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

"Knowledge is power."

– Sir Francis Bacon

Part 2: Knowledge

Almost all of us have heard or read the well-known aphorism "Knowledge is power" (attributed to Sir Francis Bacon)–an epigraph to this part. And some of us accept it as a guiding principle pursuing more "power" (and value) through gaining knowledge.

I hope, dear Reader, this book will help you with "the power to be with you" (another popular phrase, slightly altered, from the *Star Wars* movie saga by George Lucas).

But in reality, we know too little about the source of this "power". How it is generated, acquired, stored, transferred, and running us doing all those things that make us so much "powerful". As knowledge resides in the brain, unfortunately, how it works is still a mystery to us. But the researchers working in this field do their best to find out.

This part consists of three chapters in which we will address the following topics:

- **Information and knowledge**–The first chapter is dedicated to information as a "carrier" and "builder" of knowledge in our memory.

- **Humans and knowledge**–This chapter discusses what is knowledge and its role for individuals and society.

- **Knowledge transfer**–The third chapter presents a new advanced approach to a more efficient knowledge transfer and its benefits to society.

So, let's put the first things, first. **What is knowledge?**

There are many definitions of what knowledge is and also a lot of knowledge classification schemes. I will not repeat those here as this will require a lot of text (pages). If you are interested in those, dear Reader, you may find "tons" of publications on this topic online or in the printed media.

Here I prefer to present my definition of knowledge that meets the goals of this book. But before presenting it, I would like to make some modifications to the above-mentioned aphorism. To me, it may sound also like this: Knowledge gives us the power to create things (almost "everything"). So, to be able to create (things) we have to know how to acquire knowledge and to prove it by applying it successfully.

Here is my definition of "knowledge" for the goals of this book: ***Knowledge is all information perceived, processed, memorized, and structured in the brain of an individual that is used by his/her intellect (the next mental processing "level") makes that individual react correctly and meaningfully to any situation requiring a response or action (physical or mental).***

This definition may sound too "general", but it includes everything that makes us (humans) "purposefully responsive" to the changes in the

environment surrounding us. The term “changes” used here means to the incoming information (please, refer to **Part 1** of this book). It is perceived and filtered by our senses (they just can’t perceive all kinds of incoming information, its bandwidth, and dynamics) and passed via the sensory “channels” to the memory area in the brain. There it is memorized and “linked” to selected pieces of information stored already in the memory. This process is completed by the brain nerve cells (neurons) “growing” new axons (the nerve fibers that link the neurons). But how the corresponding “addressees” of those links are selected (logically, semantically, taxonomically, etc.), in my view, still should be studied and explained by the researchers working in the field of neuroscience (and especially in the field of cognitive science). But the brain “knows” it well. This way we “build” our knowledge–a process initiated by the incoming information and completed by the brain. The process is initiated and controlled by the brain itself. If the incoming information is “trustworthy”, the knowledge it builds may be trustworthy too. But this should be proved in practice – the “ultimate evaluator” of our knowledge.

Let us be very clear here on several major points related to knowledge:

First–Knowledge resides in the human brain only. If published and stored on any kind of media, it turns again into information. (Please remember the “information cycle” described in **Part 1**.)

Second–Knowledge manifests itself by action. Otherwise, it is “hidden” from the external observer(s). Any kind of incoming external information or internal thoughts may require a response. The request “ignites” knowledge and it initiates the needed response (action or changing behavior). The response may be “augmented” or assisted by the intellect.

Third–Knowledge is of two major kinds: descriptive (we may call it "theoretical") knowledge and procedural (practical/working or know-how) knowledge. The first kind is stored in the brain "vault" and is usually rare on-demand and practiced. This causes it to "fade" and/or get "outdated" in time. The second one is usually on demand and "working" daily (on the job or at home) and these repeated exercises make it perfect day by day.

If I ask you which one you need/value more, I suppose I know the answer. No one can live without "practical" knowledge (at least for a long period). The "theoretical" knowledge is of high value for people doing any theoretical research, but the outcomes of their research should be checked and proved in reality/practice or by trusted experiments. Since those proven, that kind of knowledge remains just "a set of ideas" that in case of need may work or may not.

So, when building knowledge we start witnessing the formation of the chain "information - knowledge - intellect - intelligence".

Information "builds" knowledge by "filling and updating" it via the senses.

Knowledge is the "central" and hence the most important component of the chain. It "perfects" itself by practicing (the feedback) and understanding.

Intellect "augments" knowledge internally by "forcing" it to "extend" itself by selecting and linking (adding) new knowledge.

Intelligence "enforces" intellect by adding emotions and feelings thus accelerating it in the process of making and taking decisions.

We will focus on all these topics in the following chapters and **Part 3**.

Chapter 2.1: Information and Knowledge

As already noted above in the text “Knowledge is power”, but I would like to extend this phrase as follows: “Knowledge is power **fueled by information**.”

So, starting the topic about information and knowledge (actually the role of information in building knowledge), we will focus our attention on several consecutive processes:

- **Information as a carrier of knowledge**–forms of information carrying “potential” knowledge to the human brain via the sensory channels (human senses).

- **Information representing knowledge**–forms of information representing and conveying knowledge.

- **Memorizing information**–the process of storing information in our brain for building “structured” knowledge networks.

- **Structuring knowledge**–classifying and ranking it by priority (“weight”); building “layered” knowledge structures based on its aims and uses.

- **The circle “information-knowledge-information”**–the “circular” process related to knowledge transfer.

We shouldn’t also forget that **knowledge is always personal and resides in our brains only**. Any kind of published knowledge turns into information again. We will discuss the above-mentioned **circle of “information - knowledge - information”** in more detail below in this chapter.

Building/acquiring knowledge requires also our personal involvement. Sometimes it is a time-consuming “heavy” mental activity. That’s why some (many) people try to avoid it (if possible). It is a pity! Thus, usually, they ruin their chances of improving their wellbeing.

There are only three ways in which we build/acquire knowledge:

- Building knowledge by direct personal experience/observations.
- Acquiring knowledge by (direct or indirect) knowledge transfer.
- Building knowledge by deduction (reasoning) – requires prior knowledge in that field or maybe also in related knowledge fields.

All of these above involve a mandatory step–perceiving information.

Let’s try to “decompose” each one of these three ways, mentioned above, into their components and involved activities and analyze the outcomes (results) from the “information processing” and human-centered point of view.

Information as a Carrier of Knowledge

Each piece of information we perceive through our senses contains “hidden” (potential) knowledge. The “extraction” and storage (memorization) of possible knowledge is done by our brain. The process takes place in stages and under certain (preconditioned) conditions.

The first stage of the transformation of perceived information into knowledge is in its appropriation of meaning. This meaning is connected with the object, the process, the environment, and the conditions of its generation, as well as with some necessary conditions (preconditions), which we must have “built” in advance in our brains.

These conditions/qualities are expressed in our ability, i.e. our brain to connect the perceived information with an already existing there similar (related) knowledge “base” through a built-in “scheme” (ability) to perform logical analysis and classification. I.e. to classify the perceived information we need something like a “matrix”, whose role is played by pre-acquired knowledge and our ability to logical analysis.

Through the implementation of these basic procedures (and some auxiliary), this new “piece” of information will find its place in the built “network” of neurons and the connections between them, which form the knowledge in our memory. Given the high “weight” (meaning) assigned to these connections, it is most likely that we will form sustainable knowledge. With a low weight, this knowledge may be short-lived and may require a “consolidation” procedure, or over time the “memory of it” may disappear. If the “meaning” (relation) is not found, then we are most likely to set in our brain the beginning of new knowledge (which is subject to affirmation) or to “erase” (reject) it as “meaningless” (non-working, “useless”).

The quantity and quality of the perceived information depend on two main factors:

- The qualities of our natural sensors and sensory channels transmit the “incoming” information to the brain for further processing. These are the range of perceived signals, resolution (accuracy), and dynamics (reaction to their changes). Since in many cases it turns out that the characteristics of our natural sensors are not enough, we have created many auxiliary tools to “improve” them–microscopes, telescopes, specialized measuring equipment, and systems.

- The second main factor is our brain and the qualities of its work, as well as these preconditions, which we mentioned earlier. Such personal

qualities as our ability to concentrate on the process (attention), motivation, interest, etc. improve the process of perception and processing of information by the brain.

It should be noted that contrary to popular belief, information itself is not knowledge. It only contains and “transmits” potential knowledge, if it is perceived by our sensors, processed by the brain, and meaningfully added to the knowledge already existing there.

In the course of the development of our civilization, humanity has created some methods and means by which this retrieval and transmission can be performed and continues to improve them and create new ones based on modern information and communication technologies. But we will address these issues in more detail later in the text.

In light of what was said above, I just want to mention here that the often-repeated expression to the students at school that “there is knowledge in books” is not entirely correct and it requires the explanations given above. **There is information (conveying knowledge) only in the books.** To turn it into real (working) knowledge the students (learners) need some effort, i.e. to successfully conduct and complete the process of acquiring knowledge requires not only the availability of information that transmits and “visualizes” it but also personal efforts on their part to form knowledge on their heads based on the information contained in the books (textbooks). As a result, they will acquire (if working hard) knowledge. And teachers are just their tutors and helpers (“mediators”) in this personal process.

Memorizing Information

A “mandatory” step in the processing of incoming information is its memorization in the brain. Without memorization, there is no formation of knowledge and, accordingly, our reactions (behavior) based on it.

According to neuroscience, our (human) memory is “distributed” and encompasses a wide variety of anatomical structures in the brain we call “neural networks”. All those structures work together (“collaborate”) to form our “memories” and hence build the foundations of our knowledge.

Some authors define human memory as an information processing system comprising several specialized memory areas in the brain tasked to process the incoming information, “sorting” and “storing” it thus building our memories and knowledge. These are:

- Short-term memory holds but doesn't process, a small amount of information for a short time (hence its name). The duration is of seconds and its commonly cited capacity of items to remember is “the magical number seven, plus or minus two” (according to George Miller's Law).

- Working memory has a limited capacity and can hold information temporarily. It allows the manipulation of stored information while short-term memory only serves as storage of received information. Scientists consider working memory as a component of the human cognitive system.

- Long-term memory is that part of memory where our knowledge, built on processed information, is held indefinitely (or at least for a long period). It has a “limitless” store capacity and is the central component of our cognitive system.

- Associative memory creates (contains) relationships between unrelated items (objects, processes, events, etc.). Most probably, it also

“helps” the brain build “interdisciplinary” links between various knowledge areas (not directly or logically linked). Its functionality is hard to simulate by AI, as the AI logic should usually follow some pre-determinate rules.

Information becomes knowledge after it is stored in the memory cells (neurons) and linked based on their semantic, taxonomic, and contextual connection in neural networks after semantic, classification, and logical processing by our intellect. In this way, neural networks are formed. They contain billions of nerve cells with their connections (synapses) between them. Some authors call this process memory consolidation. Probably during this process, the “accidental” (indirect) connections of the associative memory are also formed.

Knowledge is semantically (by meaning) processed and logically, taxonomically, and contextually connected information through connections (dendrites, axons, and synapses) between neurons (brain cells) in which it is stored. In the process of processing and determining the connections are “included” in the existing (available and related) knowledge and intellect, i.e. our ability to perform logical analysis and decision-making also “helps” in the process of connecting neurons in networks.

Knowledge is retrieved from memory when needed. The more often a certain knowledge is used, the more strongly it is fixed in our memory. The “understanding” of knowledge (not just the memorized information) helps to fix it even more strongly.

If knowledge is not used for a long time, it can “fade” and even be forgotten (“erased” from the memory). Dear reader, please, remember the **“forgetting curve” of Hermann Ebbinghaus** (representing the decline of

memory retention over time). Unfortunately, forgetting is a natural function of our memory. Memorization, in turn, requires active participation in the process (will, attention, motivation, etc. purposeful mental actions) and enough time to be fixed.

As the capacity (and reliability) of our memory is never enough, we created many kinds of “external” artificial media, including digital/computer media, that “extend" the capacity and processing speed of our natural memory. These new kinds of media, computers, and communication technologies help us store, retrieve, process, and transfer the enormous amount of information and data produced by humanity today.

Of course, some theories attribute to human memory characteristics and functioning similar to computer memory. E.g. a new recent theory, published by the research team, views the brain as an “organic supercomputer” running a complex binary code with neuronal cells working as a “mechanical computer” (not as an electronic one). It states, that a vast network of information-storing memory molecules, operating as “switches”, is built into each synapse of the brain, thus representing a complex binary code. This operation identifies a physical location for “data storage” in the brain and suggests memories are written in the shape of molecules in the synaptic “interfaces”. Maybe this research and its results, published as a “new theory”, is a correct one and it is a scientific breakthrough in our understanding of how the brain and memory function, but here, however, a fundamental question arises - how this theory would “sound” if today computers did not yet exist, as well as the concept of them. We humans like to project what we already know on new discoveries. So it's easier to explain them, but is this always the right approach, or is this how we fool ourselves again? As it was previously said in the text of this book, any new idea (not yet

proven and validated as a theory) must go through several “independent” checks in practice (a reality check), and only then, if it is indeed confirmed, we can call it a “theory”. Otherwise, the term “theory” is used very often instead of the more correct term “idea” (or concept), and the boundaries of the imaginary (wishful thinking) and the real (proved by practice) are “blurred” and mislead the reader.

Today AI developers design AI memory based on human memory models transferring human brain memory functionality to computer memory. The constant advance in computer processors’ performance and the capacity of the memory chips give developers hope that the new AI developments will overcome the characteristics of the human brain and will bring artificial “superintelligence” into “life” (soon). We will allocate more info on this topic in the next chapters.

The new quantum computer technology moves on to create/develop quantum memory. Most likely, new theories will appear comparing human memory functionality to quantum memory. There are already some (new) “theories” stating that our consciousness (generated by the brain) is quantum “by nature”. Sure, proofs are needed.

A variety of mnemonic devices and brain implants for creating direct (human) brain-machine interfaces are being developed in research laboratories targeted to enhance our brain performance and memory capacity. But humanity should watch (very carefully) what kind of new information technologies will appear in that field as such devices “hold” the biggest threat to humans being “enslaved” by the machines.

Information Conveying and Presenting Knowledge

Any information conveys “potential” knowledge about the changes in the objects and processes that generated the information.

In the case of an intelligent system, acting as a receiver of that information, it needs to meet some preconditioned requirements to be able to “extract” knowledge of that information and add it to the already existing knowledge thus “extending” (increasing) its knowledge.

What are those requirements?

First, the sensors (senses) used by that intelligent system (or being) must be able to perceive the whole spectrum of incoming information.

Second, the sensory channel should be able to transmit the complete signal (information) without any losses or distortions.

Third, the intelligent “device” (brain or computer) must be able to process all incoming (perceived) information in real time without losing bits of it or errors during processing it.

From numerous scientific studies and research conducted so far, we know that all living organisms (considering those as “intelligent systems”) have their limitations in perceiving and processing information coming from their habitat. All those limits reflect on their abilities to adapt and survive.

In the case of humans as receivers of information, information needs to be perceived by the human sensory organs. We know that our sensory systems have their limitations, too. The human brain has also a limited capacity and speed for memorizing and processing information.

So, what are our solutions to our limitations?

It is the invention and creation of “extensions” to our sensors and brain “processing power” most of them based on information technology–one of our major inventions. Recent developments in IT–computer intelligence systems, including the Internet of Things (IoT) and advanced network technology, will let humanity “extend” even further its artificial sensors for collecting and processing “big” data and information from our natural and artificial habitat in real-time.

But the real “revolutionary” invention of humanity, along with its social evolution, was the invention of media as a carrier of information. After the invention of writing systems, as a way to record and communicate (transfer) information, various kinds of media played crucial roles in storing, presenting, and transferring information (potential knowledge) between individuals, groups, and generations of human society. In the beginning, those kinds of media included pure natural products, such as stone, clay, tree bark, animal skins, and some processed natural products–papyrus, paper, various canvas, etc. Later, with the development of information and communication technologies, new kinds of artificial media were added to those groups–film, electrical, electronic, magnetic, and optical media are still in wide use today for recording and communicating information and data. Some of those we name today “mass media.” Multimedia (sometimes also called hypermedia–multimedia including hyperlinks) as a direct digital media widely used in network communication (Internet and broadcasting) is the most important media for presenting audio-visual information and conveying knowledge today. What is very interesting about this kind of media, and especially in wireless networks, is that it “mimics” the natural electromagnetic spectrum as a source and carrier of information. This technological approach proves that we–humans, even in our inventions,

always try to stick to the best solutions “offered” by nature. We added only some human-centered “touch” to it–the information coding system.

Presenting information for transferring and building human knowledge requires some more specific approaches and techniques. We will discuss these in more detail in the next chapters (and in my new books in this series).

The Circle “Information-Knowledge-Information”

At the end of this chapter, we will again focus on the relationship information - knowledge. Here we must remind (one more time) that knowledge is contained only in the brain of its owner. Contrary to the common expression that books contain knowledge, they are only a “source of potential knowledge”. Printed books, for example, contain only information encoded with graphic symbols corresponding to the respective writing system (language) and possibly added static images (illustrations and/or photographs). I.e. the information in them is in visual graphic form.

To be perceived by the readers (when the reading process is initiated) and transformed into knowledge in their brains, it requires an external light source (natural or artificial) to send a flux of light particles (photons) to a selected page. The graphic image on the printed page modulates the flux of light and, reflecting from it, transmits the contained information, “encoded” as a graphic, to the visual sensors (eyes) of the reader. Then, through the visual channel, the information is transmitted to the reader's brain. If there is already a corresponding “matrix” through which to “decode” the graphic information contained on the page, the brain processes the received information, and if the goal is “knowledge formation”

(not just for fun) several processes for its construction follow. We will discuss them in more detail in the following chapters.

When reading a book (or a textbook) this process can be defined as self-initiated indirect knowledge transfer (explained below in **Chapter 2.3**). If the book is a textbook or some kind of guide, i.e. it is intended for the transfer of knowledge, then when it is written by its author (or a team of authors) he/she has “transferred” the knowledge from his/her brain to some type of media that has become an “author's original”. But in this process, the knowledge in the original has again become information. I.e. the information-knowledge-information cycle has been closed. If we want this information to become knowledge again, there must be a reader who can read this book/textbook and form knowledge in his brain.

If we want potential knowledge to “reach” many readers, then in the case of a printed book, it must be printed in multiple copies. To this end, mankind has invented printing technology (thank you, **Johannes Gutenberg**!), through which it still performs this task today. Through several publishing and printing technological processes, the author's original becomes a printed book (usually copyrighted) with a certain circulation.

Although publishing technologies are part of my basic engineering background and some of my professional practice, I will not discuss these technologies and processes in detail here. The curious reader can find enough information about them in the relevant publications. Here I will only mention some major points, and more information about them is in **Chapter 2.3**, which is especially dedicated to the topic of knowledge transfer.

Today, bookstores or public libraries have become a major source of books (both indirectly and in knowledge). But with the development of digital information and communication technologies, paper versions of books are rapidly being replaced by their electronic versions (e-books) and their delivery is now via the Internet from many online bookstores and digital libraries. The advantage of e-books over printed ones is that the information in them can be in multimedia form, which makes them interactive and “more information-rich”. In addition, readers' access to information is now much easier and faster but it now requires a terminal device–a personal computer, tablet, or smartphone as media for displaying content/information conveying knowledge. Another advantage of the digital transformation of the publishing industry is that they are much more “eco-friendly” than the printing technologies and may help humanity save the forests thus the environment.

So, information not only conveys knowledge but also contributes to its transfer via communication processes/technologies. We do not transfer knowledge directly. We communicate information that conveys and represents knowledge. The transfer of knowledge is one of the most important processes contributing to the evolution of society. Through it, individuals who do not possess knowledge in the field necessary for them receive it from individuals who have proven that they possess and mastered it. It does not matter what field of application this knowledge is from. It may concern the daily activities of an individual or his/her professional activity. In this case, at least two individuals are involved in the process–the “owner” of knowledge and the one who wants (needs) to possess it too.

In the most general case, knowledge transfer is a communication process, according to the **Theory of Communication** (as we have already mentioned, now renamed the **Theory of Information**).

In knowledge transfer, information, not knowledge, is transferred in the communication process. From this point of view, this is a purely informational process, the purpose of which is to “form” knowledge in the receiver’s brain (an individual or group of individuals). The process is completed successfully when we have formed (built) knowledge – correct (trusted) and as long as possible because the main (natural) characteristic of the brain is to forget, not to remember. Dear Reader, please, remember again the **forgetting curve of Ebbinghaus**–the decline of memory retention over time (if knowledge is not used frequently in practice). We should not “blame” our brain for this–it’s a natural process. However, there are some innovative approaches (and technologies) aimed at improving knowledge retention. We will discuss those in the next chapters.

Chapter 2.2: Humans and Knowledge

Here are some introductory remarks about humans and their knowledge. They are well known, but I want just to remind them here because further in the text I based some new ideas on them and I would not want to be accidentally misunderstood.

The term "Homo sapiens" (in Latin) designated by Karl Linnaeus in 1758 to modern humans means “wise man” (in English). If we look into various dictionaries and encyclopedias about the definition of the term “wise”, we will find meanings such as: knowing, deep understanding, etc. related to knowledge terms. The human taxonomy (classification) by Linnaeus is still in use today. This, probably, means that “knowing” is still a highly ranked human quality. Why is this? Let's try to clarify it.

Humans act/react based on knowledge. Those who have acted/reacted without required knowledge are already “history” (in the past). So, knowledge is vital for human survival in the real-world environment and further adaptation. That is why they constantly (day by day) acquire and build new knowledge. They do this in two ways– intentionally (purposefully) in any organized way or unintentionally (unexpectedly) by accidental observations.

Creating knowledge is a process. It requires time to be accomplished. The required time depends on the initial background knowledge and personal mental abilities as knowledge always resides in the human brain. Knowing something “by heart” doesn’t mean that that piece of knowledge resides in the human heart. It is just a common phrase. That knowledge is

still in memory as a neuronal construction. And memory is an inseparable part of the human central brain and nervous system.

Knowledge is always personal as it resides in the brain of a specific person. It can be shared by transferring it to another individual or group of individuals. The transfer itself is also a process. It also requires time to be accomplished (and in full as planned initially).

As we noted at the beginning of this chapter, knowledge is the “force” (power) that “guides” us in our daily activities. Be it in our personal or professional life. Of course, we are talking about those of us who practice a profession.

If knowledge is not applied in practice, then this knowledge is “useless” and it would be difficult to classify it as knowledge. Rather, it is some type of information stored in cells in our memory as a result of an event, but without being “formed” into the network of neural connections in our brain as knowledge. Or the “priority” (“weight”) assigned to these links as a result of their rare use is negligible. It is possible that its “ranking” goes to the “bottom” in the priorities of our knowledge, which we use usefully in our daily lives. Most likely, over time, at the memory level, this “unconfirmed” knowledge will “fade” and can be forgotten (completely or partially). But this statement is subject to proof by appropriate tests. Sometimes, as a result of certain events, we remember things from our “distant” past that we probably do not assume we remember (know). Probably they are an element of our memory, which experts call “associative” and which plays a role in our behavior and evolution as a species.

The knowledge that doesn't give the expected positive results of our actions (verification in real conditions) corrects or supplements it when we find that there are "gaps" in it.

The knowledge that we apply successfully in our daily practice is of the highest priority for us and we rely on it in our personal life and professional activity. We could call this knowledge conditionally "working knowledge". Of course, with the changes that are constantly occurring in our lives, this knowledge must also be corrected, supplemented, or even acquired new knowledge. Otherwise, our "power" based on knowledge "weakens".

In this chapter, I would like to present my views on what is knowledge, how, and why we create it. More information on knowledge transfer, as a process and its components, is presented in the next **Chapter 2.3 Knowledge Transfer**. In it, I will focus on some new approaches and methods that would help us to acquire and manage our knowledge more efficiently.

Starting with the topic of human knowledge, we will first try to answer two main questions:

- What is knowledge?
- Why do we need knowledge?

Once we have answered these basic questions, we will move on to clarifying some of the many topics and additional questions related to human knowledge, such as:

- Characteristics of knowledge
- Classification of knowledge

- Acquiring knowledge
- Building knowledge
- Confirming (“solidifying”) knowledge
- Presenting knowledge
- Creating (generating) new knowledge
- Accumulating knowledge
- Knowledge transfer
- What comes after knowledge?

In the text below, the term knowledge will mean human knowledge only.

What is Knowledge?

Here is, one more, of my definition of knowledge: ***Knowledge is all information perceived, processed, memorized, and structured in the brain of an individual that when used by his/her intellect (the next mental processing “level”) makes individual react correctly and meaningfully to any situation requiring a response or action (physical or mental).***

Of course, there are many definitions of what knowledge is, but another one from the systems thinking point of view is unlikely to hurt.

Cognitive science says the spaced repetition (of perceived information) helps us build better knowledge. Probably, from there comes the saying “The repetition is the ‘mother’ of knowledge”.

From the biology and information point of view, knowledge is a logically connected structured “network” of information stored in our memory, which serves as a preliminary “filter” of incoming information

(coming through our internal and external sensory channels). It serves as a basis for building our intellect and “helps” it in deciding to initiate a proper response to incoming stimuli/information. This way, knowledge serves as a “matrix” that filters incoming information (stimuli) thus assisting the brain in producing decisions for storing it or acting if needed.

As an intermediate component between information and intellect, knowledge is “built” based on information entering into our brains. When knowledge in a certain area of human knowledge is already built in our brain, it serves the intellect (intelligence) to decide to initiate a proper response to incoming stimuli/information, if such a reaction is required. The “broader” (in scope) and “deeper” (in detail and understanding) the knowledge in a given area, the more likely is that the decision taken will best suit the situation (action requirements). If knowledge in the relevant field is missing, then the intellect “wanders” when making the necessary decision. As a result, the decision is usually either wrong or delayed due to the extended time to be made. And it is clear to all of us what the result might be if, for example, a group of our ancestors searches for food in the prehistoric savannah and notices that an unknown species of animal is running towards them. If they meet it for the first time and have no idea what this is, i.e. knowledge about it and respectively about its possible behavior and intention towards them, this is a situation in which (new) knowledge is acquired. If it turns out to be a hungry predator intending to dine, then usually the closest and slowest member of the group to decide on possible action becomes a participant in a “visual” lesson about the behavior of these new species of animals towards the group. If the other members of the group have the opportunity to observe the “lesson” closely (probably from the branches of nearby trees), they will probably “form” knowledge about

this new species of animal and its behavior. If one of the group was not careful or was absent-minded during the lesson, he/she can repeat the fate of that member who was late in making the right decision to act. Those in the group who have learned their lesson fast and well (e.g. the fast learners in the group) and remained unharmed can pass on the acquired knowledge to their offspring and other members of the group (if the group has already "invented" communication with each other) and thus expand its scope. i.e. we have "useful" knowledge transfer.

The definition above, and the explanations on it, probably fully answer the question posed above. But it contains several key components, as well as the links between them, which probably need some further clarification. These components are:

- (Neural) Network
- Memory
- Incoming information
- Information processing
- Saved (memorized) information
- Intelligence
- Making a decision
- Initiation of an action/reaction.

We will discuss these topics in more detail later in the text of this and the next chapter.

Why Do We Need Knowledge?

In general, we need knowledge as it is the "background" of our major mind activities–decision-making and initiating actions (if required) through intellect and intelligence.

In practice, we base all our activities–professional and in everyday life on our knowledge. When it doesn't meet our requirements, we seek updates to improve it (extending and deepening) or build new knowledge. And it is a constant process during our lifespan. Hence the saying: "One learns (i.e. builds knowledge) while one is alive". That's why "lifelong learning" (knowledge acquisition) is a common modern-day activity/need. Knowledge is of the highest importance for our self-development as persons (individuals having distinct personalities). It is the firm background for building our intellect and intelligence. We will discuss this topic in the next chapter.

Knowledge in a global knowledge-based economy is a resource (commodity) in line with all other resources–land, minerals (raw materials), energy, human, financial, etc. resources. Today, human knowledge is dispersed and stored in a variety of media and networks in highly unstructured forms. The accumulated human society's knowledge, based on collective memory and intellect, is what should still be compiled and structured in a unified way and delivered a 24/7 just-in-time on-demand easy online access.

The social demand and importance of such a collective human knowledge repository were already envisaged by such a "grandmaster" of Sci-Fi as Isaac Asimov in his *Foundation* series. Clifford D. Simak, another

grandmaster of Sci-Fi, also presented the idea of collected galactic knowledge contained in a “crystal planet” (this reminds me of a computer of a planetary scale), collected by an “ancient civilization”, which is the central point of the plot in his novel *The Goblin Reservation*. Many other Sci-Fi authors also exploit this topic. And this is not accidental. With the evolution of human society and its technological development, the need for new knowledge will constantly increase and accelerate.

A new idea of how humanity could start building such a “crystal palace” of knowledge (e.g. a global knowledge online platform) is presented in the next chapter.

Of Definitions and Men (Humans)

Each one of us, while learning (acquiring knowledge), builds his/her view/idea of the world surrounding us, and in particular of the environment, he/she inhabits. This knowledge is built according to the definitions of objects and processes located or occurring in the real (physical) environment. These definitions are transferred to us directly (verbally) or indirectly (by publishing them on some kind of media) from other members of our society who are already familiar with their meaning or created directly by them (as their authors). Definitions and our understanding of them determine our behavior (reaction) to each object or process. This is where their (sometimes vital) role in our behavior and survival in our habitat comes from. This knowledge was extremely important for our distant ancestors, but it is no less important for modern humans. The difference is only that now we need to learn (and understand) much more in numbers and more complex definitions. This process is also complicated by the fact that with the development of science and technology, humanity is constantly creating new

and increasingly complex definitions that many of us need to know and use in our practice (especially professional ones).

Many of the definitions we use in our daily lives are “implanted” in our brains during the period of our childhood in the process of learning from our parents, friends, and educational officials, and in occasional encounters with strangers. Professional terms and their definitions we learn during our vocational training (of all levels). What we need to know about these definitions is that they must be “trusted” and “meaningful” (i.e. related to real objects and processes), otherwise, they all can fall into the category of “meaningless and useless” ones (hence will be forgotten).

To be “trusted” and “meaningful” a definition should be created by an “author” (or group of co-authors) who is a world-renowned authority in the field related to the specific definition's applicability. What we usually (as novices) don't know about these definitions is that they reflect their authors' understanding of the objects and processes that these definitions explain. These understandings may be related to specific circumstances and objectives concerning which these definitions have been created. And this means that in many cases these definitions are not “universal” and probably not particularly useful if the conditions in which they are used have been changed. From here often comes the diversity in the meaning (i.e. definitions) of many terms in dictionaries. From here also comes a specific property of definitions to “age” and “lose” their (initial) meaning, especially when they are related to objects or processes that have already come out of use over time. Conversely, new (unknown) definitions constantly appear, which need to be learned (and understood) if they have any connection to our activity (in our daily lives or our professional activity). So that is, learning new definitions is and must be a constant process in the life of each

individual if they do not want to “fall behind” in their personal development (especially professionally). For this reason, we coined the term “lifelong learning” with all related definitions (and difficulties) today. This approach allows us not to be “slaves” to some notions of our surrounding world, and the definitions associated with them, but to look for their new (updated) meanings and constantly update them on demand. Thus, we can always be “up to date” with the latest advances in science and technology that we need in our daily practice.

Here, I would like to point out that to always be updated on any new definitions and knowledge in the area of interest we (and humanity) need a very different approach to this process. Such an innovative approach and methodology are described in the next chapter.

Also, here I want to remind the readers that in the book they will also encounter some new (varied from the “traditional”) definitions of objects and processes (phenomena) that aim to explain those in terms of the recent developments in science and technology related to them. They reflect my point of view and understanding of them, which in many cases differ from the generally accepted ones. These “divergent” definitions may prove useful to readers who are interested in them from a professional point of view.

Characteristics of Knowledge

Let's now consider what the major characteristics of knowledge are. Knowledge, like all complex phenomena, has some specific characteristics we should know about and keep in mind when building knowledge, managing, and using it. These are:

- Knowledge is always personal–it resides in the head (brain) of each individual and makes his/her distinctive personality and quality.

- Knowledge is subjective–it is based and depends on our personal mind activities and perceptions.

- Knowledge has to be verified (proved) to be accepted as "trusted"–the verification has to be completed by personal experience or observations in real practical applications.

- Knowledge is dynamic–knowledge on any subject can never be complete. The new incoming information about any subject area is always being updated or outdated (obsolete). If used, it is in a constant process of extending and deepening (better understanding).

- When knowledge is published (recorded) on any kind of media it turns into information (dear Reader, please remember the circle "**information - knowledge - information**" mentioned above)–to become "knowledge" again, it needs to be transferred into the brain of another person who wants/needs to acquire this piece of knowledge.

- Knowledge transfer is a complex process–it requires time and involves multiple activities, components, participants, and steps to be completed successfully.

Knowledge transfer, as a complex process, is the major topic of the next **Chapter 2.3**.

In the specialized literature, there are many terms, with their respective definitions, for variants of knowledge, such as "tacit knowledge", "explicit knowledge", "implicit knowledge", "descriptive knowledge", and so on. They are all used to explain variants in the qualities of knowledge according to their authors and some already commonly accepted terms on the topic. The reader, if interested, may find more information on these in

many resources published online or on paper. So, I will not “parrot” these here.

Some authors, based on their research on the topic, state that knowledge memorized in our brain is “layered” depending on when we need it and in what cases we use it. They “rank” it, in general, in three “working” layers:

- Memorized as reflexes and instincts, i.e. “instantaneous” knowledge–we don’t need to acquire these as they are “gifted” to us by our parents (i.e. inborn/in the absence of specific learning)

- Acquired/“standby” knowledge–ready to be used in case of need, and

- External knowledge–transferred in real-time by other members of society or retrieved from recorded media. It is used also in case of need. If not used (and “checked”) immediately it tends to “fade” (in case it is memorized in the brain).

But let’s be very clear here. Knowledge has to be demonstrated somehow externally to be recognized as existing by external observers. By voicing it, writing, picturing, acting, or expressing it any other way. If knowledge is not or cannot be demonstrated it may exist in the brain of its “owner” but it has no meaning to the others (and the society). It should be able to be demonstrated and transferred. Otherwise, it is like writing nobody can read or decipher. This way it is of no use. Hence such knowledge doesn’t exist to the external observers. In this book, we will consider knowledge as a human ability that can be demonstrated in every way, so that it can be perceived by external observers and transferred directly or indirectly by using any kind of media.

The knowledge of each individual is “limited” to his/her own area of expertise proved and “extended” by his/her real-life experience. It should be constantly implemented in practice and “updated” regularly as it tends to get “outdated” very soon because of constant scientific advancements and technological developments. The knowledge in any area should be based on proven theories and concepts. “Building” knowledge on still unproven real-life theories, concepts, and principles leads to failures in practice. And consequently, to an unjustified expenditure of resources (time, effort, finances, etc.) for those who have studied unproved theories and try to apply that “unstable” knowledge in their everyday practice.

Classification of Knowledge

As a complex phenomenon, knowledge can be classified into many categories and the experts have already done so. They divide knowledge into three major categories:

- Descriptive knowledge–related to objects, processes, facts, etc.
- Procedural knowledge–related to skills, activities, behavior, etc.
- Self-knowledge–is usually related to our own emotions, sensations, thoughts, beliefs, delusions, and other mental states.

The first two categories refer to knowledge about our “external” environment (habitat), whereas the third one reflects our “internal” environment (the body).

There are also many different approaches to the classification of knowledge. Here are some of those:

- Personal (individual) knowledge–it is of two kinds:

Explicit knowledge is knowledge that can be easily expressed (presented visually or articulated), recorded, and accessed. It can be stored in various kinds of media and easily transferred to others.

Tacit knowledge is opposed to explicit knowledge. It is the knowledge that is difficult to express (by visualizing and verbalizing it) and thus more difficult to transfer to other individuals. It usually refers to personal wisdom, emotional experience, insights, intuition, etc. similar states of mind.

Tacit and explicit knowledge can be considered as "complementary" to each other, but the first one is of higher value to society as it can be added to the accumulated knowledge of humanity. The second one is lost after its owner dies.

- Group knowledge–the cumulative knowledge of small groups, such as tribes, isolated small communities, professional teams/circles, etc. It may be of two types: "survival" knowledge–knowledge of pre-civilization human groups and "professional" knowledge–related to ancient and further civilizations when professional knowledge and skills appeared.

- Cumulative knowledge of society–knowledge from all knowledge domains collected, recorded, and preserved by many human generations in various kinds of media for use by all society members.

Knowledge can also be:

- Factual–generated by real processes in the living environment

- Abstract–based on abstract thinking, reasoning, and other pure mental activities (not initiated by external stimulus/signals)

Here we will not go into details of the classifications mentioned above, nor of their definitions. As always, there are many interpretations of

the classification of knowledge. The interested reader can find them independently in many publications on this topic.

Probably other categories, groups, and subgroups can be added to them, but this depends on the set of characteristics/indicators according to which a similar classification scheme will be made/constructed.

Here is another classification of knowledge in terms of its applicability/real-world applications:

- “Working” knowledge–it is implemented and verified in practice. Usually, we call it “how to knowledge” (or know-how). This is the knowledge that may make us successful in life if it is applied at the right place and time (occasion).

- “Stored” knowledge is memorized in the brain and used on very rare occasions or never. It may be divided into two sub-groups:

- “Potential” knowledge is restored if recalled from memory in case of need. It may need also “refreshments” and “updates”.

- “Non-working” knowledge–it is outdated or proved by checks as non-working. We have problems with it as it cannot be “erased” from memory. In computers, we can erase (delete) files we don’t need anymore, but the human brain still has no “clean up” memory function. Such kind of knowledge may “fade” in time because of no use, but it remains in our memory and occupies neurons there. It may completely “fade” away if it isn’t used for a long period.

Both kinds of knowledge (working and stored) reside in the brain and are based on memorized information there. But, as the reader can guess, the first group (category)–the working knowledge, is of the highest importance to us. We base all our practical activities on it because we know it will lead us

to success. The second one we could use in experimental cases only when we want/need to check and prove it. In many cases, if it is unverified, it may fail us.

Knowledge doesn't always have the same qualities/properties depending on its applications/practical uses. Here are three concepts of how knowledge, "possessed" by an individual, is acquired:

- "Working" knowledge–is acquired by an individual usually during any kind of vocational education, apprenticeship, or focused self-learning (e.g. on-demand). It can be used and proved by everyday practice at the workplace and at home. It may be updated constantly by the real results (the feedback) achieved in the practice.

- Stored "potential" knowledge–is acquired usually during official education or accidentally (e.g. witnessing any occasion). It may turn into "working" knowledge if "invoked" by a need, but will probably require "updates" to be applied successfully into practice (at the time and place of need). Or may turn into "non-working" knowledge if never used in practice.

- Stored "non-working" knowledge–is acquired usually during the official education at all levels. Some of that knowledge may not be used at all in the lifespan of an individual (but it still occupies our memory).

Lately, a new concept of knowledge has emerged. We call it "just-in-time" or knowledge on-demand. It is still a "strange" kind of knowledge to society, but it meets the need for the fast-changing technological development of society. We need it when a new task requires a piece of specific knowledge, not previously acquired by an individual, but he/she possesses the required background competencies. The acquisition of such kind of knowledge requires quick access to the exact piece of knowledge/information stored in an easily accessible knowledge repository

and some time for possible acquisition. The successful acquisition is proved by applying it in practice.

Acquiring Knowledge

We all know that no one was born “knowledgeable”, which means that we humans have to expand (as a scope) and depth (as details) our knowledge on topics of our interest and needs. And this process, organized or incidental, often may last a lifetime.

How do we humans acquire knowledge? This can be done in two main ways:

- Through personal observation and/or personal experience.

Advantages–the acquired knowledge is reliable (knowledge proved by personal experience) and long-lasting.

Disadvantages–this is a slow method. It may require a long period to monitor and collect reliable information. It is also ineffective – obtaining a reliable result may involve many actions such as trial and error. Still, it may be incomplete – it is often limited because it was acquired in a specific situation. Very often it is acquired unintentionally (by accident)–for example, if we happen to witness an event. It must be proven–by demonstration, etc.

- Through organized knowledge transfer.

Advantages–this is a purposeful (focused) process. It needs available sources of information on the topic. It also needs a guarantee of its quality, completeness, and reliability. There is always an “external” assistant (mediator) in the process if we do not know “how to learn” (e.g. have no experience and motivation in “do-it-yourself” knowledge transfer/learning).

At the end of the process, we can get a certificate (“proof”) for the acquired knowledge (but real proof in practice is needed).

Disadvantages–it requires a pre-organized process and settings and may often be ineffective by involving many additional “players” and conditions. It is managed (its volume, structure, method, time, and pace) by the “external” participants/mediators. The acquired knowledge is usually short-lived (please refer to the **Hermann Ebbinghaus’ learning curve**) if not practiced. Verification or validation requires personal verification in practice. The information (knowledge) source may not be reliable or complete and comparison from several sources may be required. The personalization is “poor”–it is usually done in a group and does not take into account the specifics of each participant. In the case of self-organized and self-conducted knowledge transfer, it depends on the ability of the self-learner to select reliable sources of knowledge and to know how to learn, etc. preconditions.

There are two major requirements for the knowledge we plan to acquire and use:

- To be personalized–it depends on our “background” knowledge, acquired (accumulated) so far, and the new one we need for our real-world applications.

- To be applied–the newly acquired knowledge should “work” in any real-world circumstances and activities. It needs to be evaluated/verified in practice and if needed to be updated and/or upgraded regularly.

The targeted acquisition of knowledge is a conscious and volitional process that, to be successful, requires time, and good planning and includes many components, participants, and conditions. In general, it is always a complex process.

For a better understanding, we may compare it (metaphorically) to a simple activity of our everyday life–travel. Let's imagine that we need to change our location in space–from point A we want to move to point B. In such a case we need to:

- Know the coordinates of the starting point and the final destination
- Have a map of our journey
- Plan the possible routes
- Select the means of transportation and supporting tools
- In case we select a personal vehicle (e.g. car), do we have the requested driving skills and licenses
- Where and how to get support in case of need (e.g. petrol stations, technical services, etc.)
- Check our correct routes and arrivals at the intermediate and final destinations
- Sometimes we may need to plan also the exact timeframe of our journey.

So, from this example, it is clear, that planning and completing travel requires a lot of initial and processed information–maps, navigation data, documents (tickets or licenses), supporting/additional information (e.g. road signs), etc.

Now, comparing all these transportation in space activities with knowledge acquisition (in a specified knowledge area), we need to:

- Determine the exact knowledge a person or a group has to acquire (we call it often the existing “knowledge gaps”)
- Design a “knowledge map” (“the big picture” of knowledge required to fill in the detected gaps)

- “Chart” knowledge transfer “paths” on the knowledge map and select the shortest one (the “fastest” way of knowledge acquisition “journey”)

- Select the right knowledge transfer “vehicle”–content structure, information visualization/presentation, media, methodology, technology, etc. (to detail the “big knowledge picture and journey”)

- Check the needed prerequisites–the level of background education, existing knowledge and skills, preferred/suitable knowledge transfer style (for the specific subject), etc.

- Establish personal help/support in the case of need

- Set “checkpoints” along the “road”–intermediate tests, final exams, etc. correct knowledge acquisition proving procedures.

It is very easy to see knowledge acquisition (by transfer) is a complex process and it also requires careful planning and skillful management/control. Here the major component of this chain is the information that conveys knowledge and how it is structured, presented, and managed. Without carefully designing and managing these components, any successful knowledge transfer process simply cannot exist. All these and other mandatory components, steps, and processes will be clarified further in the next **Chapter 2.3**.

Travel is a process of transferring our body in space to reach a new destination. Knowledge acquisition is the process of transferring new knowledge into our brains to reach a new level of proficiency and intelligence. Both processes need time to be accomplished to “move” our body and mind into a new quality state–in physical space (by travel) and new knowledge area/space (by knowledge acquisition).

The process of knowledge acquisition is completed by a sequence of related processes we call knowledge transfer. The commonly accepted term is “learning”, but learning is just a part of a much longer chain of processes. We will prove this further in the text.

Both processes need careful planning and control along with their completion. This way they will reach the required goal, quality, and efficiency. In the case of travel, the exact destination is in the shortest time and with the least expenses (and probably no read accidents). In the case of knowledge acquisition, we will acquire the knowledge we need at the beginning of our “journey” and with the least invested resources. And the most important result of this knowledge acquisition “journey” will be an increase in our human “value”–knowledge and intelligence level.

There are two levels of acquired knowledge:

- The “ground” level of “working/applicable” knowledge ready to be successfully applied to and checked/verified by practice.
- The next/higher level of knowledge (by adding understanding) as a basis to create “new/improved” knowledge.

Understanding (“building” logical connections, causes, and consequences) is the path to knowledge (the higher stage in the mastery of the acquired “working/applied” knowledge). Understanding is based on the individual's ability to perform (in-depth) analysis and on this basis to draw correct conclusions and make the right decisions. It is also a way to build (upgrade) new knowledge.

Building Knowledge

The sciences that study the brain and its functioning (neuroscience, psychology, and cognitive science) still cannot give us a concrete answer to the question of how the brain builds knowledge in real-time, e.g. how the biochemical and bioelectrical processes take place in it "construct" knowledge. As usual, there are many "theories" and "models" based on this or based on that, but none of them has been proven through experiments, direct observation, or "measurements" and their analyses are conducted in real-time of the process. There are no tools and methodologies developed on how to do this for understandable reasons. Scientists are still unable to make these observations at the intracellular level in real time. There are still no developed tools and methods through which to penetrate a selected (specific) living cell and to observe, measure, and analyze the processes that take place in it in the construction of a certain piece of knowledge. This study cannot be also performed for a neural network in which it participates, as well as for its interaction with other neurons involved in this network. An obstacle to this is the super-complex structure of the brain (the number of neural connections and networks from which it is built), which we already mentioned earlier in the text.

As a result, it is not yet possible to determine the exact biochemical processes (and not only biochemical) and their products that build and "fix" knowledge. And perhaps more importantly, "who" and how exactly makes the decisions to build those relationships/links.

Likely, we will never be able to answer correctly (and verify) these basic questions related to building knowledge in our brains. And, likely, the process of the "birth" of new "theories" will continue. There are enough

examples of this in the other two very complex scientific fields – cosmology and particle physics. There are many new “theories” “swarming” (and “dying”) the same way they are at the speed of light.

Therefore, for this book, a tried and tested principle has been adopted–the principle of the “**black box**”, which is widely used in the study of complex systems (and we have already said that the living brain is just such a complex system). This principle is a product of and is widely used in **Systems theory** and **Control theory**.

The principle of the black box consists in accepting an object or system as an “opaque” body, whose structure and functionality, for some reason, we cannot study and understand from there. We can only measure the change of its output signals (reactions) when the input signals change (the input information). By the reaction of the black body (i.e. the change of the output signals), we judge its functioning. This principle is applied in the study of very complex systems in technology (e.g. in electronics and automation), including also such as a living (functioning) human brain.

For a simple explanation of the process of how knowledge is built, we could use and compare some processes from our daily practice.

As an example, in research and explanation of the construction of knowledge, we can use the following metaphor: comparing the process of building knowledge with the process of building a house. Yes, it may sound strange, but building knowledge is like building a house with bricks. If all the bricks a put into the right place and order (following the construction blueprint), the house (the final construction) will be stable and cozy for use. If there are missing bricks, thus forming holes in the walls, it will be windy

and not suitable for living in such a house. The more bricks are missing, the more unstable will be that house and it may crash at any moment.

The same principles apply to the knowledge we build by knowledge "bricks" (chunks of information). Every piece of knowledge should be in the right place and correctly linked to the next ones, related to it by meaning, thus making the whole knowledge construction stable and useful when needed. When we need more space ("rooms") in our knowledge construction, we could update that knowledge by adding new knowledge areas to the already existing construction and "live" comfortably in it (use it). And this process may be endless if we know how to extend our knowledge when we need it.

Here is another of my views on the main steps in building knowledge and, accordingly, the levels of its development. We can roughly define them as nine main consecutive steps (processes) leading to the construction of the following hierarchical levels of knowledge:

- Filtering information incoming to our senses/sensors–requires threshold filters and value detection (it may be magnified by attention).

- Transmitting filtered information to the brain–communication process based on biochemical and bioelectrical signals/processes in the sensory channels.

- Memorizing incoming (to the brain) information–requires (free) memory cells (neurons).

- Sorting information–requires "labels" and established labeling schemes.

- Structuring information as knowledge–requires pre-built structuring schemes. Those structures link neurons and build neural networks. This process builds basic knowledge structures.

- Understanding knowledge–it happens after applying and verifying it ("I know and I can"). "Confirming" (solidifying) the pre-built links and networks. The process builds advanced (extended) knowledge structures.

- Forecasting (prognosticating)–requires prognostic analysis/analytics skills based on the built knowledge structures.

- Generating (new) knowledge–requires critical thinking/analysis and builds new knowledge structures.

- Transferring/sharing knowledge–requires communication skills and technology.

From the point of view of the above categories, let us now look at which processes (more precisely a chain of processes) in our brain take a major part in the cognitive process of building knowledge and understanding it.

Knowledge is always built on perceived information (external or internal to our body). There are several steps (processes) that lead to building new, updated, or extended knowledge. These processes include:

Memorizing incoming and pre-processed information filtered by our sensors. The main function of memorizing is the retention of information, but we shouldn't forget the **"forgetting" (or retention) curve** introduced by **Hermann Ebbinghaus**. Memorizing should serve as a background for further building of knowledge. Without memorized information, there is no "background" for building knowledge. In such a case, one may constantly ask himself/herself: Who am I?

In the previous section, we have already discussed that memorizing is related to storing incoming information or internally generated thoughts in

long-term memory. But neuroscientists are still debating exactly how this process is being carried out–by bits (such as computer binary code) or by small chunks of information. The exact mechanism has not yet been specified and continues to be discussed by the specialists.

Here we can also compare the process of storing information in our memory with the recording of information in computer memory. Computer memory records information and data almost instantly (the speed depends on the system's technical characteristics), but human memory needs time to memorize incoming information in long-term memory (the process is based on the "mix" of biochemical and bioelectrical processes). So, we need to give enough time for our memory/brain to store (and fix) the information. Brain biochemistry just needs more time to complete the process of memorization.

And, unfortunately, the information stored in human memory fades away in time. This process doesn't happen to the computer memory (if there are no hardware failures). The recorded information may be lost only in case when the computer (digital) media is destroyed physically or the record is erased (deleted) deliberately.

The next process in the chain of basic cognitive processes is structuring the stored information. The function of this process is to classify by syntactic, taxonomic, logical, and other features the input information at an initial stage of structuring knowledge. The brain processes the input information and decides in which cells of the long-term memory to store it. Next comes the decision with which other nerve cells of the memory to connect those. In this way, the brain builds structures of nerve cells (neurons)–neural networks that correspond to certain characteristics

belonging to a certain area of knowledge. The decision-making process, in addition to the knowledge base built so far, most likely involves also various mental processes, such as reasoning, logical analysis, comparison, etc. All of these are related to our intellect/intelligence. Moreover, the brain performs all these actions independently, without our “active” participation. We cannot intervene in this process in real-time, but we can only “help” it with the so-called “spaced repetition” method–the process of re-reading a text after certain alternating pauses or repetition of some motor activity, for example when learning the movements of a dance.

Here we must note that the construction of neural networks is a dynamic process that is constantly “working” as a result of the perceived new information “stream” incoming to long-term memory. Thus, with the increase of knowledge, the classification groups are constantly increasing, supplementing and detailing, as a result of which relatively long-lasting neural networks are built. Their longevity depends on the frequency of use of the knowledge stored in them.

Here we shouldn’t also forget about the associative memory, whose connections are probably built based on some emotional experiences (events) coinciding in time with the input information. So, “remembering” those we need an accidental “synchronization” with the same kind of (or similar) emotions.

Now follows some more information on the process of understanding knowledge.

Understanding, as well as building knowledge, is an individual process. It is related to the “understanding” of logical connections, hierarchy,

priorities, etc. between the individual units in the established networks and between the separate networks (areas of knowledge) at the stage of structuring new knowledge. It is also a dynamic process. New information can restructure the network to “improve” understanding. Understanding is long-lasting. State The “understood” knowledge cannot be forgotten, especially if it is often used in practice. Its function is mainly in decision-making, practical applications, evaluation and analysis, refinement of classifications, self-development, and processes/activities. Its main characteristic is that it helps to increase the intellect and works together with it. People who have mastered this higher degree/level of knowledge (understanding) are often characterized as smart, understanding, knowing, experts, intelligent, etc. Therefore, when we say that a person is intelligent, we usually understand that this person “knows”, i.e. understands things and applies them creatively, which means adaptive to the situation.

Understanding requires physical time to achieve this higher level of knowledge and in the meantime applying knowledge in practice (e.g. in problem-solving) to obtain the required feedback to assess and confirm the truth (correctness) of knowledge. This leads to an understanding of the causal relationships that build it and confirm it as “true”. During this time, the connections in the neural network can be strengthened, i.e. their semantic “weight” to increase or drop as unconfirmed. At the same time, new connections can be created to “rearrange” the network. I.e. the process of understanding is a dynamic process that requires time, during which we have a semantic and structural “completion” of the respective neural networks. The result of this process is a long-term fixation of the stored information and the built neural networks. In this way, understanding helps to fix (consolidate) knowledge.

Without understanding there is no “reliable” knowledge. One cannot and should not trust such knowledge.

Here is one simple knowledge “equation”:

Knowledge + understanding = “working” knowledge

Working knowledge may be applied successfully in practice. Skills are built on working knowledge and its successful application in practice (equal to verification) generates feedback information for improving it in case there are any knowledge gaps and/or detected discrepancies.

Understanding the acquired knowledge is a higher result/level in the stage of its acquisition and use in practice. Understanding can lead to the generation of new knowledge or the expansion of the scope of what has already been acquired/learned. Understanding the acquired knowledge also strengthens our ability to achieve the next levels of its application– forecasting, and intuition (making the right decisions with insufficient knowledge or information).

Typically, the process of understanding involves building additional internal and external logical connections between the components of this “portion” of knowledge and with external portions of knowledge that may belong to other areas of knowledge. These links help to speed up and deepen the application of knowledge in practice or its transfer. We usually intuitively prefer the transfer of knowledge from individuals who demonstrate true and profound understanding in a given field of knowledge. They enjoy our trust if, in practice, we do not encounter a case that demonstrates the opposite of what was expected. Then we lose confidence in this source and start looking for another reliable one. If we are not satisfied with the results of the search, then we move on to a process of

“trial and error” until we find the “truth” (reliable knowledge) on our own. In this case, we can become a source of knowledge and initiate a transfer by publishing it or sharing it with other individuals who want to own it.

An important stage in the acquisition of knowledge is its verification in practice. If the knowledge is not checked for “fidelity” by receiving “feedback” from a credible practical application, then it knows it is only a "potential" one, i.e. it has not yet become a “working” (verified) knowledge and may “fade” in our memory over time.

For knowledge to be accepted as credible (something that can be trusted without a doubt), it must be proven to be true. Every truth is proved in reality. Knowledge must be proven through its practical application in a real situation with a positive result for the “knower” (i.e. demonstrating his/her knowledge) and the present unbiased observers (eyewitnesses).

Any “new” knowledge stated by its author (“owner”) must be proven to be true by verification in a real environment/situation. In case it coincides with such already stated, verified, and proved to be true by another “owner” (independent and unknown to the applicant), it may be necessary to prove the copyright on this knowledge. Such a need arises constantly in the area of proving intellectual property rights.

Without generally accepted evidence, the stated knowledge is only an assumption, which is subject to proof according to officially established rules. A positive test (check) in practice confirms the fixation of knowledge as “true”.

Our ability to predict future developments, trends, and/or events is also based on the built knowledge, its (deep) understanding, new

observations, experiences, analytics, and reasoning. Forecasting is not just our human “privilege”. This level of knowledge is also present in animals. If we watch how predators hunt their prey, we will see two cases of prognosis. The first is related to the ambush. The hunter manages to predict the path of the prey and waits for it at the most appropriate place and time for the attack. In the second case, the hunter does not exactly follow the trajectory of the fleeing prey, but often “calculates” (in real-time) its future trajectory and seizes it at the appropriate place and moment. Naturally, the increase in efficiency is achieved here by accumulating information from the real results, through the method of trial and error. I.e. a self-learning process is underway.

There are three major methods of building knowledge:

- By personal experience (observation)–requires a direct involvement or witnessing of the event/phenomenon.
- By information/knowledge transfer–requires pre-recorded information (conveying knowledge) and use of any kind of information (communication) technologies.
- By reasoning (deduction)–it may be a purely mental activity.

Here we can also mention such a mental quality as intuition (“loosely” related to knowledge). We can know (“understand”) something instinctively without using rational processes. It is also based on the knowledge we possess already.

All the processes listed above are related to the construction of the levels of knowledge of a certain individual and are performed by his/her brain, including the basic functions of the intellect (**Part 3** in this book is dedicated to the intellect). The more knowledge “grows” in scope, depth,

and level, the more the intellect develops and makes the right (correct) decisions faster. This process of mutually assisted growth (development) is virtually endless and is limited only by the time of the individual's biological existence and the state of health of his/her brain.

If we now compare how we and how AI builds knowledge, at this stage of technology development according to its creators, we will probably note that so far AI has “superiority” over the functionality and performance of the human brain in three areas only–processing speed, recording the incoming information in the memory and duration of storage in it without losing information. In principle, a properly functioning system with AI does not have a “forgetting curve”, except in case of failure in the system. In all other “intellectual” areas, so far AI is far from reaching the functions of the human brain or simply lacks them. In what form and with what quality these functions will be created, depends on their future creators–us humans.

I believe that this will not happen soon and hardly with the qualities that popular opinion and Sci-Fi attribute to it for now. The science that studies the brain (neuroscience), despite some claims of advances in the field, is still far from fully understanding how the brain functions on intellectual levels, as it is clear that they work also with acquired knowledge.

So for now, let's consider the information on any AI developments as fast-paced and still at “primitive” stages, which corresponds more correctly to the current level of development of AI technology. So most likely, the predicted fast-coming “technological singularity” should be postponed (maybe indefinitely). But there is more information on this topic in **Part 3**.

Confirming (Fixing/“Solidifying”) Knowledge

Verification of knowledge needs always checking and proving in reality (practice). A logical inference itself, based on not-proved knowledge (no matter how wide and deep), usually doesn't work. But the direct personal experience does.

Therefore, the test of any knowledge is performed by applying it in a real environment and conditions. We usually call this verification a practical application (verification through practice). The verification must demonstrate that the results of this application are equal to those (theoretically) expected. To exclude random coincidental results, multiple checks can be made, observing the initially set conditions. If the results are confirmed, the knowledge is considered “reliable/trusted” and confirmed as “true”. It can be used with predictable/expected results.

Presenting Knowledge

We (humans) can present/demonstrate knowledge we “possess” personally by expressing it as information (again).

There are three ways only to do that:

- Verbally–using words and sounds (understandable to the auditory). Using audio and communication technology we can transfer audio signals/information to long distances (around the globe).

- Visually–using any graphical representation, e.g. by sign systems or images (drawings and pictures). The graphical representation of knowledge requires specific skills, any kind of media, and tools for recording it. By using digital media and technologies, we can transfer our knowledge (as information) also everywhere in the world.

- By actions–e.g. movements (gestures) or “doing” the right “things” (pushing the correct button, choosing and moving in the right direction, etc.). In cases requiring complex actions, those can be split into simple steps (actions). Using information and communication technologies these can also be recorded and transmitted around the world.

Presentation of knowledge (as information) is a mandatory requirement in knowledge transfer. We will discuss this topic in more detail in the next chapter.

Creating (Generating) New Knowledge

Knowledge has a quality to get “old” (outdated and not working anymore). Sometimes this happens after a considerable amount of time, but lately, because of the fast new scientific discoveries and technological developments, its “aging” has accelerated. Knowledge needs to be constantly “updated” and if needed to be replaced by a new (proven and working) one.

How do humans create new knowledge?

In general, the process of creating new knowledge involves three major human activities–scientific research, engineering innovations, and “pure” mental activities. The first two may include focused studies, explorations, experiments, discoveries, technology innovations, etc. human creative activities. The third one is based mainly on human imagination. But all of them need prior knowledge in specific areas.

Several major approaches/methods are used depending on the environment/nature under study and the “tools” used:

- The first approach is by observation/study of the external (physical/natural) world. The main methods used in this process are scientific observations, studies, experiments, etc., and working approaches. A huge variety of man-made tools (and complex systems) may be used.

- The second one is by observation/study of the human internal (mental) world. The main methods used in this process are psychoanalysis and other mental studies of human mental processes, internal experiences, emotions, feelings, imagination, etc. The major tools used are verbal communication, various questionnaires, and tests usually using information/computer systems.

- By linking existing knowledge (maybe in interdisciplinary areas) thus creating new knowledge.

- The method of using "pure" mental activities involves reasoning, deduction, imagination, etc. intellectual activities for generating new and/or by "linking" existing ideas and concepts. After research and confirmation, those may turn into new (working) knowledge–theories, approaches, methodologies, know-how, etc. To be demonstrated/presented all of those must be recorded on any kind of media.

All of those methods lead to discoveries (proven facts) thus "giving birth" to new (usually scientific) theories (sometimes interdisciplinary). Those new theories, used as new "tools" and approaches by scientists and researchers, can generate more new knowledge.

The most important result of reaching this level of knowledge is the creation of new knowledge that did not previously exist (was not known) in the public space until its presentation. There is a requirement in society that for new knowledge to be recognized, it must be published. In this way, its

author retains his copyright. However, before it is published, it must be checked by assigned expert groups.

Accumulating Knowledge

Accumulating knowledge is a social process. It needs external media knowledge to be stored and preserved for the recent society members and generations to come. It is aimed at storing knowledge created so far by individuals we call “knowledge contributors” (authors). It is also aimed at sharing knowledge by giving access to all individuals (or selected groups) to the knowledge accumulated so far.

Along with the human civilization evolution, various kinds of media were used for storing knowledge. Those ranged from clay tablets (used in antiquity), followed by paper (still in use) to digital media (the preferred one today).

As we have already mentioned above, knowledge is stored as information (dear Reader, please remember the “**information-knowledge-information**” **circle**). So, we need information and communication technologies to access and share the accumulated knowledge.

The most common forms for accumulating, structuring, and accessing knowledge today are various kinds of archives and libraries. Digital technologies and the Internet made all those processes as easy as ever before. The accumulated (stored) knowledge is the basis of and source for knowledge transfer.

Knowledge Transfer

Knowledge transfer is also a social process. It requires at least two participants–a knowledge contributor (generator) and a knowledge receiver. Some knowledge transfer methods (schemes) may include more participants.

The transfer of knowledge between members of society and generations is extremely important, both for the development of individuals and society as a whole. The main tool in this process, of course, is communication, and the main component is information (please remember what was said above about the information-knowledge-information circle).

The major purpose of knowledge transfer is the transfer of knowledge between the present members of society and future generations. It needed to be stored and accumulated (preferably in a unified way), which accelerates the process of knowledge acquisition in society and, accordingly, its knowledge-based progress.

For now, we usually attribute this last and highest level of knowledge only to humans, because we associate those with the highest level of intelligence–creativity. But if we take a closer look at the nature around us, we will notice that it is not just our “patent”. As an example, all predators “teach” their young how to hunt to get food, and hunted animals (the prey) also teach their offspring how to avoid hunters. Sometimes this knowledge is embedded in the instincts passed down from generation to generation by those who have best mastered the “lessons” (knowledge) and through them have survived and passed them on to their generations. I.e. there is a knowledge transfer in the animal “kingdom” too, but there is not a stage of

its registration on any external medium for storing it. Such knowledge is recorded directly in the brains of those who follow the “lesson” closely, so it is always there when needed. Therefore, attending and paying attention to these practical lessons is “mandatory” for survival purposes. If somebody is absent or not paying enough attention–we know what follows…

Achieving different levels of knowledge requires time, which depends on the individual characteristics, the environment, and the conditions in which a person self-develops. This time is needed by the brain to biologically build these new internal structures (connections and circuits) thus moving to the next level of mastered knowledge.

If knowledge is not transferred by its “owner” to other members of the community or society, it “dies” with its owner. It gets lost for the new generations. So, knowledge transfer is a very important activity in the life of any individual and hence for humankind. The personal value of knowledge transfer is related to the level of our human “social value/importance”–knowledge, skills/proficiency, and intelligence. The “social value” of accumulated global knowledge of humanity drives its progress towards a better quality of life for all members of society (or at least it should do this).

Further in the text, we will focus on knowledge transfer and new approaches how to make it more efficient.

The next **Chapter 3.3** is entirely dedicated to the knowledge transfer process and an innovative idea and approach to increasing its efficiency.

What Comes After Knowledge?

Here we will only note that all levels of knowledge are interconnected. They “work” together and build our intellect and intelligence (including AI). They, in turn, “help”/assist it to self-develop, thus expanding and deepening the field of acquired knowledge (and its understanding). Knowledge and intellect/intelligence work as a “closed” system, with each component supporting the development (improvement) of the other.

Dear Reader, you will find more information on these processes, in **Part 3** of this book.