



Research Article

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From Micro to Macro Complexity Organization Scale of the Living Organisms, Their Informational Structure/Functions Are the Same

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Abstract

In this paper it is shown that an informational system can be defined both in human and in the composing unit of the body – eukaryotic cell, a better organized structure than that of the prokaryotic cell, but with the same informational functions, consisting in seven components, indispensably acting in micro unicellular bacteria and in macro multicellular organisms. Such a coherent development is allowed by the introduction of a new concept of information at the micro-level, as this is typical in the living organisms, showing that any interaction between the micro-components of a system is associated with information, which is embodied/absorbed in a composing structure and can be released during its decomposition. This new concept, defined as matter-related information, shows that the structuration/destructuration mechanisms in the human body and living structures, on the entire micro/macro organization scale, are info-absorbent/releasing of information, along the micro/macro circuits of any living body. Therefore, the human body and the body of living organisms is able to structure/organize themselves, and develop their functions on the basis of such dynamic info-operational processes, all of them based on the activity/informational stock of the central Informational “library” of every cell, the genes and genome. Such processes explain the informational nature of the mind and consciousness at human and even at subhuman organisms, with less degree of development. Consistent experimental evidences on the entire living scale, from bacteria to human, including plants and animals are also presented and discussed, strongly supporting the common informational structure of the informational system of the human body and living organisms and its consequences, on the entire organization scale of complexity.

Keywords: Information and matter-related information; Micro/macro complexity organization scale; Informational System of the Human Body and Living Structures; Prokaryotic/eukaryotic cells; living organisms; Bacteria/plants/animals/human.

Introduction

Information is nowadays a largely spread concept entered in the common use when this is referred especially to language and mass-media communications [1,2] by internet, radio and television [3], with a specific predictive effect in the management by big data analysis [4,5] and interaction of the artificial intelligent devices with human [6], or in healthcare field [7,8], all of them based on the unprecedented development of the microelectronic structures, devices [9] and micro-technologies [10,11], but practically not

known or not understood when this concept is referred to the structuration and functioning of the living organisms [12,13]. Little was known also on the decisive role of information in various domains of the human activities, with various problems or dilemma, which are still open issues, like the relation between the body and mind of human [14] and of living structures [15] in philosophy, the predominance of nature (inherited predispositions/abilities) or nurture (training/learning) performances [16] in psychology,

mental aggressiveness [17], mood dysfunctional disease [18] and psychic/health equilibrium [19] in neuroscience, to name only a few of them. Life itself seems to be still a mysterious enigma for science [20], and not too much importance, and even much less as an essential role [21] is accredited to information, despite of the accumulating evidences, although information is actually the fundamental “unobservable” substrate matrix of reality at micro and macro level, both for lifeless [13] and especially for living structures [12].

Therefore, taking into account the extremely importance of such an issue for all mentioned domains and even more, in this paper is demonstrated the effective role of information in the living organisms on the entire scale of organization, from micro to macro evolution/organization scale of complexity, showing that the informational structure of all living organisms is actually the same on this entire scale. To be more explicit, the paper is organized in the following sections: (1) the introduction and clarification of the information concept used for the info-structuration of the living organisms; (2) the informational structure of the human body and living organisms, revealing the components and functions of the extremes of the micro to macro organization scale, i.e. eukaryotic cell, as composing unit structure of plants and animals, and that of the human body i.e. the most complex structure; (3) experimental evidences demonstrating the common properties on the organization/evolution scale, from cells as micro unit structure, to multicellular organisms.

Information and Info-Structuration in the Living Organisms

In the semiconductor/silicon based structures, information/signals are carried out by electronic/holes currents [9,10]. Holes in silicon substrate material are opposite (positive) charged entities to (negatively charged) electrons, raised from their lack in the bonding relation between the lattice silicon atoms, acting therefore like a YES/NO contrary unit. The concept of information in such informational devices was based on a probabilistic (binary YES/NO Bit-type) theory regarding the certainty/uncertainty of apparition of a (new) event, different of the rest, in electronic transmission systems [22]. In the living organisms, the info-conduction/transmission/communication between organs is much more complex, carried out by various types of microparticles, interacting between them and with the unit components of the multicellular organisms – plants and animals – the eukaryotic cell. The main electric conduction is typical for the cells of the nervous system, as discharge YES/NO (all or nothing) Bit-type pulses, triggered by the interaction of the surface cell receptors with the stimulating/inhibiting (YES/NO) type of neurotransmitters [23]. The electro-communication “language” in the nervous cells is differentiated therefore by the number and frequency of these pulses, like in a “Morse”-type codified transmission, and not by amplitude, which is practically the same for all nervous cells. To understand how the information operates in such systems, Draganescu proposed a philosophic model [24], in which an “informatter” agent should activate it, both in non-living and especially in living structures [12,13]. As it was recently shown [3], information raises actually

from a change, in particular from a change of configuration of microparticles in a multi particle system, like the living systems are. Such a process is not actually either matter neither energy, is distinct of each of them, is information [25]. This is the result of an operation, and the activation operators are actually the physics, chemistry, biologic or mathematics laws, producing a new event, a change, a message for an observer, able to decode the significance of such a message. The structuring/restructuring processes, which are typical in the living organisms, produce and release information, respectively, so such operations are informationally assisted/driving processes both for the body structuration and its functionality.

A significant and suggestive example of information-assisted structuration/destructuration process is represented by a system of two microparticles A and B, or a microparticle and a stable component of a cell (for instance a signaling info-chemical agent (ligand), binding to a surface receptor [26], interacting according to the relation: $(A+B) \Leftrightarrow (AB)$. However, this represents only the chemical interaction/reaction process, where information is not revealed as a participating agent. The correct, full informational process is actually described by the informational relation/interaction as following:

$$(A+B) + I \Leftrightarrow (AB)(I) \quad (1)$$

where I is the participating information during the structuration (\Rightarrow) process of the new composed product (AB), where I becomes a hidden/absorbed information (I), which could be released by a decomposition (\Leftarrow) reverse process/event. The information received by a surface receptor (small orifices and triangles (ligands) in the cell membranes represented in Fig. 1 left side), is in this way transmitted to a next step, triggering usually a cascade of informational reactions, which can attain the nucleus, producing the activation/deactivation (YES/NO process) of certain genes, and therefore a new protein production and/or a function, during a transcription/translation process, as it is discussed below. Another effect is an acquirement of a new trait by epigenetic process, as a consequence of a repetitive/intensive signal received by the cells [27] (schematically represented in the central part of Figure 1 by the big arrow pointing down). Significantly, this arrow shows suggestively the integration of the external information in the living matter, where becomes a matter-related (“embodied”/hidden) information [28], according to the forward relation (1).

Another suggestive example is the replication process (Figure 1 left side) of the deoxyribonucleic acid (DNA), consisting in the splitting of the symmetrical helical molecule formed by two strands connected by only four distinct nucleotides (Adenine (A), Thymine (T), Cytosine (C) and Guanine (G), with complementary structures, so that A may bind only the T nucleotide, and C only G, as a YES/NO informational binary Bit-type operator), but in extremely large number of combinations. Finally, each half of DNA molecule is recomposed (\Rightarrow) in a full complete molecule by the addition of the corresponding complementary nucleotides (forward rel. (1)), forming two identical DNA mother-daughter pair, which contain full information as parts of the genes of the genome, able to rebuild a new cell/organism.

From the physics and chemistry point of view, DNA is “only” a very large molecule in chromosomes, in proportion of 30-40%, besides RNA (1-10%) and histones (50-60%) – some proteins which anchor the double helix type DNA structure to avoid its physical damage, these proportions depending on each species, different tissues of the body. and even in the same cell, on the evolution/life cycle of the cell and its specific functions/tasks. The largest human chromosome contains about 220 million base (nucleotides) pairs (bp) and measures 85 mm long if straightened [29]. However, from the informational point of view, DNA and associated (RNA) components, contain and support the necessary information/mechanisms for body structuration and functions, expressed synthetically by rel. (1). This fundamental task is fulfilled by the specific DNA structure and associated activity. Indeed, the human DNA can contain hundreds of millions of pairs, so the enormous number of possible combinations/permutations of such structural units (“letters”), allows the formation of a specific DNA informational “language”, transmitting information during the transcription/translation process for the “fabrication”/“blue-printing” of proteins, the bricks of the body structuration. The

participation of amino acids (20 in human, 11 fabricated and 9 taken from foods [26]), makes the transmitted message more complex, with the implication of the additional participation of the info-“machine” of ribosomes (Figure 1 left side). According to the biomolecular dogma, such reactions are only in a unique (\Rightarrow) sense, from nucleus to proteins in cytoplasm, never reversely [30]. Such a transmission is performed by the mRNA (messenger ribonucleic acid), which copies/transcripts a sequence/information of/from DNA molecule and passes/transfers it by a chain of info-reactions with absorption/releasing (embodiment/disembodiment) of information through ribosomes, to form tRNA (transfer RNA) and cytoplasm, to form a protein, with the participation of amino acids (Figure 1 left side). As DNA is the central information source, specific for every living organism within the species genome, the calculation of the quantity of information in each case [31], allows to compare the complexity degree of living structures on the evolution scale, as follows: 5.07×10^6 Bits (Staphylococcus aureus (bacterium)) < 1.08×10^8 Bits (Aegypti (mosquito)) < 4.13×10^8 Bits (Gallus (chicken)) < 5.28×10^8 Bits (Bos Taurus (cow)) < 8.38×10^8 Bits (Homo sapiens (human)).

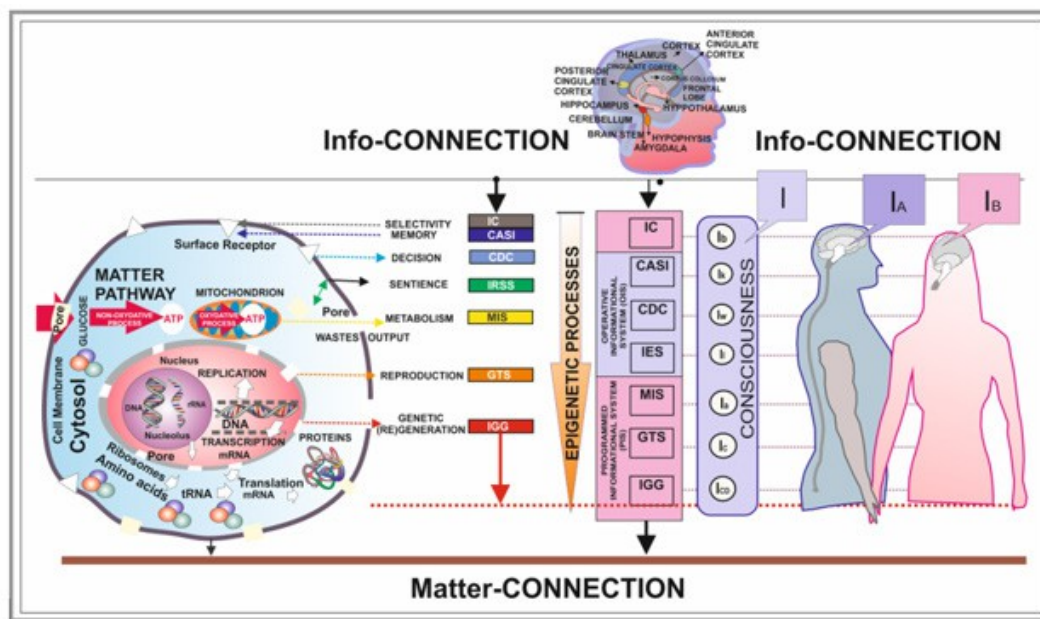


Figure 1: Schematic representation of the info/matter connection and informational system of the living structures, from eukaryotic cell to the informational system of the human body and consciousness.

The above discussion demonstrates that the relation (1), is really determinant and effectively operative for the understanding of the structuration in the living organisms, revealing the fundamental role of information, not evident otherwise at the micro-structural level. This relation reveals also the general form of the reactions/interactions in nature, where the physics/chemistry/biologic/mathematics laws act actually as informational operators, determining generation processes of absorption and release of information in the material structures. Such processes are therefore determinant especially in the living organisms, starting from micro to macro dimensional scale, where in human for instance there are

millions of reactions/min. [26]. Moreover, one of the great merit of such an approach is that this permits for the first time to describe unitarily and coherently the living systems, independently on their structure/architectural/physiologic forms/shape and their informational detection/decisional/sentient tools or complexity scale, as it will be presented in detail below.

From Micro to Macro Organization Scale of the Human Body and Living Organisms, Their Informational Structure/Functions Are the Same

According to the above presentation and with the Informational

Model of the Human Body (IMHB) [32] and Informational Model of Consciousness (IMC) [28,33-35], the Informational System of the Human Body (ISHB), defined as a system assuring both the structuration/maintenance of the body and the info-connection with the external/internal reality for real-time adaptation, consists in seven Informational components, as they will be described shortly below. At human and subhuman organisms (animals), the brain is the central info-processor of the entire organism, and is connected with the body organs, working as transducers/sensitive (sensorial) components, each of them with specific functions, in particular with the execution elements (EE) – muscles, as it is schematically shown in Figure 1 by the dashed horizontal lines. The body of the multicellular organisms, in particular the human body, is composed by the multitude of the eukaryotic cells, with specific functions and tasks, according to their belonging/competence, the main implication in the distribution of information in the body having the nervous cells and their circuitry [36]. An important contribution to the info-communication at distance is also given by the hormonal info-agents, managed at the central level by hypophysis, the master gland of the body, by means of the fluid media in bloodstream and lymphatic circuits, which leads also the immune system, in close correlation with the brain [37-39]. The activation/triggering of the activity of the immune cells is made by small molecules which circulate by the fluid streams of the organism [39].

The maintenance of the cell existence is assured by the metabolic processes, providing both the cell energy and the primary components of structuration/restructuring of the cell, which mainly are the organic components. The energy supplier is the adenosine triphosphate (ATP) synthesized during the catabolic/metabolic processes, which is broken down into adenosine diphosphate (ADP) and inorganic phosphate, in cytoplasm and mitochondrion (in eukaryotic cell), an organelle working similarly with the lung in human and sub-human organisms on the basis of oxygen-assisted reactions [28,22] (Figure 1 left side). The concentration of ADP is determinant for a signal transmission (YES) concerning a lack of energetic material or NOT, in the case when the concentration is sufficiently high. Therefore, such a balancing relation between the concentration of ATP and ADP is a suggestive example, showing how some sequential metabolic processes are informationally/automatically managed inside of the cells, in agreement with the relation (1). The informational automatic/autonomic (“programmed”) system, managing the metabolic (matter-related) processes, can be therefore defined as the Maintenance Informational System (MIS), and the corresponding cell pathways of the associated reactions as metabolic circuits. The inflow of the metabolic circuit is represented by matter (foods, air, water) and the outflow by wastes and uric acid.

The components of the informational system of the human body and cell unit (more details in subsequent comments), can be described shortly as follows (Figure 1).

- CASI is the Center of the Acquirement and Storing of Information (memory – the info-creational “field” of data [23]) and represents the info-input of the organism, either human or cell, connected with the network of the external/internal sensors, and with all areas of the brains in human, fulfilling such functions,

represented basically by the prefrontal cortex (short-term current memory), hippocampus (long-term memory), cerebellum (acquired skills), thalamus – a relay/integrator of sensory impulses, and with the cerebral cortex for the interpretation of the main sensorial signals like touch, vision and hearing. Memory plays a fundamental role for the interpretation of the explored reality [3], because this is a reference (learned) experience of life, necessary also for mind and consciousness activities [40]. In cell, this system is connected with the network of the surface receptors, as information input/local memory and is correlated with the decisional network and info-activity in the genetic system, as a basic/stable memory reference of the cell.

- CDC is the Center of the Decision and Command (of the voluntary EE system), representing the info-output of the organism, connected in human body to the specific brain areas responsible (cortex hemispheres) for the main dynamic/operational abilities of the mind like thought (the info-operator of the mind [23,40]), language/communication [1,2,23], info-analysis/info-interpretation/comprehension [23], arithmetic/writing symbolism (left hemisphere) [23], creativity [41], artistic and musical skills (right hemisphere) [23,41], intelligence, motivation, judgement, planning (prefrontal cortex), with respect to the decision criteria [42,43]. In cell, CDC is represented by the activity in the decisional/reactive pathways of cascade-type chain info-reactions (rel. (1)), which in correlation with CASI (memory) process the info-input signals and transmit a reactive response to the info-input of cell, or to the cell itself.

- IES is the Info-Emotion System in human, managing the emotions, sensorial impulses and moods [18,44], connected with the limbic system, composed by thalamus, hypothalamus, hippocampus, midbrain and amygdala (info-alarm component) and in the body especially with the hearth, for the blood distribution to the action/impulse involved reactive zones to the input information, beauty/ugly concepts playing an important role in these reactions [45], each of these concepts triggering specific distinct reactive activities/circuits. In cells, a Info-Reactive Sentient System (IRSS) can be defined, equivalent with IES in human but not identical, as it is discussed below.

- MIS in the human body and cell (Figure 1) is the Maintenance Informational System, which operates automatically the metabolic circuits/pathways of the cell/human body. In the human body, this is connected with the hypothalamus, brain stem (a relay between cerebrum, cerebellum and spinal cord) and medulla, and in the body with the digestion and distribution (cardio-respiratory) system/organs of the necessary nutrients to assure/control breathing, heart rate, body optimal temperature, wake/sleep cycles, reflex cardiac functions – the rate and force of heartbeat, vasomotor regulation, variation of diameter of the blood vessels and blood pressure [29], so is connected to the matter-related external resources for energetic/material maintenance of the body and life [46]. The human and cell organism appears therefore as a bipolar info-material system [46], connected to information and matter, as it is represented schematically in Figure 1.

- GTS is the Genetic Transmission System, which represents the info-genetic output of the organism [29], connected mainly in human with hypophysis and hypothalamus in the brain, supporting the sexual activities of the associated organs in the body. This system manages thus the output matter-related (genetic) information of the body, including the epigenetically acquired traits and inter-generationally transferred [16]. In cell, this is specifically represented by reproduction, initiated by replication process of DNA of genes.

- IGG is the Info-Genetic Generator of the organism, transferring the information from the parents to the next generation, connected in human especially with the hypophysis and hypothalamus to regulate the body growth and its development. The nucleus of every cell contains the genetic/stable memory of species. The basal ganglia are also involved in the personality features, genetically transmitted [29,16]. IGG includes the immune system, responsible of the organism protection against invaders/intruders, acting efficiently and coherently by means of mobile (white-type – B and T) cells under the coordination of the hypophysis/hypothalamus axis and in correlation with stationary/fix components (thymus, spleen, lymph vessels and nodes), on the basis of strict/coherent and precise micro/macro informational activity and inter-communication on the 3D (tridimensional) map of the organism [37-39]. IGG in cell is represented by the activity during the transcription/translation processes, allowing the growth/development of cell during its life cycle.

- IC is the Info-Connection system, supported by the anterior/posterior cingulate cortex (ACC/PCC), automatically (rose color in Fig.1 central side) acting as a YES/NO-type hub/selector/warner for the suitable/adequate (accepting/rejecting) decision, with respect to the genetically inherited or acquired life experience [29] This was demonstrated by electroencephalographic (EEG) studies, which have been shown that ACC produces “distress signals” upon the detection of errors/conflict/expectancy violation (error-related negativity – ERN) [47], so serving for the correct/right/reliable orientation/“navigation” among the uncertainties of life [3]. These findings were also revealed recently in rats, showing that ACC sustains attention to a goal with accuracy and performance of the judgement [48]. The posterior cingulate cortex is a scrutinizer of the future, at the border between the certainty and uncertainty, supporting the planning dreams/daydreaming/imaginary reality and future projects [49]. Therefore, IC represents/maintains the received information within the informational prefigured “window” of the organism, gained both by info-genetic structuration/inheritance or acquired info-luggage of data by education/self-formation, as a part of mentality, during the interaction with the surrounding informational sources. IC can be manifested therefore as a degree of compatibility/empathy between persons in the social relations [50], or as “flair” for finding a solution to a certain problem, inspiration/revelation/intuition/precognition phenomena belonging to the same category [51,40], at the border between certainty and uncertainty, during the exploration of reality [3,1], or in near-death experiences (NDEs) [52]. This behavior shows the need of trust support in life, so the religious and mystic experiences (RMEs) [53] are parts of the manifestation of this system. IC serves

to distinguish a GOOD/ACCEPTABLE (YES) vs. a BAD/REJECTABLE (NO) solution/information within the confrontation with the life events and experiences, so acts as an informational (YES/NO Bit-type) selector/interpreter during the exploration of reality, contributing to the trustworthy-related states [54]. The memory at the cellular level of the surface receptor refers to the maintenance their functions during the time, and IC functions are derived from the diversity of their types, their concerted participation is a base for the fulfillment of the specific tasks of the cell, in the case of multicellular organisms according to the specific tasks of the organ which they are part from.

The memory of cell is evidenced in the drug/alcohol addiction [17,18]: after a long-time consumption, the cells configure new surface receptors on their membrane [55], memorizing this new behavior according to the new consumption product, emitting afterwards signals of “need” of subsequent consumption, which explains the addiction effect. This is also a demonstration of a false, wrong “educated” of IC, which accept as “normal” this new type of trait. The wrong addiction could be referred also to the mass-media consumption of certain types of products like games or “strange”/trivial movies, inspiring the violence, fright or sexual obscene content [2]. This effect is a consequence of the high capacity of adaptability of the cells and organism, by acquisition of new structure configuration and functions/traits at micro-level (rel. (1)), which influences/determine the macro-level behavior, showing also that the reverse process of recovery is also possible, as a therapeutic treatment [45,56]. The sum therefore OIS = (CASI+ CDC + IRSS) + IC can be defined as the Operative Informational system (OIS), for adaptation, where IRSS is the equivalent of IES of the ISHB as mentioned above, representing the sentient response to an input information. The equivalent system in the human body is OIS=CASI+CDC+IES+IC, while PIS=MIS+GTS+IGG is the programmed informational system, automatically acting.

During the interaction of various parts of a system, in this case formed by sensitive structures/micro-structures of an organism, a chemical/physical intervention is partially felt by both interacting participants. In the human body, the emotions or emo-states are induced by chemical interaction of neurotransmitters with the neuronal cells, so the cell itself is a sensorial/sentient entity in the successive chains of pulses/impulses of interaction. The sentience is therefore a part/effect of the interaction in the living organisms, which can be “felt” both at micro and macroscopic level of organization. At the macroscopic/global level of human, this interprets the informational reactive sentience signals as emotions, although other living structures can “feel” this type of reaction distinctly, depending on the sensorial tools which these dispose of, any way producing an ACCEPTANCE/REJECTION (YES/NO) reaction, as a function of the signal nature. The sentience is therefore a necessary part of the regulatory process of the decision and adaptation to the external cues [57,58] un cells or multicellular organisms.

As the living structures are composed by sentient material, explicitly expressed with relation (1), the body of the living structures can be defined therefore as informed-matter,

understanding by this definition the implicit property of sentience/sensitivity/embodied information and matter at the same time, from the “simplest” and smallest unit structure – the eukaryotic cell of the animals and plants, to the more complex multicellular organism – the human. In the subsequent section it will be shown that bacteria, independent unicellular organism, with less degree of organization, so the simplest one, exhibit the same range of info-sensorial/decisional characteristics. The earlier mentioned definition reflects the potentiality and effectiveness of the living body of any living organism to contain and express information, in a dynamic continuous process of info-absorption/release, as a reactive/sentient system/structure. Besides the capacity of self-reproduction and self-organization, this is one of the fundamental characteristic which distinguishes the living from the non-living structures.

The human body is composed by approximately 3.7×10^{13} cells or more, organized in organs and tissues [59], each of them complying with specific functions. However, translating the above discussion to the eukaryotic cell, the structuration unit of the multicellular organisms of the animals and plants, a relevant analogy of the info-structural organization of cell with the info-organization of the human body can be observed. Indeed, every cell disposes of a MIS-like system, fulfilling the metabolic functions as follows: vacuoles are like the stomach, accumulating the nutrients, the mitochondria like a “lung” for oxygen-assisted energy production from glucose, the Golgi apparatus like a “heart”/ blood vessels system for fluids distributions in the cell body, the endoplasmic reticulum and lysosomes for lipid/fats and insulin metabolism like the pancreas and spleen in human [60]. The cell membrane is similar with the skin, the skeleton of the cell with the bone structure of the human body. The functions of GTS and IGG are evidently played by the cell reproduction, initiated by the DNA replication in nucleus and by transcription-translation processes respectively (Figure 1 left side). The main distinctive characteristic of the plant cells is an additional organelle, which is chloroplast, for the preparation of glucose, by a light-assisted processes involving chlorophyll [61]. Although does not disposes of distinct organelles, the similar functions in the prokaryotic cell (bacterium) – the most inferior organism on the complexity organization scale, are fulfilled by specific components spread in the cell cytoplasm.

The energy of the cell is provided through a relation of the type (1), by the decomposition of adenosine triphosphate (ATP) synthesized during the catabolic/metabolic processes, which is converted into adenosine diphosphate (ADP) and inorganic phosphate, in cytoplasm and mitochondrion (in eukaryotic cell) (Figure 1 left side). This reaction is informationally derived by the ratio of the (ATP)/(ADP) concentrations, indicating the necessity (YES) of (ADP) production if the energy is insufficient, or not (NO) in the contrary case, within an automatic “programmed” informational process [20,32]. This process in each cell is performed following specific metabolic pathway circuits, where the inflow consists in matter (foods, air, water) transported by blood, and the outflow in wastes and uric acid, eliminated by pores. At the macroscopic scale, this process is performed by the

metabolic/digestive system, with the participation of the specific organs and structures, and with similar in/outflows of matter. As the reproduction/multiplication in GTS and IGG activities are also programmed, an Programmed Informational System can be defined by the sum: $PIS = MIS + GTAS + IGG$, as mentioned above.

Every cell communicates with the external environment not only to change matter, but also information. This process is fulfilled by means of info-receptors, situated on the cell membrane (Fig.1 left side). As it was discussed above, such a communication is a YES/NO-type process, determined basically by the complementarity between the structure of the surface receptor and the binding info-agent (ligand), which should fit each other like a key into a lock [26]. Such an interface system represents the sensorial input, which forms together with the specific pathways the cellular CASI, in relation with CDC – an elaborated reactive system of pathways of cascade/chain processes [26], which can reach the stable central memory of the cell, nucleus, determining (YES) or not (NO) the activation or deactivation of some specific genes [20,54]. The communication pathways are definitely maintained as accurate and distinct circuits by the intervention of the scaffolding proteins [62,26], which form together with other proteins stable configurations in the cell cytoplasm.

According to the above discussion, an Informational System of the Human Body and Living Structures (ISHBLS) can be defined by the following expression:

$$ISHBLS = (CASI + CDC + IES/IRSS + MIS + GTS + IGG + IC) \quad (2)$$

This relation reveals that the structuration/functions of the ISHBLS are the same at human and eukaryotic composing cell, and practically on the entire organization scale of the living organisms. That is because the multicellular organisms of animals and plants are composed by this cell, and the prokaryotic “simpler” cell (bacterium) shows the same behavior, although does not exhibits organelles. Experimental evidences will be presented in the next section.

The possibility to retrieve from the external environment audio and visual signals and convert them in mass-media audio-visual “clips” is already demonstrated by the microelectronic/microsystem devices and equipment, where the information is basically transferred and processed by means of electronic support. In the living structures, relation (1) is fundamental to understand how they are able to retrieve information from their environment (by the sensors of CASI), to transport it through the body info-“circuits” to the central “info-processor” (CDC), to “feel” it (IES) and to convert it into audio-visual “clips” of life experience, deposit them into the info-memory (CASI), which serves also for their rapid evaluation comparatively with earlier experience (IC). Within such a process, it should be recognized the distinct role of memory and data processing in the exploration of reality, represented basically by CASI/CDC. The mind can be defined therefore as the capacity of human to have access to the informational “field” of data represented by memory and to operate with them, by means of the thought, which is the informational operator able to search a

specific address on this field of data, CDC acting/operating with this info-operator. Consciousness is therefore the result of this activity, consisting in the info-representation of reality processed in the body by means of the intervention of chemical/physics/biologic laws assisted by embodiment/disembodiment of information according to relation (1), transduced/integrated at various info-processing levels, and "projected" on the mental "screen"/display, which is the prefrontal cortex, the headquarter of the short-term memory and judgment [40]. Consciousness at human (and probably at subhuman organisms [15], but differently expressed) is therefore the result of such a projection, individually obtained and interpreted, by means of own informational media and tools (Ia =/=Ib in Fig.1), so the self – "I" (consciousness), could be expressed as a sum of the info-contribution of all components of the ISHBLS, as follows:

$$I = I_{\text{know}} + I_{\text{want}} + I_{\text{love}} + I_{\text{am}} + I_{\text{create}} + I_{\text{created}} + I_{\text{believe}} \quad (3)$$

where I_{know} (memory) [23], I_{want} (decision/attitude) [63,64], I_{love} (emotions, including all subdivisions [45,41,44]), I_{am} (power/health/vivacity/self [19,18]), I_{create} (sociability/family [42,43]), I_{created} (inherited abilities [16]), I_{believe} (trust/info-reliability/decision criteria/mentality [3,40]) are cognitive centers resulted from mind detection of the info-activity of each informational component of ISHBLS, suggestively expressing their focusing/central domain, which can be schematically expressed finally by the transducing info-relation:

$$C = M(\text{ISHBLS}) = M(\text{CASI} + \text{CDC} + \text{IES/IRSS} + \text{MIS} + \text{GTS} + \text{IGG} + \text{IC}) \Rightarrow I = (I_{\text{know}} + I_{\text{want}} + I_{\text{love}} + I_{\text{am}} + I_{\text{create}} + I_{\text{created}} + I_{\text{believe}}) \quad (4)$$

where C is consciousness (the total/multitude of information represented/contained in mind at a certain moment) and M is the mind operator (by thought). As C is time-dependent, not necessary all cognition centers should be activated at the same time [63,64]. The mind is able at human to operate with "pure" information by language, symbols and concepts, so with "ideas" and "forms" [12,13], virtual information, demonstrating actually (again), the informational nature of consciousness and mind [14] and the effectiveness of info-matter processes in the body, expressed schematically by rel. (1).

Experimental Evidences Supporting the Informational Structure/Functions of ISHBLS on the Micro-Macro Complexity Organization Scale

The experimental evidences show that the living organisms, from virus (parasitic sub-living structures in hosts), bacteria – the "simplest" (independent prokaryotic unicellular) organisms (but with very sophisticated sensorial/decisional system) [65-67] and eukaryotic cell [66], to yeast, metazoans, plants [61,68], animals and mammals/human [69,70] are metabolic (MIS)-genetic (IGG/GTS)-sentient (IES/IRSS)-decisional (IC/CDC), so ISHBLS-based structures, connected to matter/nutrients and information. The role and activity of IC/Ibelieve is evidenced at human (through error-related negativity) by social empathy [50], or even by anxious

states [71], induced by the agreement (YES) or disagreement (NO) respectively, between the received information (CASI/Iknow + IES/IRSS) and expectancy (CDC/Iwant), and at bacteria by the reduction of the food resources [67], the basic required condition of functionality of any living organism, independently of the micro or macro dimensional/organizational scale. Indeed, the discussion concerning 'what bacteria want', initiated and presented recently [67], actually highlights/recognizes just this fundamental propriety, and the reactive/decisional character of these microscopic organisms, believed to be rudimentary, but demonstrated to be really complex, endowed with an effective/efficacy informational/reactive system.

IC is a selector/warner system on the deviation from the safe/reliable informational open windows of the permitted info-operations, among the large range of existing ones in the environment, with respect to the endowed/acquired traits and requirements, so able to select between certainty vs. uncertainty in the exploration of the environment on the entire complexity organizational scale. This acts as an informational decoder for a right interpretation of the received information, as a function of the reference inherited/acquired information. The powerful of the info-operational ISHBLS in human/mammals for instance, referred both to the micro and macro-structuration, is emphasized by the spectacular inter-communication between the small unicellular white cells, the fighters of the immune cells, and the IGG axis of brain, allowing not only the orientation/navigation (IC) on the 3D map of the organism, but also to intervene in their plasticity (MIS/IGG) for invaders destruction, through macrophage mechanisms [38,39]. Moreover, this is also a relevant evidence of IRSS/IES reactivity, demonstrated by the inflammation of the local tissues, felt at human macro-level and by cells themselves. Moreover, the dysfunctions of the cellular IC at immune cells, not able to distinguish between the intruders from the cells of the body itself, manifested by allergic symptoms, diabetes, cancer [72,38] and even nervous dysfunctions [73,38] demonstrate the relevance of IC activity.

This behavior corresponds therefore with a pre-decisional YES/NO-type regulation mechanism, typical for IC activity, as this is defined within the IMHBLS. Such a behavior includes "quorum" sensitivity of bacteria, which is a special type of intercommunication in various "languages" with themselves and others [74], which determines the (re)configuration/(re)organization of bacteria colony [65] (by EEs), when a critical density is reached, requiring a regulatory process for a "consensual" decision on the CASI/IRSS/IC/CDC chain. This is based on metastable reactions ("Go on/Go off" – YES/NO reactions [66], when the critical value is exceeded, determining thus the reset of metabolism (MIS)/growth (IGG)/reproduction (GTS). The empathy at human [50] is an individual/"quorum" sensing capacity of a pre-selective IC driven activity within the social relation, not limited therefore to spatial orientation, which is manifested at some species of insects and birds by precise navigation of bees and pigeons, precision of the tool-using crows, the right orientation of fish and bats during the spatial/migratory processes [75], at plants by light/sun orientation or by anticipative ability of roots to avoid the obstacles [61,76,77],

or by the anticipative abilities of danger/ weather change and seismic phenomena at same animals [69]. Such info-selective sensitivity of IC comprise thus solutions to various situations in the confrontation/interaction with reality. IC is manifested therefore on the entire micro/macro complexity organizational scale, from prokaryotic/eukaryotic cells to multicellular organisms, as a selector/warner to maintain the "right way" to a target/completion of a goal, asking a solutions/corrections/adjustments, as a function of the species characteristics, tasks/goals, "navigation" project/tools and power/complexity of the informational system.

At human, IC activity is also relevant in creativity domains, engaging the deep resources as intuition, inspiration, revelation and even anticipation phenomena in intelligence services, medical/ industrial/didactical diagnose, scientific investigation and arts [41], at the border between certainty and uncertainty during the exploration of reality [1,3], showing the complex cognitive capacities of the mind and consciousness [40], but always based on a previous solid/consistent preparation (CASI) in the specific field. At the cellular micro-level, the adaptation needs allows the reconfiguration of the sensory surface receptors by intervention of epigenetic processes during the interaction with reality, or mass-media/drug interactions [2], so IC concerted activity is also subjected to formation/adaptation/"education" [18].

Wherever examined, the specific components of ISHBLS, could be discovered even at the smallest living cells – prokaryotic bacteria [66]: these demonstrate sophisticated regulatory networks for real-time adaptations to stress conditions, which maximize the probability of survival, by using remarkable decisional/executive capabilities for intercellular/intracellular info-coordination, which allow the observation that all living cells are cognitive [66]. This is manifested by info-perception (CASI in IMHBLS), undertaken reactive responses (CDC/IRSS) for survival, growth (IGG), and reproduction (GTS) of themselves or their clonal relatives. As it was recently shown [66], since it is not possible to document comprehensively this feature for every kind of cell, but can be demonstrated for the simplest (prokaryotic) organism, and for the derived one (eukaryotic cell), it can be admitted that this is a basic characteristic of life for all living organisms, as a reliable guaranty for the safe adaptation of their physiology and behavior to the novel required circumstances determined by the neighborhood environment, as actually the informational structure/functions reveal. An additional argument is the continuity of the right functioning of the living organisms since millions of years ago till nowadays following the same living "formula", when the eukaryotic cell was formed by the fusion between a bacterial cell with an archaeal cell to generate the initial mitochondrion, as ancestor of all eukaryotic cells [78]. Studies on bacteria show that these dispose of a signal transduction systems (OIS in ISHBLS), which is able to detect/manage the sensing (CASI/IC/IRSS/CDC) environmental info-cues, to adjust (CDC) the cellular behavior (OIS) and/or metabolism (MIS)/PIS in response to these cues, to monitor intracellular/cytoplasm/membrane conditions to counteract adverse changes [67], and their plasticity [38].

Animals, endowed with a nervous system, can move in search of food [MIS], with the help of the execution elements (EE in ISHBLS). Plants, without a nervous system, cannot do that, but they can develop their roots in earth, where they find their necessary nutrients. Maybe surprising, but showing the high capacity of the living organisms at any micro/macro scale to adapt according to the local conditions, although with a unicellular (prokaryotic) structure, without a nervous system or sharply defined organelles, many categories of bacteria dispose of the capacity to cognitively guide/manage (OIS) their mobility in fluid environment by using small motor-like "microdevices" embedded in membrane (powered by proton gradients), able to move flagella (EEs), which are helicoid appendixes for swimming [66]. Such a remarkable natural microdevice is also active in other unicellular organisms like protozoa, or spermatozoa in the multicellular organisms like mammals/human. According to ISHBLS, but also with experimental evidences, such small unicellular (prokaryotic) structures dispose of a cognitive (OIS) "tunable"/IC system, consisting in surface receptors (CASI) with adjustable sensitivity (IC) for specific nutrients [66], connected with a cascade/chain-type reactive/decisional system (CDC/IRSS) in cytoplasm, informationally driven (rel. (1)) by means of enzymes/proteins (IGG) assisted response regulation on specific reactive pathways (circuits) (Figure 1 left side), acting/monitoring the motor-flagella (EEs) in a rapid adaptation response, to move toward food [MIS], or in a contrary direction, if food concentration falls. In the same manner, some bacteria are guided by their specific sensitive/selective/sentient-decisional (OIS) system (CASI/IC/IRSS/CDC)=>EE to move toward more oxygenated locations [79], others according to the Earth magnetic field orientation [80], or toward/against the light sources [81].

The complex info-sensorial/decisional behavior of bacteria under various conditions and the ability to surveillance and solve/adapt to the external/internal situations led to treat it as a "bacterial intelligence" [67], even at the most simple/primitive bacterium [78,82]. Despite of the different genomes, so different kind of signal range involved in the regulatory machinery on the organizational micro/macro complexity scale, and of far fewer signaling proteins than a typical eukaryotic cell in human, which encodes more than 600 protein kinases (enzymes acting as a YES (active) vs. NO (inactive) switch) and about 800 G-protein-coupled (a large family of) receptors [83], showing however relevant parallels between the sensory "logic" of human and that of the bacterium's cell [66]. Regulatory processes refer actually in essence to the reactive adaptation to the external/internal conditions by info-communication between different parts of the whole, with the activation/deactivation of the genes, by protein structuration/destructuration/interactions mechanisms, according to the relation (1).

The sentient response IRSS/IES is actually supported by a regulatory process [57,58], engaged at any species at least by the missing of food, danger or reproduction. Just like in humans, in which emotion mobilizes the organism for action readiness, in animals (sponges, worms, insects, fish, amphibians, reptiles, birds,

and mammals), the IRSS is reflected by preparation to movement and action [84]. The sensing capacity in plants is revealed by the long-distance communication of the wounded leaves, which signalize their damage status (IRSS), for the stimulation of a potent regulatory product (jasmonates) for defense response, or by cascade of molecular activation/suppression [85] (YES/NO) mechanisms [61,68]. The more than 600 carnivore species of plants show also an effective sensing (CASI/IRSS)/decisional (CDC)/executive (EE) abilities to suddenly trap big insects for the digestion (MIS) [86,87]. IRSS defined here is therefore manifested as a form of cognitive reaction on the evolutionary scale, even for organisms without nervous system [15,66]. The cognitive capacities/abilities of bacteria, plants and animals depends on their own specific conditions and physical systems [15], i.e. no one cognition does exist [88], this depending on the specific eco-system and adaptability of every species to local living conditions [89,25].

Conclusions

The introduction of a new concept defined as matter-related information allows to reconsider the analysis of the living structuration and functions under unitary conditions, showing that from micro to macro complexity organization scale, an informational system can be defined, with the same informational structure. The components of this system refer to the structuration capacity, revealed by info-genetic processes of development and info-transmission, to metabolic processes, all of them common for any living organism, from micro prokaryotic (bacteria) and eukaryotic (plants/animal) cell to macro multicellular organisms, structured with microcell units.

The sensorial/sentient/decisional/executive system at human, allowing the Inter-communication and exploration of reality, is also necessary for the smaller unicellular organisms, starting with prokaryotic/eukaryotic cells and referring to all other composed organisms on the complexity organization scale, for their survival: firstly, because they need foods for body maintenance (energy and micro-constituents) – thus by the connection with matter, and secondly, to be able to find the living resources and to defend, by means of a “live” (real-time) connection by a suitable sensorial/sentient/decisional/executive system for efficient info-communication with themselves and environment – which is the informational connection. At human, such a system allows the functioning of mind and consciousness by micro/macro-processing of information in the body micro/macro circuits, manifested/detected as projection of the components of the informational system on prefrontal cortex, the mind/consciousness display. The mind appears therefore as an informational “device”, which allows the access to the informational field of data stocked in memory (the life experience), and operates by means of the thought – the informational operator of the received information with respect to the existent acquired one. Consciousness is therefore a manifestation/resultant state of such a process, consisting in the access to the own virtual internal/acquired reality, obtained/build/composed by own sensorial informational system, which transferred/transduced the outside reality into an inside/inner interpretation. Treating mind and

consciousness in such informational terms, it is evident therefore that each “consciousness” or “knowledge”/cognition is distinct not only between distinct (human) individuals, but especially between individuals of distinct (non-human) species, more rudimentary as the complexity degree of their specific informational tools decreases on the complexity organizational scale.

The large range/variety of relevant examples of the manifestation of the info-sensorial/sentient/decisional/executive system at bacteria, plants and animals, supports the consistence of the predictions of the exposed informational model. A special attention was focused on the component defined as Info-Connection, revealing its subtle but essential role on the info-“navigation”/orientation of individuals and species, through the huge informational range of environmental information. These findings show that from micro to macro complexity organization scale of the living organisms, their informational structure/functions are the same, but the cognition capacity of every species/individual depends on the local conditions of development and on the specific complexity of the endowed informational tools.

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Conflict of Interest

None.

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