enough of those), of all the above attributes of living matter, usually the first five are described in quite a detail, while the latter (responsiveness), is almost always mentioned vaguely without giving much explanation about its nature and role. Since, in my opinion, it is directly related to the information, I want to address it in more detail here.

Scientists studying the origin and evolution of life so far focus mainly on the biochemical processes that build and maintain it, such as metabolism, growth, homeostasis, etc. This is, probably, because biochemists and microbiologists are mainly involved in these kinds of studies. It is normal for them to study the processes from their point of view–biochemistry. And the influence of the environment and the reaction to its changes, i.e. response to stimuli (changes generating information) and adaptation, for now, they remain somehow on the "second line", even though the targeted response to information coming from the environment is one of the main characteristics of living matter. If there is no reaction, then it is not alive. For example, in seeds that are made of biochemical matter, there are no processes of metabolism, growth, homeostasis, etc.–i.e. they are not "alive" in terms of the "vital" processes that take place in them. But with a favorable change in environmental conditions, such as temperature and humidity around them, all these processes are "awakened" and metabolism begins with the accompanying growth of a living organism. I.e. the sense of change ("reading" the information about the change) awakens life in them.

Here we can give another example with the freshly deceased organisms. They are still made of the same organic matter, which, however, is no longer alive, as they no longer respond to any stimuli from the external environment. I.e. the purposeful response to stimuli from the external environment unambiguously defines them as "alive". Naturally, dead organisms do not have the other accompanying life processes, but we define them as alive when they unambiguously respond to external stimuli. In the simplest organisms, such as unicellular organisms, this reaction can be limited to "eat this" or "do not eat that". For the more complex ones, it can

become more complicated. It is “extended” to “go to eat this” or “run from this, (so you will not be eaten)”, etc. orders leading to (possible) survival.

Responsiveness is the ability of living matter to target responses to environmental stimuli. These are the living organism’s reactions to incoming (perceived) information. These are the responses of every living organism to changes in the surrounding energy, gravitational fields, and related forces.

In my view (no matter how unusual it may sound), life started at the moment when a “bit” of organic matter (e.g. a proto-cell) started to respond purposefully to the information perceived from the environment. Here, the key term is “purposefully.” Before that moment, all its interactions with the environment have been simply chemical (more precisely biochemical) reactions. The phenomenon of “selectivity” has been lacking, such as: "eat this, don't eat that"; “Go for, run from” and other similar life-saving “orders” requiring correct reactions to them.

It seems that the researchers have to “switch” their focus on discovering which cell component in the early prokaryotes (the first forms of life on Earth) may have triggered such an initial reaction (response). Probably, this way, they will find the right answer to the “ultimate” question about life (on Earth). In the search for the answer to the question: “What exactly is the moment when inanimate matter becomes alive?”, such an idea is likely to change direction in previous research, which focuses mainly on the synthesis of biochemical molecules (e.g. proteins) in the existing conditions of the planet. Earth in the period about 4.3 to 3.7 billion years ago, when, according to modern science, life most likely originated on our planet. This is “extremely” soon (and at extreme environmental conditions) after its formation as a planet (about 4.5 billion years ago) and the appearance of the first oceans on its surface. During that period, changes

were a “constant” thing on our planet. That means there was a constant flow of information/stimuli (changes in the energy fields) that might trigger life.

Perhaps the question above may be rephrased as follows: “Which chemical compound or component in the structure of inanimate (nonliving) matter that made up the “first” cell, has begun to “feel” and respond purposefully to changes in the environment?” These changes were related to the chemical composition and the energy balance in the living environment and “carried” information about their change. Once this information has begun to be perceived by the bio-matter and to provoke a purposeful reaction, such as “go eat” or “run” thus not to be eaten, we can assume that this is the moment of life–inanimate bio-matter has become alive with the acquisition of a response to external stimuli.

However, since I am neither a biologist nor a biochemist, I cannot point out more specific directions/areas of possible research. I leave the decision to the relevant experts if they are interested and undertake research to answer this question.

The “real” life started after purposeful reactions appeared to incoming stimuli (sensations), such as “eat this, not that”, “run after/from”, “hot, nice, cold, too hot/cold”, etc.

Therefore, in my understanding, the moment of the emergence of life in organic matter (the inanimate one) must be sought at the moment of the emergence of “sensing” the changes in the environment.

Most likely, this is how life originated–with the acquisition of the quality “sense of change”, i.e. perception of information. Therefore, when studying the processes and conditions of the origin of life on Earth (we call it abiogenesis), in my opinion, attention should be paid not only to biochemical

processes but also to the accompanying or more precisely initiating information processes generating “bio-information”. Obviously “something”, any (still unspecified) substance in proto bio-matter, and components in the first prokaryote cell (organism) have begun to respond to stimuli thus “igniting” life (all life processes). Probably bioinformatics should “join” biochemistry in this quest to discover the origins of life. But without this “kick-off” moment the biomatter is still not alive. It just reacts to/with other chemical substances.

In my view, information has played a crucial role in the emergence of life. Dear Reader, please refer to my definition of information, in the previous section in this chapter.

So, probably the major characteristic of life is its response to stimuli (i.e. perceived information). Usually, in publications on the first unicellular organisms, the explanation of this characteristic is mentioned vaguely or even omitted. Due to this fact, it is not clear exactly which component of the cell structure of the first unicellular organisms is “responsible” for the perception of stimuli and the production of the corresponding reaction (perceiving and response) – their shell, nucleus, or any of the other components of the cell? As suggested above in the text, perhaps this should become one of the main directions in the study of the “exact” moment of the origin of life (the beginning of life).

Or, to put it more “poetically”, energy and matter create the “magic mixture” from which biomaterial is born, and information (change) is the one that “breathes” life into it. Over time, it also leads to the emergence of intellect in living matter, and it helps it to be a winner in the eternal struggle for survival via adaptation.

If the modern researchers of the origin of life direct their efforts in this direction, using the tools provided today by biology and bioinformatics, they may be more successful in answering this still one of our “ultimate” questions about the origins of life on Earth.

Life and Information

For living organisms, information has two sources of origin (generation)–external and internal. The external source is the environment that this organism inhabits (its habitat), and the internal one is its own “body”, which generates signals for its condition. In the case of unicellular organisms, the term “body” is replaced by “cell”, which is also a constituent unit of all multicellular organisms.

Both types of information (external and internal) initiate all life processes that are related to the existence and survival of living organisms. I.e. the organism acts like a “system”–the small amount of energy at its entrance puts the whole system in “motion” (functioning).

For this book, we will focus on the external source of information – space and the environment and the forms of information that they generate and that living organisms can perceive through their senses.

The internal source of information (changes that generate signals in the cells/bodies of living organisms) often plays the role of a generator of feedback signals. This is a term from the “Control theory” that defines a connection that “closes” the output with the input of the system and “stabilizes” its functioning. In this particular case, it is our body that, as it has been said earlier, functions as a closed biological system. As a consequence,

the brain generates correcting signals in response to signals (information) coming from the external environment.

Externally generated information can be divided into two subtypes, according to its origin:

- Generated from distant sources (remotely generated), such as the effects of cosmic radiation and force fields on living organisms.

- Generated as a result of direct impact (closely generated), for example, contact in physical/mechanical processes and chemical reactions caused by objects and changes in the state and ongoing processes in the immediate habitat of living organisms.

The influence of the two subtypes of externally generated information on living organisms is different, as a result of which they have developed (created) specialized sensory systems for their perception and “control” (nervous) systems for the development of the respective reaction.

The remotely generated information, mainly due to streams of high-energy charged particles and changes in force fields generated by near and remote space objects, affects the energy balance and mutation of living organisms. For the life of our planet, of course, the strongest is the influence of our nearest star–our "father" the Sun, and our planet–the “mother” Earth as cosmic objects. The influence of our nearby planets and other space objects in our solar system (our “big sister”–the Moon, asteroids, comets, meteors, space dust, etc.) is also strong. According to the latest scientific research, they may have played a decisive role in the origin and evolution of life on Earth.

Of course, we must not neglect the influence of more distant space objects in our galaxy, as well as from other galaxies in the universe.

According to space science, powerful streams of high-energy particles emitted by them in cosmic collisions can have a decisive impact on the development or even the existence of living organisms or at least those life forms that we know so far.

Closely generated information, as a consequence of changes in the living environment, influences the adaptation of living organisms to these changes. According to the Theory of Evolution, changes in the habitat are a major factor in the evolution of living organisms that inhabit it. Therefore, the information that is generated as a result of these changes and is perceived by the sensory channels of living organisms is an important factor in their survival and evolution.

The information that living organisms generate as a result of their presence and the changes they cause in the environment, as well as the specially generated information, serve them for survival and communication between them.

In this sense, communication, which is a process of transmission and reception of information, takes place and makes sense only for living organisms or artificially (especially) created by devices and systems with artificial intelligence (AI). More information about AI can be found in the following chapters of this book.

Natural objects made of inanimate/nonliving matter have a structure, but no purposeful functions. They have only those functions which are conditioned by the chemical processes and physical interactions of the inanimate matter from which they are made. As an example, the fusion in some types of stars (such as those taking place in “our” Sun).

In organisms naturally evolving from organic matter (let's leave aside the theory of a “higher” intervention in the origin of life), the structure is also primary, but they also have specific purposeful functions. There are two groups of functions. The first group of functions is determined by their material (biochemical) structure, and the second group of functions is purposeful reactions that aim to maintain their “vital” processes and of course their existence (survival in their habitat).

Any purposeful reaction in response to incoming information (stimuli) is proof that this structure (form) is “alive” (functioning). The purpose of the reaction may be of the type: “go to (eat)”, “run from (escape)” or any other suitable for the specific case.

A similar reaction to the information can be observed in many artificial structures made of inanimate matter (“machines”), which we purposefully create and control. In them, the form (structure) determines their functions. But their reaction always follows their predetermined goal (function, algorithm, application) set by their creators–the people. But they (at least for now) do not have a whole class of “higher” (e.g. mental) functions (characteristics) that are present in objects (structures) made of living matter–the living organisms.

From this point of view, we can assume that living matter is at a higher stage in the evolution of matter. From there come its more complex/higher-level functions.

Here the idea is immediately “imposed” that the constructions (structures) that we humans purposefully create and which (for the time being) are built (produced) from inanimate matter, will naturally not have the higher functions of humans built from living matter. Here, of course, I exclude those “constructions” that we create and call “babies” as a result of

our reproductive process because they are made of the same living matter that we are made of–the adults who create them.

This chain of thoughts immediately raises some questions about the "limits" (possibilities) in the mental activity (functions) of these constructions, which we have set out to create and which we call "artificial intelligence". However, the topic of these limits (restrictions) will be discussed in more detail in the following chapters of the book.

Here I will only note that in all artificial creations ("things") that we create, the function is primary, and from it follows their structure (construction). No engineer creates a structure whose functions (purpose and application) are not predefined (set in advance).

As we see, nature creates structures from which their functions follow (and are tested they survive). And we humans first build "thought" functions (applications), and then we create "real" constructions that perform them. I.e. the two engineering processes (nature's and humans') are "reversed in time" (in their sequence). Maybe we are, after all, the "better" creators? So far we are not creating stars, planets, and other space objects, but who knows what we can learn to do in time? Of course, if we have that time "ahead of us".

Information and Evolution of Life

Apart from the role of information in the origin of life, we must not forget that it is also the "engine" of the evolution of living matter. It initiates survival reactions, which means adaptation to the living environment, and at a later stage in the evolution of life, when we humans have emerged and mastered technology, then our actions to actively change the environment to meet our (ever-growing) needs. Information is generated by the change in

the living environment and it initiates the change of living forms for their survival in this ever-changing environment. I.e. information is also the main “assistant” in the evolution and for the survival of the species.

Of course, we must not forget that it “works” also with the "inherited" information stored in our genes, which we have inherited from our biological parents and ancestors.

Here we should note that all responses to the incoming stimuli require prior memorized knowledge to “elaborate” the right reaction based on the comparison and analysis. But knowledge is built on information. So, we come again to the beginning of everything information. The topic of knowledge will be discussed below in **Part 2**.

The change in the environment always generates information that is perceived by living organisms as a stimulus for a purposeful response. This change may be due to a change in the energy field (temperature and lighting), physical (proximity/contact, pressure), chemical (chemical elements or compounds), or other environmental characteristics.

In the process of their adaptation and evolution (two of the main characteristics of life), organisms have developed specialized organs, and subsequently systems for:

- Perceived changes in the living environment, as specialized sensors that have allowed them to perceive as accurately as possible changes in different spectra, ranges, dynamics, composition, etc.

- To process the input information and generate the relevant “commands” and signals for the “correct” response (force, direction, speed, etc.). These organs and systems, with a controlling function, include all

nervous systems, with a simpler or more complex organization depending on the structure of the respective organism.

According to one of the basic views of modern science, and as always there is enough of those, life on our planet arose around the so-called hydrothermal vents formed on the bottom of the ancient oceans due to volcanic activity in the Earth's crust. Changes in the surrounding seawater (temperature, pressure, mechanical vibrations, chemical composition, etc.) have reached pre-life matter. As a result of the change (generated information) in the environment containing matter and energy, a "conscious" and purposeful reaction of this matter to the detected/perceived change has appeared. Probably this is the moment when the still inanimate primordial matter has become "alive", in which the perceived information has provoked a purposeful reaction, i.e. an action that is not a characteristic of natural inanimate matter. So, life always adapts to the environment.

Two types of reaction over time were the possible–fast (short-term) and slow (long-term) reaction to the change in the environment. Both kinds have one goal–the survival of living organisms. The quick reaction is for survival at the moment (in case of threat to life), and long-term for adaptation to the changing environment (for "adaptation" to the changes for long-term survival). Key reactions here are sensory sensation and conscious/purposeful (usually motor) response. Perhaps this is the moment of the origin of life and its main "conscious" (meaningful) characteristic–the primary consciousness (with the main purpose of survival), which is obviously as "old" as life itself.

Sensory sensations require chemical components in the organic matter capable of detecting change/changes and those that would make the

targeted reaction feasible. This is probably the beginning of the "specialization" of the components that make up living matter, and hence the evolution of specialized cells in the beginning and subsequent groups of those (organs).

The "slow" adaptation of living organisms to the environment to survive is carried out through their mutations. They usually affect the morphology of organisms–their structure and shapes. "Successful" mutations (i.e. in surviving individuals) are passed on to subsequent generations and are "fixed" as their permanent characteristics. We can count the unsuccessful ones as unsuccessful experiments of Mother Nature. This is the continuing influence of our common cosmic "parents"–our mother Earth and father Sun on the evolution of all their children–living organisms born and inhabiting the planet. It is done by radiation–their constant irradiation with high-energy particles emitted by radioactive elements in the Earth's crust and core and contained in the solar "wind" caused by energy eruptions of the Sun and possibly some neighboring "more active" stars in the galaxy and beyond.

The "rapid" adaptation is due to the impact of information (represented by "low-energy" radiation) on the sensory channels of living organisms and from them transmitted to their "brain" (command) centers for processing and elaboration of the reaction. But this low energy impact leads to much faster changes and adaptation in the behavior of organisms to changes in the environment and, accordingly, to the evolution of their nervous systems–the brain, nerves, and sensory organs. This process of "slow" adaptation leads to the evolution of living organisms to targeted adaptation–based on the changes in their habitat. Those species, which have not evolved fast enough, are now a "paleontological" history, i.e. fossils and

some of them are parts of the exhibits in the museum's paleontological collections.

Chapter 1.3: Information and Humans

In this chapter, we will focus on the following four topics:

- Information and communication
- Humans as receivers of information
- Humans as generators of information
- Human communication

The topic of communication, and in particular human communication, is important to us because it is directly related to information (without information there is no communication) and is one of the most important activities in our daily lives–as individuals and as members of society. Without communication, there is no transfer of information and knowledge between members of our society, and without the transfer of knowledge between members of society, the development of the intellect of individuals will be much slower. This is because it will be based only on one's own experience (and mistakes that sometimes can be fatal).

Since communication is “vital” to us, let's dedicate more information to it in this section.

Information and Communication

The processes of studying the universe and the environment we inhabit are based on the information that is generated by natural objects and processes and that we perceive with our senses. But we humans have also “invented” a way to speed up this process, and that is communication between us. It “helps” us to accumulate the knowledge acquired by other members of society over time and to share it by passing it on from one to

another or from generation to generation. Communication between us is one of our most significant “technological” achievements–from gestures and inarticulate speech to the Internet and 5G mobile communication networks today.

How do we humans perceive the universe and the environment around us?

The most general approach to the sense of and understanding of the universe shows that each of us is at the center of his/her “personal” universe. It is “perceived” and recreated especially for him/her by his central nervous system, which includes the brain, peripheral nervous system, and sensory organs. Standing in the center of this “personal” universe, if we look around, we notice many “things” and “phenomena”. If we try to classify them, they can all be arranged in two large groups/categories–material objects and processes, i.e. the changes that take place in (or with) these objects in a certain period. Of course, the time scale of those ongoing processes must be compatible with our own “biological” time scale. Classifying them (e.g. organizing in groups based on common properties), in this way, as objects and processes greatly simplifies our perception of our “own” universe.

Objects are material and are “placed” in space (here we exclude imaginary objects). If they are distant from us, then we perceive them as a result of some energy field or flow of particles that they emit or reflect. The energy, more precisely the changes in it, which reaches our sensory organs, is perceived as information about these objects. If the objects are distant, then we perceive the information about them with our two most important sensory channels–the visual (eyes) and audio (ears). If they are close and we can touch them, then the third group of our sensory organs located in the

body and our skin, which respond to touch and temperature, generate the relevant information in our nervous system. These sensors are parts of our somatosensory system. We perceive the information about the chemical composition of the objects (and more importantly whether they are edible or not) through our other two sensory channels–our sense of smell (nose) and taste (mouth). Our sixth sense is the sense of balance and spatial orientation. The corresponding sensors are located in our inner ear and are part of our vestibular system. To this list of our senses can be added a “vague” sense of time based on our heart rate (pulse) and circadian rhythm (a natural, internal body process that regulates the sleep-wake cycle) produced by a small endocrine gland (the pineal gland) located in the brain. All these seven senses “form” our “picture” of the real-life universe around us. The so-called “micro” and “macro” worlds we perceive using very sophisticated tools we create especially for such specific purposes.

The processes, in turn, take place over time. They are related to the changes that take place in the objects as a result of some physical or chemical interactions between them or processes that take place in them and reflect the nature and dynamics of these processes. The energy generated as a result of these processes is perceived by our respective sensory organs again as information.

Here we must note that our sense of time (our seventh sense) is connected precisely with the observation of the changes that take place in or with the observed objects and processes. If no changes are observed due to large differences in the scale of time, for example, if the process is very slow or very fast compared to our “personal” time (“naturally” measured by our heart rate and the circadian rhythm) then we are not able to perceive the generated information and accordingly, the time does not “flow” for us. In

this case, we cannot feel and judge it unless we use artificially created devices for this purpose (clocks, chronometers, etc.).

From what has been said so far, it follows that information is the basis of our (personal) perception of the world around us. And here I just want to recall what has already been said about the information in **Chapter 1.1**–information exists in the universe as an inseparable part of the dynamics of the processes taking place in it, but it makes "sense" only for the living organisms. And of course, it is of great importance for the development of our intellect. We will discuss this topic in more detail in **Part 3** of this book.

Let's now focus on a process called communication and its relations to information and role for humans.

Communication is a process of sending and receiving information, usually called a "message", from a "sender" to a "receiver" of that message. It is of vital importance in living communities. As it is a process it needs (takes) time to be completed.

Any communication process needs four mandatory components to be accomplished:

- A sender producing/generating the message to be sent–without the sender (called also "generator") no message can be produced and the communication process cannot start.

- A receiver should receive the message–without a receiver, the communication process is "pointless" as it cannot complete its mission/aim.

- A channel (or medium) that transmits the message (information) from the sender to the receiver–it may be material or non-material. In non-material media, the information is propagated by energy/force fields.

- The message itself–usually it is a stream of information in any physical or chemical form. Information conveys presents and the message.

The first three components form a communication system. But without the fourth component–the message this system is not functional. It is useless. So, the message (information) makes it complete and functional (useful). Here we can see, one more time, the vital role of information–no information, no communication. Information is the only "thing" that makes communication work. Sure, all three other components of the system are mandatory. Depending on the "nature" of the message, the media may be material or non-material (e.g. electromagnetic field only). There may be various configurations and modes of the system which we will discuss in the next chapter devoted to knowledge and its transfer.

Any communication process aims to transmit a message or a stream of messages. The process must be successful and fully completed.

Now, let's discuss in brief the role of communication for living organisms and communities.

Communication between living organisms has a vital role in their survival individually or in groups.

We originate from and inhabit the biosphere of the planet, which we call the Earth, and from which we draw the basic matter and energy for our existence. The purpose of this existence is survival and a satisfying way of life (survival and well-being/welfare). Our main "tools" for survival and having good/satisfactory living in the natural and social environment (which is a sub-system of the former) are our behavior, adaptation, and mutation, leading to our evolution as a species.

In terms of the Systems theory, each one of us is a separate biological system consisting of multiple subsystems, all of which form a single living organism “housed” in one body. The human body contains many (sub) systems (as medical science classifies them): central nervous system, cardiovascular, motor, digestive, etc. These subsystems are built by the relevant organs and function in an interconnected way under the “supervision” and management of the brain, which is a central organ of our nervous system.

As we noted earlier in the text, our vital functions and behavior depend on the work of our brain, and it is “controlled” by incoming information from the environment and the systems in our body. The conclusion that comes naturally is that information is what governs us through the brain. It is the basis of our internal life functions, as well as our behavior in the external environment/habitat.

According to the Systems theory (again), mentioned above, the human brain can also be considered as a complex system consisting of a multitude of systems. Each one of those may also be considered a complex system. As an example, the brain cell–the neuron (the structural unit of the brain). This applies also to the neural network they form. Both change dynamically based on the incoming stimuli (information). Thus we build knowledge on which we build our intellect and intelligence. Further in the book, we will discuss how knowledge helps us grow our intelligence. Intelligence creates “human-generated” information. And if our intelligence grows, our civilization (and its cumulative intelligence) grows as well.

The scientists (paleo-archaeologists) track the modern-day human (Homo sapiens) brain expansion, starting the hominine species, closely with the refinements in tools and technology they invented, created, and used.

Other factors that have contributed to the brain's increasing size are the tribe/social complexity, foraging strategies, symbolic communication, and capabilities for culture-related behavior. If we analyze in deep all of those human activities, they are all dependent/related to perceived information coming from the habitat and the need to communicate it to the group members to survive as a separate person or as a group supporting its members.

The systems approach in studying the functioning of the brain as a result of perceived information leads us to the idea and metaphor that the brain and sensory perceptions work as a single system for processing information. The main task of this system is to manage our behavior in a way that ensures our survival and prosperity in the environment and society. At the "entrance" of this system are all the stimuli (external and internal to our body) that we perceive, and at the "exit"–the reaction that is produced by the work of the brain. The task of this system is to generate timely and correct responses and adaptations to survive. Here the term "survival" is used in the broadest sense–biological and social. Its use means both: survival at a specific time of need through proper response and in the long term through a targeted (planned) change of behavior and adaptation to changed conditions in the living environment and/or social environment.

Of course, depending on the environment we live in, unforeseen factors such as large-scale unexpected catastrophes, pandemics of still incurable diseases and the like can occur when even the best-functioning brains will not be able to fulfill their basic task and protect us from extinction as individuals, and perhaps as a species. But to prevent such events, the brain has developed "tools" such as intelligence and intelligence, through which it "predicts and plans" response options to avoid or minimize harm to

us in such cases. We just need to “follow” its advice and instructions and prepare for them in time.

Humans as Receivers of Information

Information we perceive is of external and internal origin. The external-origin information is generated by changes in the ambient environment. The internal-origin information is generated by the processes in our body.

When there is no change, there is no information generated. Because there are energy fields everywhere in space (universe) and information is the change in those fields in time, there is always information permeated into the fabric of the space-time continuum. Except probably in the singularity point, as there we cannot define “physical” time (and space) and consequently sense any change in the energy (and related mass) “hiding” in that singularity. As we know from cosmology, (gravitational) singularity is a location in space-time usually related to so-called “black holes”.

We perceive information via our naturally evolved human senses. In some cases, we produce artificial devices (some of those specially designed as implants) that have to help people with sensory problems improve their senses. Our sensory channels have their natural limitations, such as sensitivity, dynamics, and bandwidth. The (external) artificial devices we create are often designed to “expand” the boundaries of these constraints.

The information that we humans perceive is the following:

- The information generated by the external natural (physical) environment and perceived by our sensory organs has energy characteristics

produced by electromagnetic and gravitational fields (forces), mechanical forces (in contact), and chemical reactions.

- Variety of “external” information is information generated by other people and transmitted (exchanged) through the process of communication. Here for us, the most important is the audiovisual information, and sometimes that is produced by touch (tactile).

- The information generated by our internal organs and systems is perceived directly by our nervous system.

All of this information we perceive through our human senses. So, what does modern neuroscience say about our sensory organs, sensing, and the senses that carry information from the outside world into our bodies?

In kindergarten, we learn that there are five human senses (or sensory systems) that have discrete and identifiable organs in our body. The eyes are for sight (our visual channel of information), the ears are for hearing (our audio/sound channel), the nose is for smelling (our olfaction sensory channel), the mouth (tongue) for taste (the gustatory channel), and skin for touch (the tactile channel). Probably, teaching kids in kindergarten, that our senses are limited to five because we have five fingers in each hand which makes counting easier.

So, we learn there that we have five “major” senses–sight, hearing, smell, taste, and touch. But after that, we usually read/hear that we have a sixth even a seventh sense. What are these?

The sixth sense is a product of our vestibular system and it is related to our sense of balance, spatial orientation, and sensing acceleration (pushing us out of balance). It is a part of our inner ear and heavily depends on the Earth’s gravitational field. It is the first of our senses that gets

“disordered” when we are far from the Earth, orbiting it in a spaceship or station. The vestibular system “proves” that we are “Earth creatures” as it is “tuned” to the Earth’s gravitation.

The seventh sense is associated with our “vague” sense of time. Probably, it is based on (“reads”) our heart rate and brain circadian rhythm. According to the American Heart Association, the “normal” resting adult human heart rate is 60–100 beats per minute. This way we “feel” short periods measured in seconds and minutes. The circadian rhythm is a natural, internal biological process that regulates our sleep-wake cycle and repeats on each rotation of the Earth roughly every 24 hours. It “gives” us the sense of relatively longer (day and night) periods. The science “says” that the circadian rhythms are “built-in” in plants, animals (including us), fungi, and some kinds of bacteria.

But what could we say about our internal senses, like, hunger or thirst? Science describes those more as motivational states of our body than part of our somatosensory system.

So, we have developed (by nature) seven senses so far. Maybe in the future, when we become “galactic” citizens, we will develop additional senses needed for our survival during the galactic or even intergalactic travels for colonizing exoplanets. Or (probably more realistic) we will use new “augmented” senses via AI helping us to survive and thrive on alien worlds.

The unique thing about our senses is that we have specialized receptors that are “tuned” to individual kinds of stimulus (signals). The reason why we can see light with our eyes is that we have specialized photoreceptors (rod and cone cells) in the retina of our eyes. The chemoreceptors, reacting to chemical compounds and gases, make possible

our taste and smell. For touch, which we define as our somatosensory system, we have a variety of receptors. Some of them pick up pressure and temperature, but also pain and itch. Some help with proprioception, which keeps track of where our limbs are at any moment, like whether our arm is reaching out for an object.

The information for those individual types of stimulus, our senses convert into bioelectrical and chemical signals passing into the nervous system. We name those “bio” because they are produced by the biotic matter building our body.

From a neurological perspective, we can think of our senses as an internal representation of our external environment as well as our place (position) and movement through that environment (if we move). So, the senses, usually, are broadly defined not as a specific type of stimuli based on incoming information from the outside world, but by the highly specialized systems in our bodies containing all receptors triggered by different stimuli and then converting them into signals our brain can understand (interpret and react accordingly). They all get aggregated in the brain to give us, in large part without the involvement of our consciousness, a mental representation of the things we see, feel/touch, hear, smell, and taste.

The audio-visual signals/stimuli that we perceive from the environment (near or distant to us) are of an energy nature (mechanical and electromagnetic forces). The sense of touch reacts to mechanical (physical) forces, and taste and smell are the results of chemical reactions. As we can see, these are all changes in the energy field that surrounds us. The other two sensations–the vestibular apparatus and our sense of time (however “vague” this feeling is) are related to our “presence” in the space-time

continuum (movements in space, reacting to gravity, and of course “moving synchronously” with the time).

From the text above, we can conclude that we humans are well adapted to accept all the changes (information) that occur with the matter, energy, time, and space in our universe. Well, we might want the accuracy, dynamic range, and frequency range of our sensory organs to have better characteristics, but we have achieved this so far through our natural evolution on the planet Earth. We can expect (any) positive changes in the future when (if) we become “galactic” or “cosmic” citizens.

Humans as Generators of Information

The next step after perceiving information from the environment/habitat (no matter natural or social) is processing it by the brain. The brain works on the information. As we have already noticed, information is energy transformed by senses into stimuli forming bio-electric nerve impulses/signals. The brain is triggered by the incoming energy and its main function is to process those input signals. So, the brain is a kind of an “information processing bio-computer”. What are the “technical” characteristics of that computer?

Some recent publications about the brain structure give us the following information on its characteristics and capacity:

- The human brain contains about 86 billion neurons.

- Neurons communicate with each other via synapses. Each neuron has on average from 7,000 to 10,000 synaptic connections to other neurons.

- The number of synaptic connections in the brain of an adult ranges from 100 to 500 trillion.

- It has been estimated that the number of possible link combinations between all synapses is hyper-cosmic–it exceeds the number of all elementary particles in the known universe (An interesting question: Who and how calculated them as JWST constantly discovers new galaxies?).

So, based on these human brain numbers, I do not expect that humanity will be able to design and produce such complex artificial "supercomputers" soon. We took another route and easily produced such complex "bio-computers" the traditional way and in remarkable numbers according to the statistics of human population growth. The problem with those "bio-computers" is how to fill in them with meaningful information turning it into working knowledge (and making them using/applying it). But more information about it, you will find in the next chapter.

The brain processes the incoming information by filtering it (selecting which one is important) and storing it in the memory. Next follows structuring it by building links and forming neural networks in the brain where the information is stored. The brain is doing it by following some predefined processing "algorithms"–e.g. ranking and linking it logically, semantically, taxonomically, and by other criteria into "knowledge matrices" for further use when (and if) needed. Those predefined processing algorithms/patterns are based on already-built knowledge. The more knowledge is prebuilt (and stored in our memory) in the brain, the faster is the information processing speed.

Here the brain yields in performance to the modern-day computers as the mixed bio-electrical and biochemical processes, which it is working on, are always slower than the processing of pure electrical signals in the computer chips. But the brain executes much more complex algorithms than

today's computers. It builds "ready to use" knowledge that also helps our intelligence grow.

Our memory isn't that much more precise than the computer memory but lasts much longer (sometimes lifelong), despite sometimes it being in "fuzzy" forms (as "misty" memories).

The brain links the memorized information by applying logic (reasoning), semantics (meaning); and taxonomy (classification of objects and processes according to their presumed natural relationships). It also creates associative links (relating to similar ideas, images of objects, etc.) for a "non-direct" recall. Building links always requires time as it is a biochemical process in steps of growing new axons (and dendrites) between selected neurons.

That's why the process of "recording" information (and turning it into knowledge) in human memory is much slower than recording information in computer memory. However, the advantage of human memory is that information is stored (memorized) there and forms parts of knowledge, while information stored in computer memory is just information (usually data–filtered fragments of information). To turn information into real/meaningful knowledge (not pre-programmed by an algorithm) and finally into a decision for action it must be processed by a human brain.

So, the brain is always preoccupied with mental processes, including knowledge acquisition (based on incoming streams of information) and simultaneously with many other active processes, such as forgetting (which is a natural process), making decisions, controlling our body functioning, etc. vital processes.

That's why the "performance" of the human brain doesn't match the performance in processing information of today's computers but it performs simultaneously many more (and much more important to us) operations.

First, the brain controls the human body as a live system in real time. Here, probably, is the right place to remind you, dear Reader, that according to the Systems theory, in all closed-loop (feedback loop) systems the incoming and measured information controls all matter-energy processes that run in the system. And the human body is exactly such a system. So, we (humans) run on energy controlled by our brain (matter) based on perceived and processed information.

Second, as a result of information processing, involving also our knowledge and intelligence, the brain generates another stream of information that is meant to be used "externally" for our communication needs with other individuals or groups of individuals. These information streams, based on brain mental activities, are coded by language (voice/sound) and/or writing systems (visual representation). Information coding for communication purposes may differ from our "natural" coding systems. It can also be recorded (stored) in various kinds of "external" media for later use and communication.

So we humans are also active "generators" of information that we need to communicate with other members of society. This is a process vital to our survival as individuals and as a society as a whole. Some publications indicate that at the end of 2020, humanity has generated over 44 zettabytes (1 zettabyte equals around one trillion gigabytes) of information (data) per year. This is information that it transmits, receives, records (stores), and perceives through sight and hearing, and uses in industry, business, and everyday life. We have created some sciences dedicated to the study of

information such as Information Theory, Communication Theory, several computer sciences, and many others related to information processing (e.g. bioinformatics, cognitive science, etc.). We create information technologies that are the basis of the information industry. We live in the “information age” and are preparing to “step” into its next evolutionary phase–the age of AI.

In conclusion, we can say here that information “feeds” our mental activity related to changes in the environment. If the flow of this information stops, the brain will “switch” only to the processes taking place in our body and will stop communicating with the environment and other people.

We also think of consciousness (dear Reader, please, remember Rene Descartes' “*I think so I exist*”) as an intangible product of a material object–the human brain that forms us as persons and intelligent beings. Hence follows the extremely important role of information about our existence and the development of our intellect.

Human Communication

The evolution of human communication took place along with the evolution of humans and their society. Its evolutionary process may also be primarily linked to the evolution of human intelligence. This is probably the second most important role of human communication after the “supreme” one–the survival of the human species.

As already mentioned in **Chapter 1.1** the beginning of the study and accelerated technological development of human communication was set by Claude Shannon in his famous article entitled “A Mathematical Theory of Communication” published in 1948. In subsequent years, most prominent scientists work in this field and Communication Theory is evolving and

entering many applied fields. Today it has been renamed Information Theory and “covers” a wide range of related scientific and technological fields. As a consequence of the scientific and technological progress in these fields, there was talk of an “information revolution”, which logically followed the “industrial revolution”.

The information revolution (also called the information age) has contributed to the mass digitization of many of our professional and everyday personal activities. It steadily leads us to the age of AI, thanks to the continuous development and accelerated implementation of various information and communication hi-tech innovations.

We are witnessing a convergence of many new technologies including cloud computing, big data, artificial intelligence, the Internet of things, and their applications that were inconceivable even 10 years ago. In 2021 the telecommunications industry will be dominated by over 3.8 billion smartphone users worldwide (48.37% of the world's population). The digital transformation of business and our everyday activities is at “full speed” ahead.

Human communication has played many vital roles during our evolution. Probably, the most important one was its role in our survival– informing the other members of the group about approaching predators, during hunting, asking for help, etc. In the beginning, it was mostly in the form of hand gestures (non-verbal) and/or sound communication with others around. When the spoken language evolved verbal communication appeared. The role of communication extended to teaching everyday skills. Thus the first “knowledge transfer” took place in our society. With the invention of the writing systems, human communication extended its reach through space and time, and from a direct (face-to-face) type only became

also indirect using various kinds of media for recording and communicating. This way the recorded knowledge was able to be passed to future generations (in the forms of handwritten works–scrolls, books, etc.).

With the invention and development of information and communication technologies (printing, the telegraph, the telephone, computers, computer networks, etc.) the number of roles, forms, and importance of human communication increased drastically. Today all these communication technologies play a central role in knowledge transfer vital for the development of any individual and for accumulating the knowledge of global human society.

Naturally generated information (information generated in our environment), as already mentioned above in the text, is a dynamic change in the state of an object or process in time and space (environment). If this change is not registered by the appropriate means, then with the “passage” of the time of the change the information “disappears” for the observer. It becomes inaccessible to us because we cannot follow its “bearers” in time. In the case of visual information, these are mainly streams of energetically charged particles (for us, these are mainly photons from the visual part of the electromagnetic spectrum), and in the case of audio (sound) information, these are wave oscillations in the transmitting medium). In both cases, due to the dynamics and speed of dissemination of this type of information, it is unattainable to be fully registered (remembered) by us without the appropriate technical means. Therefore, the registration of information is our main way to store and use it for our purposes. Between storage and use, a process of appropriate processing is usually required to make the information “usable”, both for the individual (direct receiver) and for other

members of society who have not been present (observed) the appearance of the relevant “portion” of information and eventually use it.

A specific feature of indirect communication is the need for both recording/registration of information on some type of media and its transmission at a distance. Here we could think about the “triple role” of light (the flow of photons) that it plays in the process of communication–as a “message” (carried by the modulation/change of the signal), as a “communication channel” (the flow of accelerated photons also serves to transmit of the contained message) and as a “medium” using optical technology and recording media. It is probably no coincidence that we define our vision (visual information channel) as the most important of all our sensory channels.

We know that some ideas are simple enough to communicate in words (by speech) and/or written text (by symbols). Others are complex and require more sophisticated techniques, tools, and skills to be communicated. The visual representation, sometimes synchronized with audio, can help the auditory understand concepts that might otherwise be impossible to explain. That is the case where information technologies, we call now computer “multimedia”, come to the rescue. Today, producing computer (digital) multimedia is as simple as never before. Using it we can transfer information-reach messages (files) conveying knowledge around the world in seconds to be used when and where needed.

As mentioned above, for us humans there is a second type of information–generated by ourselves as a result of the work of our brain. These are the thoughts–the result of the mental activity of our brain. If we want to express, preserve, distribute (transfer), or use them at a later stage, they must also be registered, processed for their presentation (visual and/or

vocal), and transferred, as so far no one has been able to read directly other people's thoughts. And it is not clear whether this will ever be achieved. For the time being, telepathy (direct reading of thoughts), for good or evil, is present only in “not-so-scientific” science fiction. But “tomorrow” with the help of direct human brain-computer interfaces (via implants) and AI this can change.

So, we can conclude this chapter, that from the Communication theory point of view, we humans can be receivers, producers (generators), and senders of information. To communicate (transfer) it to other humans, we use various communication channels, media, and technologies. The information we communicate is coded in a language (spoken or written) we speak (master). The languages we use for this may be natural or artificial, but still, both of them are human-made.