Chapter 62
Information and Informational Modeling in Living Structures

Florin Gaiseanu
Science of Information and Technology, Bucharest, Romania

ABSTRACT

Information is a concept not easily penetrated in science when this refers to the involved mechanisms in the body structuration and functionality. Limited only to describing the genetic info-activity, a general coherent approach and modeling of the human organism and of the composing eukaryotic cells has not yet been explored, so this chapter is dedicated to this issue. For this, the concept of matter-related information, operating by structuration/destructuration mechanisms typical for living structures, is defined. This allows us to approach/describe the body structuration and functionality in relation to the mind and consciousness, independently on the informational sources and their nature, and to reveal a similar informational system at the human/eukaryotic composing cell level, referred to as metabolism, genetic transmission/info-generation, info-selectivity, and cognitive/sentience/decisional processes, well supported in animals, plants, and micro-organisms (bacteria) by the experimental data.

INTRODUCTION

Information is a powerful tool in industry, healthcare and scientific investigations, managed by artificial intelligence (AI) machines in big data analysis and processing (Filip, 2020) for decision making (Filip, 2022) under conditions of compatibility with human health (Filip, 2021) with remarkable results, in particular for the control and prediction of the evolution of COVID-19 infections and variants in the entire world (Gaiseanu, 2021c, 2022a), an urgent task which still preoccupies the entire society at the worldwide scale. However, when this concept is used to investigate the involved mechanisms in body structuration and functionality, and the relation between the body and mind, the question concerning the

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role and implications of information is not yet well understood (Gaiseanu, 2022b). However, information is actually a major component of biological organisms, not only to self-organize them (Gaiseanu, 2020a), but also to animate and capacitate them to communicate permanently with their environment (Gaiseanu, 2022b) and with their own body (Gaiseanu, 2020a, 2021d), allowing/supporting their existence, maintenance and adaptation. In this regard, remarkable advances have been made in the last several years to observe/reveal from the informational perspective the human mind-body mechanisms and the nature of structuration and self-organization processes of our own body (Gaiseanu, 2021e). Such investigations revealed fundamental information-assisted mechanisms involved in biologic creatures on the entire scale – cells, plants (Gaiseanu, 2022c,d), animals (Gaiseanu, 2022b), and humans (Gaiseanu, 2020b) – within their permanent effort to maintain and adapt their structure with respect to environmental cues and body tasks (Gaiseanu, 2021f, 2022e), highlighting ultimately the implication of information in living structures (Gaiseanu, 2020c,2021e,2022c) (Schrödinger, 1944).

In this chapter is presented a new concept of information defined as matter-related information in biological organisms, allowing to achieve informational modeling on the entire biological scale, in particularly referring to the human body, eukaryotic cells, and plants within the informational model of the human body and living structures.

BACKGROUND

Information was not a concept easily penetrating in science, and long time efforts were made to crystallize its meaning during the human and science evolution (Gaiseanu, 2021b), starting from the antique philosopher like Plato, who believed that ideas/forms are the fundamental element of universe, in opposition with Aristotle's view, promoting matter as basic composing material of the world (Gaiseanu, 2021a, 2021b). Passing by the Maxwell's demon paradox (Dougal et al., 2015; Gaiseanu, 2021a), an imaginary experiment based on the intervention of an "intelligent" demon which opens a small door between two recipient to pass the more rapid molecules from one side to another, infringing therefore the thermodynamic laws, and arriving to Szilard, who resolved this paradox showing that the system receive actually information by such a demon intervention (Szilard, 1929), the concept of information was defined in electronic communication systems by Shannon, in probabilistic terms (Shannon, 1948). However, the role of information in living and non-living systems was intuitively expressed by Draganescu's philosophic view, suggesting that matter structuration is the result of the intervention of an "informatter" agent, able to activate this process, while the structuration of the living systems results by the intervention of this "informatter" agent on the structured matter (Draganescu, 1990). It is still not well understood however the operability of information in the living systems, although its role is acknowledged in terms of information theory, referred in particular to the genetic activity in the cell (Jiang & Xu, 2010), and no a general coherent approach and modeling of the human organism and of the constituting eukaryotic cells was given so far, so the goal of this chapter is to cover this gap.

INFORMATION AND INFORMATIONAL MODELING IN THE LIVING STRUCTURES

Information from the perspective of the science and technology of information is related in its initial form with the communication between an information source and a receiver, linked by a communication

channel, treated in YES/NO-like, bit (binary digit) terms, usually for electronic systems (Shannon, 1948). The accuracy of transmission and reception depends on the encoding of information at the source, on the errors induced during the transmission channel, and on the decoding abilities at the receiving terminal.

Information in Living Structures

Distinct from the communication in informational devices, where the informational carriers are the electrons and holes (opposite positive charges by lack of electrons in the bonding structure) in the semiconductor (silicon) junctions of the microprocessors' components (Gaiseanu 2013, 2017), the communication in living organisms is carried out by different specific mechanisms in which the dynamics of the chemical reactions between the composing microelements is the determinant for the structuration and communication of the living structures with themselves and with the external environment, on which they permanently depend for food needs and interactions. Therefore, it is necessary to revise the concept of information, and to extend it in accordance with the reality of such systems, introducing the concept of matter-related information conveyed by structuration/destructuration processes which absorb and release information in the living organisms.

For this, it should be taken into account that a process of interaction between two components A and B actually takes place with the absorption and releasing of information, denoted by the symbol I, which could be schematically written as:

$$\left(A+B\right)+I\left\langle =\right\rangle \left(AB\left(I\right)\right) \tag{1}$$

where (I) is the absorbed/"embodied" information in the composed (AB) structure during the forward-type (=>) reaction, which can be released during the destructuration processes, represented by a revers-type (<=) reaction. It is to be noted that while the components A and B are material participants, information is an immaterial, non-observable (hidden) participant in relation (1). That's most likely why information and its essential role in the structuration of matter, either of living or non-living structures, is still not acknowledged, at least at the micro-structural level (Gaiseanu, 2021a,b).

In particular, the interaction between two micro-components in the living structure cell, like, for instance, between a ligand (external informational agent) and a specific surface receptor of the cell membrane triggering a chain of specific reactions in the cell cytoplasm (Alberts et al., 2015), is actually a matter-related information process generated by structuration/destructuration mechanisms, as represented by rel. (1) (Gaiseanu, 2023a).

In the nervous system, the excitatory/inhibitory neurotransmitters accessing the synapse transmit information by a similar mechanism, and moreover, these trigger (or not) the electrical conduction mechanism of the nervous cell as a YES/NO – bit-type operation. Each message is distinguished from others through a specific "language" based, in this case, by the number and frequency of the electric pulses and the nature of neurotransmitters, which moreover intervene in such a communication process between two neighbor neural cells, by a inhibitory/excitatory YES/NO – bit-type competition (Gaiseanu, 2021h, 2020g).

A suggestive and relevant example is represented by the transcription-translation process of information from the deoxyribonucleic acid (DNA) of the cell nucleus to the proteins (Albert et al., 2015), the

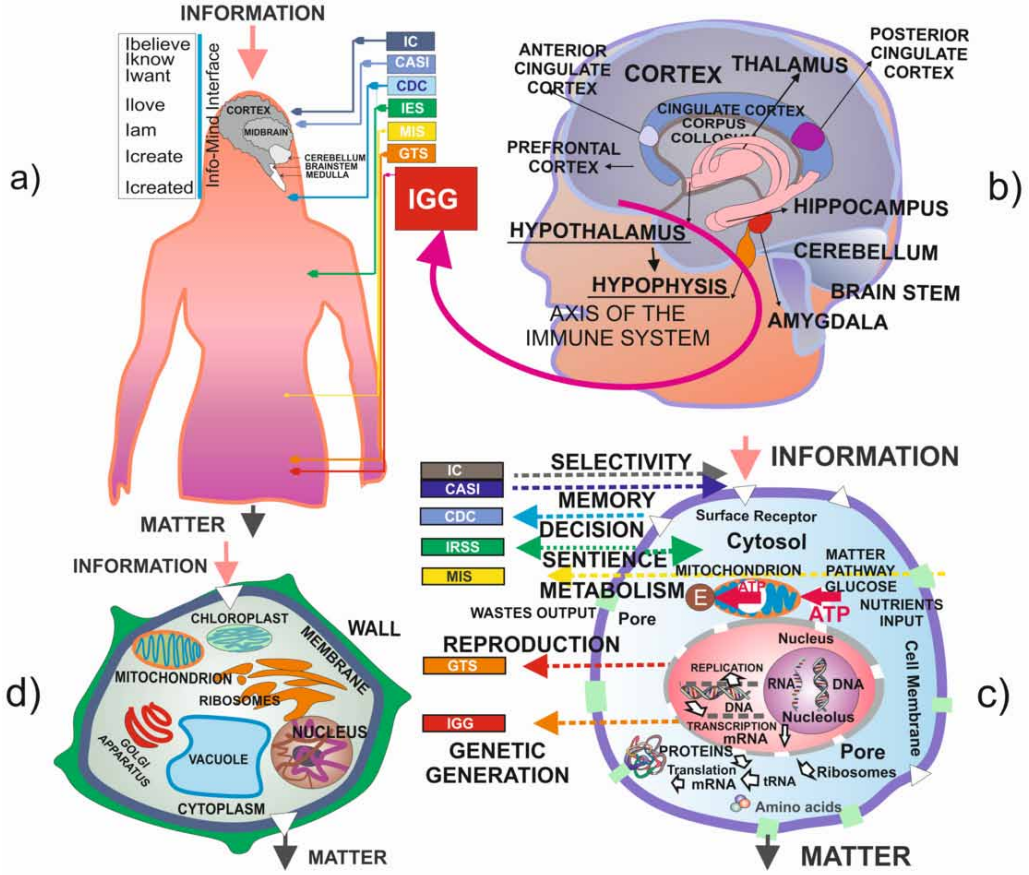
bricks of the body, according to the following scheme transcribed in the informational symbols (=>) of rel. (1) as follows:

$$DNA => mRNA => tRNA + \left(Amino\ \ Acids\right) => Protein \tag{2}$$

where the transcription molecular process consists in the copy of a sequence of a DNA molecule of genes in nucleus (Figure1), translation of information (=>) to a further info-component which is given by the messenger ribonucleic acid (mRNA), transmitted to tRNA (transfer RNA) in ribosomes with the participation of amino acids.

However, according to the main dogma of molecular biology (Lodish et al., 2008), such a relation operates only in a unique sense (=>), similarly with the forward current through the electronic diode junctions of the silicon microelectronic devices (Gaiseanu, 2013). The info-transmission in this case is carried out by various combinations of DNA sequences in the "language" of the four "letter" alphabet of the nucleotides, i.e., adenine (A), guanine (G), thymine (T), and cytosine (C) in DNA, and adenine, guanine, uracil (U), and cytosine in RNA, combined with the contribution of amino acids from the 20

Figure 1. Schematic representation of the Informational System of the Human Body (a), the relation with the brain (b) and of a eukaryotic cell in animals (c) and plants (d)



existing types to form a certain protein, with adequate characteristics, according to the body necessities of structuration or functionalities (Gaiseanu, 2021f). A basic rule of coupling between these constitutive elements by means of a hydrogen atom is that they have complementary structures, admitting only a binary (YES/NO-type) combination, i.e., A-T and G-C in DNA and correspondingly A-U/G-C in RNA. The ribosome organelles act as with additional codifications of information by means of tRNA and various combinations of amino acids (20 in human) (Alberts et al., 2015) in a mixture "language" based on the (YES/NO binary) complementarity of the structure of the communication components (Gaiseanu, 2023a).

Translating this situation in communication terms, relation (1) shows that a certain material body, or a part of it, can contain information integrated/"embodied" inside its structure which can be "communicated" by a MESSAGE (information) to another entity, which is able to receive and INTERPRET this released/"disembodied" message (information) in a certain mode (by a specific "LANGUAGE") much like in our computer/informational devices. This is a fundamental key for the understanding of biological systems as regards their (self)-structuration/(self)-organization and self-functionality by bioprocessing mechanisms: a chain of informational processes on a certain pathway (micro-"circuit")/communication "channel" can transmit a chain of informational operations/instructions successively to a target, according to a certain "logical scheme"/algorithm/pattern, for the execution of a final process with a certain result, either for structuration or for triggering/driving a function, *expressible also as information*. In other words, biologic organisms are able to themselves drive informationally their growth/development and functionality by means of info-operational processes, as will be presented specifically below. From the informational point of view, such an approach also permits a useful comparison with informational devices, with useful conclusions, both to understand their functionality as well as to mimic the design of natural biologic organisms in artificial systems.

In a larger sense, information can therefore be defined as a result of an operation, of a change within a system, which is determined by physical, chemical, biological or mathematical laws. In mathematics, an operation gives a result, which is a (new) event/news –information. In a physical, chemical or biologic system of interacting micro-particles/micro-components, the corresponding laws act on these micro-particles as informational operators, determining the absorption/"embodiment" or releasing/"disembodiment" of information (Gaiseanu, 2019b) by structuration/destructuration mechanisms, schematically represented by informational relation or a chain/cascade of relations, as expressed by the basic rel. (1).

As a result, it can be observed that both living and non-living structures contain hidden (embodied) information, which can be released (disembodied) by informational reactions of the type (1), so an universal triangle of reality can be defined, showing that – besides matter and energy – information is a fundamental constituent of the living world (Gaiseanu, 2021a) (green circle in Figure 2b) and of the non-living world (Gaiseanu, 2021b).

The Informational Model of the Human Body

On the basis of these specifications, the following informational systems can be distinguished in the human organism (Figure1 a and b) (Gaiseanu, 2019b): (i) CASI, defined as the *center of the acquisition and storing of information*, expressed by memory, connected mainly with the prefrontal cortex for short-term memory, with the hippocampus for long-term memory, and with the sensorial network as an informational input, the cerebellum being involved in memory of the mechanic-informational stereotypes; (ii) CDC, the *center of decision and command*, expressing the decision, connected mainly to the

prefrontal cortex and the mayor part of the cortex area for judgment, analysis and decision, and with the voluntary execution elements (EE) – muscles, in particular with the vocal system (Gaiseanu, 2019f) as an expression of the attitude – the output of reactive information; (iii) IES, defined as the *info-emotional system* managing emotions, connected with the limbic system (hippocampus, amygdala, hypothalamus) and with the hearth – the dynamic emo-sensitive feeder with nutrients for the tissues in permanent and momentary need (Gaiseanu, 2019f); with all of them (CASI+CDC+IES) connecting the organism to the external/internal reality for adaptation (Gaiseanu, 2019f).

Other informational components of the Informational System of the Human Body (ISHB), with distinct function as represented in Figure 1 (a) and (b), related to the body maintenance and its development or reproduction, are: (iv) MIS, defined as the *maintenance informational system* managing the metabolic processes, connected with the brain stem, and expressed especially as power and vitality; (v) GTS, the *genetic transmission system*, acting as a genetic informational output, manifested by sexual activity and managed by the hypophysis and hypothalamus; (vi) IGG, the *info-genetic generator*, which expresses/coordinates the genetic inheritance, acting as the genetic info-input of the body, with development and defense (immunity) functions (Gaiseanu, 2023b), depending on age and on the body circumstances, and managed basically by the hypophysis and hypothalamus (Figure 1b). Started from the fertilized egg and following the development of a new organism by body growth and cell differentiation in organs, the activity of IGG is continued with the development of the organism during the lifespan, including during ageing. The immunity system is an active part of IGG, working to defend the body against the foreign micro-organisms and any other kind of intruders, and is dispersed through the entire body as individual fighters – the "white" cells, circulating through blood and the lymphatic system, and coordinated by the hypothalamus and hypophysis axis (Figure 1(b). From the informational standpoint, these components compose the *programmed informational system* (PIS) of the human body, so PIS=(MIS+GTS+IGG), assuring its development/defense/maintenance and genetic transmission to offspring.

A special role in the ISHB is assumed by IC, which is defined within this *informational model of the human body* (IMHB) as the info-connection center. This selects/distributes the information in a binary YES/NO – acceptance/rejection mode, with respect to the internal criteria, warning on an error/deviation from the existing right/trusting/reliable life experience (Gaiseanu, 2019b), supported by the anterior cingulate cortex (ACC) (Gaiseanu, 2020d,e) (Figure 1 a and b). This behavior is demonstrated by electro-encephalographic experiments (Inzlight, 2011) indicating that ACC produces a 'distress signal' upon the detection of errors, conflict, and expectancy violation, called the error-related negativity (ERN). The posterior cingulate cortex also plays a role in the attention/orientation to the internal from the external world (Gaiseanu, 2020f) through daydreams disruption for the initiation of an introspection process of personal projects and planes for the future. Therefore, this center also acts as a discernment operator between certainty vs. uncertainty in the cognitive-exploration of reality and as a scrutinizer of the future, stimulating intuition and revelation (Gaiseanu, 2020a). In informational/device-type terms, this tool could be assimilated with a corrector against the induced errors on the communication channel/line at the receptor terminal, assuring the accurate interpretation/decoding of the signal, in accordance with the existing trust/reliable reference/experienced values.

The activity of the Informational System of the Human Body (ISHB) is expressed therefore as a combination of activity of all informational components described above as the following:

$$ISHB = \Big(CASI + CDC + IES\Big) + \Big(MIS + GTS + IGG\Big) + IC = OIS + PIS \tag{3}$$

where OIS=(CASI+CDC+IES)+IC is defined as the operative informational system for adaptation, and PIS=MIS+GTS+IGG is the programmed informational system, automatically working. With an automatic/inherited operability like PIS, but educable center, as a function of the acquirement of stable/verified/experienced decision criteria (Gaiseanu, 2018a), IC manages the information also in an automatic selective YES/NO manner, addressing it to the prefrontal cortex of CDC during the OIS connection to reality, serving therefore as a right error-free decision/orientation control, which can be suggestively compared with an "info-navigator" of ISHB.

From the form of this informational system, it can be deduced and expressed the cognitive nature of consciousness, as a reflection/detection of the activity of ISHB at the info/mind interface, represented in the left side of Figure 1a by a vertical line, as follows: CASI=> *Iknow* (detected in mind as memory), CDC=> *Iwant* (decision), IES=> *Ilove* (one of the fundamental/significant driving/associative force of living), MIS=> *Iam* (self-status, power/vivacity/vitality, health), GTS=> *Icreate* (genetic/biological creation), IGG=> *Icreated* (structure and behavioral genetic inheritance, talents/predispositions), IC=> *Ibelieve* (trust, confidence, info-selective functioning based on mentality, inherited or experimentally confirmed acquired criteria for stable/trusting judgement (Gaiseanu, 2018a, 2019c).

With these definitions, and according to the Informational Model of Consciousness (IMC) (Gaiseanu, 2019b; Gaiseanu, 2020j), consciousness can be described by the awareness of the explored reality by the self (I, ego) as:

$$I = Iknow \div Iwant + Ilove + Iam + Icreate + Icreated + Ibelieve \tag{4}$$

expressed therefore by means of the activity of the seven cognitive centers described above.

A special discussion can be done on the info/mind interface, allowing the awareness process through the cognitive centers, taking as an example the sight sense. In the human, the circuitry involved in the sight sense occupies more than 50% of the cortex, so this is a very complex process (Hagen, 2012; Gaiseanu, 2021i; 2022f) used both for recording and recall of sight information. However, although the intimate mechanisms of the "displaying" of the recorded or memorized images on the mental "screen" are at present not well understood, it can be taken into account as a starting point for operability of the informational relation (1), which shows that the destructuration of micro-material complexes can allow the release of information which can be displayed on the "mental screen" (prefrontal cortex), which is actually the mental recorder *and* screen player of information. A fundamental role in the simultaneous integration of information from various senses is played by the thalamus, with a strategic position in the middle of the brain, accessing/administrating the internal and external information from various sources (Tononi et al., 2016).

The human body can accumulate/integrate information by epigenetic processes (Gaiseanu, 2019g). If the same signal or set of signals are insistently/repetitively/intensively applied, a long-term adaptation process is achieved, consisting in the acquirement of new (adaptive) traits and behaviors, without the genetic modification of the species features. Such a progressive process of transfer of information (=>) can be schematically described as: Info => CASI => CDC => IES => MIS (prototype motor-info abilities) => IGG => (GTS) ==> (transgenerational info-transfer to) (IGG) of offspring, which can explain a progressive evolution of species and of the informationally-assisted evolution of the brain (Gaiseanu, 2020e).

The Informational Model of Living Structures

The existence and the maintenance of all biologic organisms, not only that of humans, depends permanently on the connection with reality, either with the external one for finding material resources and for integrity defense, or with the internal states of their own body (hunger, thirst, pain, etc.), to fulfill momentary and long-term needs. At human, this is recognized by the detection though the regular sensors/senses. Although this is not so evident for the inferior organisms on the evolutionary/organization scale, in particular for the smallest living unit – the cell, or for plants, which do not dispose of a nervous system yet whose informational structure is similar with that of human.

This can be observed taking into account the structure and functions of the eukaryotic cell, the typical constituent of the animal and plant multicellular organisms (Figure 1 c and d). An external signal attaining surface receptors of the cell, transpasses the semitransparent membrane, only if this is suitable/complementary with the specific structure of the receptor (Alberts et al., 2015), as a binary (digital) YES/NO bit-type selective mechanism. Therefore, the surface receptors represent practically a local memory of the living cell structure as a part of a CASI system. This consists in the network of surface receptors, and in the genetic memory of the "dormancy" genes, which can be activated by external/internal signals to produce proteins and their specific functions. The activation is triggered by the initial signals which pass through the membrane, followed by a suitable response in the CDC circuits of the cell consisting typically in a cascade of reactive chains on specific reactive pathways (Figure 1 c). The surface receptors are also involved in the IC circuits, because they can/must guide the signal appropriately on the right circuitry to CDC informational system, according to the specific inherited tasks, as it is represented schematically in the same figure. The reactive pathways/micro-circuits are sharply defined by the intervention of scaffold proteins (Alberts et al., 2015), which control the sharp differentiation of such local trajectories to avoid interferences with other pathways (Gaiseanu, 2022f).

On the other hand, analyzing from the physiologic perspective the structure and functions of an eukaryotic cell, it can be observed that this disposes of all specific/typical components of the human body (Gaiseanu, 2021d). The metabolic processes (marked by interrupted horizontal line in Figure 1c) are managed by a MIS like in the human organism, automatically running specific chemical reactions on corresponding internal pathways in the cytoplasm body, engaging similar organelles like the corresponding organs in the human: vacuoles (food "reservoir") like a stomach, mitochondria like a "lung" of the cell producing energy from glucose in interaction with oxygen, the Golgi apparatus as a "heart"-like/blood vessels distributer of fluids in the cell body, and the endoplasmic reticulum and lysosomes with the role of lipid (fats) and insulin management, working as a precursor of the pancreas and spleen for degradation of obsolete products in human and animals.

The role of GTS is evidently played by multiplication, initiated by the replication mechanism (splitting of the DNA molecule in the nucleus), the role of IGG by transcription-translation mechanism, described schematically above by rel. (2). The plant cells are distinct from the cells of animals by a protective wall around the cell with a supporting role, and by an additional organelle – chloroplast (Figure 1d), for the preparation of glucose components directly by light-assisted processes and chlorophyll participation (Gaiseanu, 2022c). The high importance of the energetic/metabolic processes and their control is highlighted/manifested by the existence of DNA in mitochondria themselves, which can explain also the processes of aging due to a lower reliability of this local genetic system (Alberts et al., 2015), inducing a faster degradation of the info-communication. The functionality of the prokaryotic cells, the most

inferior organisms represented typically by bacterium, is similar with that of the eukaryotic cell shown in Figure 1c, but the distinction of the organelles in the body is not evident.

Resuming, CASI is thus represented in individual cells by the network of surface receptors (sensors) and the nucleus, the informational master of the cell, CDC by decisional network of the reactive pathways in the cytoplasm, IES from the human organism corresponding with an info-reactive sentient system (IRSS), and IC as represented by the selective network of the specific signals according to the specific and special tasks and functions of the cell within the collective multicellular organism, assuring the right designated functionality. IRSS is defined as a general *information reactive sentient system,* equivalent with IES in the human, and dedicated to "feeling" the reactive effects of information on the own body in any living structure.

IC of the cells in the multicellular organisms are definitely represented by the fulfillment of their specific tasks within their specific structure/organ. The immune cells of the human multicellular organism, as mobile and singular but interrelated components of the immune system, are the more suggestive/evident and representative examples of the dynamic functionality/fulfillment of their specific tasks (Gaiseanu, 2023b). Indeed, as was shown in these recent papers, the correlated work between the central processor (hypophysis-hypothalamus axis) and the individual immune cell, couldn't be operative without the info-communication and info-signalization basically by hormones and signaling molecules throughout the entire body. A dysfunction of IC induces a bad interpretation of signals, leading to dysfunctions of the cells manifested by allergic symptoms or diabetes, and disorders such as cancer, asthma and arthritis (Daruna, 2004; Goodwin, 2022), or even disorders of the central nervous system (Wraith & Nicholson, 2012). The sentient/reactive response (IRSS) is manifested in the involved cells themselves at the local level (inflammations), and also at the macro/central level (IES) of the organism by their effects and the associated symptoms.

Taking into account the similarly informational structure of the human body with that of the eukaryotic cell components, an *Informational System of the Human Body and Living Structures* (ISHBLS) can be defined as follows:

$$ISHBLS \,/\, \left(ISLS\right) = CASI + CDC + IES \,/\, \left(IRSS\right) + MIS + GTS + IGG + IC \tag{5}$$

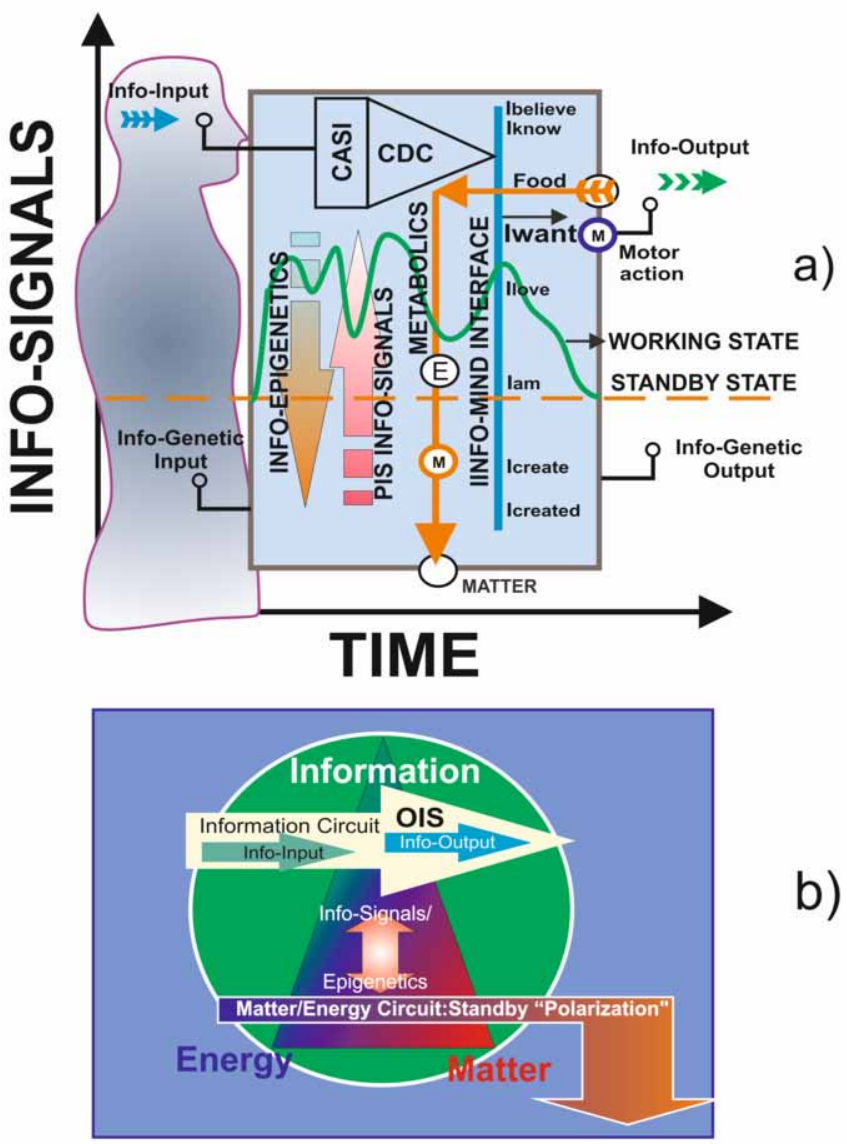
where IRSS refers to the informational reactive-sentience system in the *informational system of the living structures* (ISLS), which is expected to be different from IES, according to the species characteristics.

Human and Biological Structures as Informational Devices

According to the schematic representation in Figure 2, the human's and body's living organisms, from the simplest living structure – bacterium, to the most complicated one – the human, are complex informational systems, connected to matter/energy and information, that are able to detect, transduce, process, decide and produce information. Therefore, the living organisms work like informational devices (Gaiseanu, 2021k,l): the functions of living organisms are the results of the intimate informational processes in the body, which act as a "hardware" support of operational circuits and processes, creating an operational software.

In Figure 2a is represented schematically a diagram of the info-signals as a function of time, overlapped on a schematic representation of the ISHB and its projection in mind by the cognitive centers,

Figure 2. Schematic representation of human as an informational device (a) and as an informational system in the Universal Triangle of Reality for living structures



according to IMHB, under two basic situations: (1) the human body is disconnected from the external reality (OIS inactivated – sleeping state, so the consumption of energy (E) for automatic/motor (M) actions and chemistry is minimal); (2) when the human is (re)connected to reality (OIS activated), so under a working state, shown by the variable blue working line. The human "device" is prepared to learn by info-interchange CASI <=> CDC, and to "stock" it into the genetic system by epigenetic processes (shown by vertical up/down big arrow in Figure 2a), trans-generationally transmitted (GTS==> IGG of the offspring). As it is represented in the same figure by the vertical down/up big arrow, PIS transmits info-signals to CASI/CDC, allowing the permanent communication and evaluation of the internal

self-status and of the correct/incorrect functioning of the maintenance/physiologic of the "hardware" for further/appropriate adjustments.

The human can be regarded therefore as an informational "device" with four terminals: (1) an info-genetic input (IGG/Icreated) for the structuration of the material "hardware" connected to PIS – specifically to MIS/Iam for matter/energy achievement; (2) an info-genetic output (GTS/Icreate) for the transference of the genetic material to a zygote (fertilized egg cell); (3) an informational input, summing the activity of the multitude of sensors communicating information to CASI/Iknow; and (4) a decisional output (CDC/Iwant//IES/Ilove+IC), connected to the voluntary motor system (EE), which is expressed by attitude, as a result of a combined contributory response of all cognitive centers (Gaiseanu, 2020h, 2021m), among which the emotional one (IES/Ilove) is of a major/immediate importance.

Actually, any other living organism can be regarded as an informational device with similar informational terminals, with the distinction that IES is represented by IRSS, so an informational model of the human body and living structures (IMHBLS) can be defined. At human, OIS operates with mental/virtual information (Gaiseanu, 2021g) expressed by language, symbols and concepts. At subhuman organisms, communication with the environment and own or other species is achieved by a direct relation between the signal and instinctive reactions, as a rudimentary/impulsive response, which could be expressed by specific vocalization, posture and movements.

DISCUSSION: EVIDENCES SUPPORTING THE IMHBLS AND FUTURE RESEARCH DIRECTIONS

To discuss the IMHB and IMHBLS/IMLS from the informational/biological perspectives, it is useful/necessary to look to two main directions: the experimental evidences and studies supporting them from the biological point of view, and to the informational equivalence of the informational artificial devices for comparison and conceptual developments in these two branches. In the following section are presented experimental evidences supporting the activity of each component of the informational models, and according to their dynamic interaction.

Experimental Studies and Evidences Supporting the IMHBLS/IMLS

The self-structuration abilities driven by information are evident even from the development of a new individual from its native fertilized egg. The growth of a living structure of plants, animals and the human is initiated starting from a small "zipped"/compressed seed/egg grain/cell unit, which is driven by a priori "knowledge"/"know-how" designed project/algorithm, necessary/useful to "blueprint" the growing structure, otherwise such development being impossible. In the seed, where IGG is highly activated, in particular in that of a plant called *Arabidopsis (or thale cress)*, the info-activity of two groups of cells drives development: one of them promotes dormancy, another germination, and the intra-communication is assured by a hormonal mechanism (Tophama et al., 2017). The balancing between the excitatory/germinating and dormancy/inhibitory states is operated therefore by contrary/complementary YES/NO functions, even at this elementary level (Gaiseanu, 2022c). In a suggestive way, the running of the informational system of genes can be compared with that of a musical organ or piano, where the constituent

tubes/strings under dormancy states are specifically activated by keyboards/pedals, which control the input signals and give rise/trigger an orchestrated response of structuration/functionality of the body.

Maybe surprisingly, but experimentally determined (Kondev, 2014), with a composition of about one million proteins and a few million base pairs of DNA, as well as RNA molecules, lipids, sugars, inorganic salts, and water in a micron-sized container, bacterium – considered the "simplest" (prokaryotic) unicellular independent living organism, is endowed with a sensing system (CASI according to IMLS) connected to the environmental reality, able to detect and process the information for decision making (CDC), performing the most elementary but efficient cognitive functions like: interpretation of (chemical) messages; differentiation between internal and external information as a self/non-self distinction; the ability to sense and communicate with the other individual cells within a collective colony – like a multi-cellular organism able of spatiotemporal synchronization with geometric orientation (IC) (Gaiseanu 2020c, 2021e) (known as Quorum sensing)**;** learning and performance of specific tasks (Jacob et all., 2006)**;** and, moreover, the ability to make decisions (CDC) on where and when to swim (EE), what to eat (MIS), and when to divide (GTS/IGG) (Kondev, 2014), how to direct their trajectory as a function of concentration of nutrients (food chemotaxis) (CDC/EE) by a ''sniffing before eating'' (sequential measurement of food concentration (CASI)), and to activate some suitable dormant gene for the appropriate enzyme production for suitable digestion (MIS) (Jacob et al., 2006; Shapiro, 2020). The info-communication is carried out by biochemical informational agents, from simple molecules to polymers, peptides, complex molecules, proteins and genetic compounds like plasmids (circular extracromosomal DNA molecules replicating independently) and bacteriophages viruses (Jacob et al., 2006).

Plants and the other living organisms without a nervous system are reactive/sensitive systems too. The unicellular organisms are able to drive their own life without a nervous system, only on the basis of info-reactive (OIS) response with IC participation and the gene activation processes. Plants enter also into such a category of organisms. Although static structures, they are also capable of communicating by electrical conductive channels (Debono, 2013a), comparable in some cases with a protoneural network (Debono, 2013b), or by a constant spontaneous emission of low voltage potentials allowing cognitive functions, learning capabilities, and intelligent behaviors (Debono & Souza 2019). Through thee processes, plants dispose of a large range of sensory elements (CASI) and reactive capabilities (CDC/IRSS), modulating their development (PIS) by plasticity processes, even if such an expressivity is slower than that of animals. Although not always, because more than 600 carnivore plant species can catch their victims quickly with their EEs, showing cognitive-sentience qualities by their real-time exhibited reactions (Gaiseanu, 2022c,d). Experimental evidences show that plants dispose of more than twenty cognitive-sensitive capabilities (Gaiseanu, 2022d), referring to info-communication by sensitive network detecting humidity/humidity gradients, light/light intensity, electrical signals and vibrations, gravity and electromagnetic fields, and volatile chemical components, activating the pollination (GTS) and defense against predators (IRSS/CDC) through intervention/interaction with eco-system external agents (animals, insects), or with themselves (internal damage signalization (IRSS/CASI) of wounded leaves) (Gaiseanu, 2022d). Plants are sensitive to numerous mechanical signals like gravitropic, thigmomorphic, thigmotropic, self-loading, growth strains, turgor pressure, xylem pressure potential, and mechanical vibrations of sound (Telewski, 2006) and light receptors/sensing networks (CASI), responding/reacting (IRSS/CDC) in function of circumstances through auxin hormone modulation as an info-communication agent, which monitors their plasticity/body shape (MIS), germination (IGG), and flowering (GTS) (Gaiseanu, 2022c,f).

The eukaryotic cells dispose of organelles with similar functions/operability like the organs of the human and animals. Studies of plants show that plants dispose also of organs with specialized functions which assure their similar operability, "intelligently" adapted to the local/specific living conditions/ substrate. With their "head" (roots) in the soil to absorb directly the necessary basic nutrients, the "neck" (stem) and sexual (flowers/seeds) and metabolic organs (leaves) in the air, they absorb light and inter-communicate/"collaborate" with pollinators from the animal kingdom for reproduction (Gaiseanu, 2022c,d), in this way completely fulfilling their needs. The complexity of the "head"-like organ is demonstrated by the complex functions of their roots (Gaiseanu, 2022f): the root apex transition zone seems to make timely decisions and solve problems concerning the optimal orientation (Baluška et al., 2004; Debono, 2013a) and, like a "brain" center, also managing the local lung-like respiration, pumping water with nutrients as a "heart"-like device, and maintaining/managing the physiological/hormonal balance/ info-communication by means of auxin-like "neurotransmitter" and plasmodesmata – neuro-gap-like junctions throughout the entire plant (Alberts et al., 2015).

The existence of a specific level of cognition of any living structure, promoted by the informational model of living structures (IMLS) (Gaiseanu, 2022f), is appropriately supported by a recent study showing that stochastic fluctuations in the expression of genes allow a cell to exhibit a kind of free will (Kondev, 2014). With an operative system supported by the nervous structure and detection senses (sight, hearing, touch, smell, taste), animals exhibit evident and relevant structural and functional characteristics (Shettleworth, 2010), as described by IMHBLS. However, if their sensorial system (CASI) is compared carefully with that of inferior organisms on the evolutionary scale, a similar sensitivity can be observed: (i) the chemical composition and composition gradient (chemotaxis) of bacteria and plants could be assimilated with smell; (ii) touch is a communication tool characteristic to cells in multicellular organisms and evident to some sensitive (carnivore) plants; (iii) the sensitivity to light and to vibrations (sound is one of them) is also a common sensing for plants; (iv) the selection of GOOD/BAD concerning the chemical acceptance/rejection of the foods ("taste") is evident in bacteria; and (v) the chemically-based mood origin at human determined by neurotransmitters could be also similar to animals and even more to other inferior organisms, even that they dispose of other chemically-based mechanisms, which is shown for instance by the reactive movement of bacteria (IRSS) toward or faraway of accepted/detected chemical source. Therefore, when the concept of cognition is discussed during cognitive/decisional/ sentience acts, more evident for animals but not so evident at the inferior organisms without a nervous system, it is necessary to strictly differentiate the cognition at human from the species (Bräuer et al., 2020). The connection to reality of each of them depends on the informational limited and specific window through which each living individual/species perceives and interprets the reality, on their own info-processing available/complexity tools, and on the available/adaptation instruments of expression/ behavior (Gaiseanu, 2022f,g).

The structure of the informational system of animals (described by IMLS), endowed with a nervous system, is well supported by evidences. Emotions are expressible by the impulsive movements and their initiation on the entire scale evolution (Frijda, 2016). The alarm impulses triggered in humans and mammals by the amygdala have an ancestral origin, existent even in bacteria and inferior organisms by the development of repulsive action practiced within the attractive/repulsive YES/NO – GOOD/ BAD decisional experiences, acquired and transmitted throughout generations. Such a characteristic is evidenced also in bacteria and plants, as exhibited above. Actually, emotional regulation is part of the regulatory processes of cells and multicellular organisms (Peil, 2014, 2015), with participation of the

info-communication by chemical agents. At human, the neurotransmitters induce various mood states depending on their nature and concentration (Gaiseanu, 2021j), determining a local or general equilibrated/non-equilibrium state (Gaiseanu, 2020g), obtained by the competition between excitatory/inhibitory activation/inhibition YES/NO mechanisms, so their imbalance could determine bipolar dysfunctions and diseases: noradrenaline increases alertness/arousal. A high concentration of norepinephrine can trigger a false sense of superiority and invincibility/impulsivity or depressive states and non-ability at low concentration since serotonin regulates happiness.

IC is evidenced in plants and animals by the following features: the migration/orientation effectiveness of some species of insects and birds, like the navigation and precise orientation of the bees and pigeons, the precise tool-using by crows to obtain foods, and the spatial/migratory orientation of fishes and bats (Shettleworth, 2010). In plants, IC is manifested by light/sun orientation, by anticipative ability of roots to avoid the obstacles (Gaiseanu, 2022c,d; Nick & Schäifer, 1988; Gruntman et al., 2017), in some species of animals by the danger anticipation, in particular the detection of the weather change and natural perilous phenomena (Gaiseanu, 2021f), and also to comprise solutions to various problems in confrontation/interaction with reality, according to inherited or acquired experience. A relevant example of IC expression is represented by the orientation of the immune cells in the human and subhuman organisms to the right place where they should intervene, and the precision of task execution, which otherwise could be transduced in undesired effects (Daruna, 2004).

According to recent reported results, the decisional reactivity, even a given "fate" of the individual cells in multicellular organisms, is a universal characteristic of biological organisms (Balázsi et al., 2011), even from bacteriophages viruses, bacteria, yeast, lower metazoans to mammals. This is achieved during interaction with the environmental by OIS, through the specific informational 'window' from the entire informational spectrum permitted by their own informational tools, according to the specific tasks of each cell in multicellular organisms. From this point of view, IC acts as a selector of certainty vs. uncertainty within the process of exploration and interpretation of reality, which in the human being, as well as in subhuman organisms, is consolidated by learning processes during the interactive YES/NO educational mechanism. The integration of information during the epigenetic process is actually a learning/educational mechanism applied during the interaction with reality, and this is a key of adaptability and evolution of living organisms. As it was recently demonstrated (Gaiseanu, 2023b), the activity of the immunity system in humans and mammals demonstrates relevant evidences of the informational structure stipulated by the IMHBLS, showing that dysfunctions of activity of IC of the immune cells, devoted to assure the fulfillment of the required specific task, produce allergies, diabetes, chronic inflammations, and other undesired diseases.

As represented in Figure 1c, all living organisms are connected to matter, which is used as energetic support and elemental material for the structuration processes. The basic reaction for the achievement of energy (E) is assured by the conversion of the adenosine diphosphate (ADP) into adenosine triphosphate (ATP). This process is controlled by a critical value of the concentration of ADP and ATP: when the concentration of ATP is insufficient, the ATP synthesis is initiated, whereas when this is sufficient, the conversion is stopped, so that such a mechanism is manifested as a switching YES/NO operability, controlled by the ratio (ADP)/(ATP) between the concentration of these two reacting components (Gaiseanu, 2020c, 2021a,e). The chemical bonding breakdown of food compounds, consisting basically in carbohydrates, fats, proteins in animal cells, and glucose as a result of photosynthesis in the chloroplast in the case of the cell plants, is a process releasing energy assisted by oxidation in mitochondria, followed by elimination of wastes (uric acid, various molecular rests, water, dioxide carbon) (Gaiseanu, 2020c,d),

like in the human/subhuman multicellular organism (Gaiseanu, 2020c; 2022f). The importance of the informational control of energy production is highlighted by the existence of an additional DNA center in the mitochondria, acting as an autonomic informational generator, which originates from a presumable endosymbiotic relationship (the living of an organism in another) in ancestral time between the primitive eukaryotic cell and a prokaryotic cell (bacterium) (Alberts et al., 2015). The damages accumulated by the genome of mitochondria is a contributing process to ageing (Gaiseanu, 2022f).

Future Research Directions

Starting from the obtained results and applications (2023a), the informational models presented here open new directions of researches in a large category of fields in: (i) philosophy, referring to the mind-body relation (Gaiseanu, 2021d) as an information/matter solution and to the nature of mind and consciousness (Gaiseanu, 2023c); (ii) neuroscience/neurology/psychiatry/psychology, concerning the euro-circuitry of information corresponding to the cognitive centers (Gaiseanu, 2019e,f; 2021i), their inter-correlation (Gaiseanu, 2020h; 2021m), the detection/determination of the failure effects on psyche (Gaiseanu, 2020c, 2021d,j,o), and recovery therapies (Gaiseanu, 2020i); (iii) immunology, concerning the inter-relation between the brain, the mobile composing cells and immobile components and circuits (Gaiseanu, 2023b); (iv) biology and life science (Gaiseanu, 2021e; 2020c), concerning the structuration and functioning of the informational system of various categories of the living structures in the unicellular and multicellular vegetable and animal kingdom; (v) bioengineering/biotechnology and microbiology, biostatistics/biometrics (Gaiseanu, 2021c; 2022a), up to design and achievement of biocompatible artificial structures (Gaiseanu, 2020j; 2023d).

CONCLUSION

Showing that the structuration and communication within the same living structure is based on the matter-related information, as a result of the configuration/reconfiguration of parts of complex compounds of the body as informationally-assisted processes of absorption/release of information, the comparative analyzing in terms of information of the biological structures of human/sub-human and of the eukaryotic cells, allowed to deduce that the functional/informational organization is the same for all living structures on the entire biological scale, which can be described by the informational model of the human body and living structures (IMHBLS). At human, the perceived informational reality is converted/translated in words/conceptual/virtual information, allowing external communication with the community. The basic informational structure of living organisms consists in a programmed system and in an operative informational system, the first one assuring the maintenance and the reception/transmission of the genetic information, and the second one the interconnection with internal and external reality for adaptation.

The binary/elemental YES/NO informational unit is fundamental to explain the structuration, and the functions and functionality of human/sub-human organisms, from the simplest unicellular organisms of prokaryotic and eukaryotic cells to the most developed multicellular organized structures, plants and animals. This is actually the key of the functionality and structuration of living organisms, because this simple but fundamental balance between these binary alternatives determines the basic process of dynamic steady-state equilibrium, the key for the existence and survival of such systems. Any deviation from the equilibrium with self and the surrounding environment, which is actually equivalent with an

informational signal, triggers input chain processes tending to re-establish this equilibrium by an adequate reaction/response. Basically, the matter-related needs are that which determine the development of the morphological/functional structure/behavior, allowing body plasticity and info-communication with the environment for adaptation and survival. The connection to information is a fundamental working key for the exploration of external/internal reality, necessary first of all for the maintenance and development of the individual living structure, stimulated/determined actually by the necessity of connection to material resources. The external environment information is operated on a short-time scale and integrated on a large-time scale in the momentary and stable/genetic memory respectively, with the living organisms acting as an informational device/"pump" with four terminals as a reactive absorbent/releaser of information.

These findings are well supported by the experimental evidences on the entire evolution/organization scale, and open large bases/gates for new and effective developments on still stagnant fields of neurosciences, consciousness and related branches, with positive stimulatory directions in biotechnology/bioengineering and AI interested domains.

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REFERENCES

Alberts, B., Johnson, A., Lewis, J., Morgan, M., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). Garland Science, Taylor &Francis Group.

Balázsi, G., van Oudenaarden, A., & Collins, J. J. (2011). Cellular decision making and biological noise: From microbes to mammals. *Cell*, *144*(6), 910–925. doi:10.1016/j.cell.2011.01.030 PMID:21414483

Baluška F., Mancuso, S., Volkmann, D. & Barlow P. (2004). Root apices as plant command centres: The unique 'brain-like' status of the root apex transition zone. *Biologia, Bratislava, 59*(13), 1-13.

Bräuer, J., Hanus, D., Pika, S., Gray, R., & Uomini, N. (2020). Old and new approaches to animal cognition: There is not "one cognition". *Journal of Intelligence*, *8*(28), 1–25. doi:10.3390/jintelligence8030028 PMID:32630788

Daruna, J. H. (2004). *Introduction to psychoneuroimmunology*. Elsevier Academic Press.

Debono, M. W. (2013a). Perceptive levels in plants: A yransdisciplinary challenge in living organism's plasticity. *Transdisciplinary Journal of Engineering & Science*, *4*(1), 21–39. doi:10.22545/2013/00044

Debono, M.W. (2013b). Dynamic protoneural networks in plants: A new approach of spontaneous extracellular potential variations. *Plant Signaling & Behavior, Landes Bioscience, 8*(6), 1-39.

Debono, M.W., & Souza, G.M. (2019). Plants as electromic plastic interfaces: A mesological approach. *Progress in Biophysics and Molecular Biology, 146*, 123-133.

Dougal, R. C. (2015). Kelvin, Maxwell, Clausius and Tait: The correspondence of James Clerk Maxwell. *WIT Transactions on State of the Art in Science and Engineering*, *89*, 136–151. doi:10.2495/978-1-84564-149-8/005

Draganescu, M. (1990). *Informatia materiei [Information of matter]. In Editura Academia*. Română.

Filip, F. G. (2020). DSS—A class of evolving information systems. In G. Dzemyda, J. Bernatavičienė, & J. Kacprzyk (Eds.), *Data science: New issues, challenges and applications. Studies in computational intelligence, 869* (pp. 253–277). Springer.

Filip, F. G. (2021). Automation and computers and their contribution to human well-being and resilience. *Studies in Informatics and Control*, *30*(4), 5–18. doi:10.24846/v30i4y202101

Filip, F. G. (2022). Collaborative decision-making: Concepts and supporting information and communication technology tools and systems. *International Journal of Computers, Communications & Control*, *17*(2), 1–10. doi:10.15837/ijccc.2022.2.4732

Frijda, N. H. (2016). The evolutionary emergence of what we call "emotions". *Cognition and Emotion*, *30*(4), 1–12. doi:10.1080/02699931.2016.1145106 PMID:26943795

Gaiseanu, F. (2018a). Destiny or free will decision? A life overview from the perspective of an informational modeling of consciousness part II: Attitude and decision criteria, free will and destiny. *Gerontology & Geriatric Studies, 4*(1), 1-7. https://crimsonpublishers.com/ggs/pdf/GGS.000576.pdf

Gaiseanu, F. (2018b). Information: From philosophic to physics concepts for informational modeling of consciousness. *Philosophy Study, 8*(8), 368-382. http://www.davidpublisher.org/Public/uploads/Contribute/5c06323653cd2.pdf

Gaiseanu, F. (2019a). Language patterns and cognitive-sentient reality: Certainty/uncertainty in cognitive-sentient exploration of reality. In S. B. Schafer (Ed.), *Media models to foster collective human coherence in the PSYCHecology*. IGI Global. doi:10.4018/978-1-5225-9065-1.ch003

Gaiseanu, F. (2019b). The informational model of consciousness: Mechanisms of embodiment/disembodiment of information. *NeuroQuantology: An Interdisciplinary Journal of Neuroscience and Quantum Physics*, *17*(4), 1–17. doi:10.14704/nq.2019.17.4.2009

Gaiseanu, F. (2019c). Destiny or free will decision? A life overview from the perspective of an informational modeling of consciousness part I: Information, consciousness and life cycle. *Gerontology & Geriatric Studies, 4*(1), 1-7. https://crimsonpublishers.com/ggs/pdf/GGS.000586.pdf

Gaiseanu, F. (2019d). The silent voice of those who are no longer: Transgenerational transmission of information from the perspective of the informational model of consciousness. *Gerontology & Geriatric Studies*, *5*(1), 482–488. doi:10.31031/GGS.2019.05.000604

Gaiseanu, F. (2019e). Informational mode of the brain operation and consciousness as an informational related system. *Archives in Biomedical Engineering & Biotechnology, 1*(5), 1-7. https://irispublishers.com/abeb/pdf/ABEB.MS.ID.000525.pdf

Gaiseanu, F. (2019f). Informational neuro-connections of the brain with the body supporting the informational model of consciousness. *Archives in Neurology & Neuroscience, 4*(1), 1-6. https://irispublishers.com/ann/pdf/ANN.MS.ID.000576.pdf

Gaiseanu, F. (2019g). Epigenetic information-body interaction and information-assisted evolution from the perspective of the informational model of consciousness. *Archives in Biomedical Engineering & Biotechnology*, *2*(2), 1–6. doi:10.33552/ABEB.2019.02.000532

Gaiseanu, F. (2020a). Informational structure of the living systems: From philosophy to informational modeling. *Philosophical Studies*, *10*(12), 795–806. doi:10.17265/2159-5313/2020.12.004

Gaiseanu, F. (2020b). Information-matter bipolarity of the human organism and its fundamental circuits: From philosophy to physics/neurosciences-based modeling. *Philosophy Study, 10*(2), 107-118. http://www.davidpublisher.com/Public/uploads/Contribute/5e5b3d8e74433.pdf

Gaiseanu, F. (2020c). What is life: An informational model of the living structures. *Biochemistry and Molecular Biology, 5*(2), 18-28. https://www.sciencepublishinggroup.com/j/bmb

Gaiseanu, F. (2020d). Informationally-assisted equilibrium and health: Specific ACC contribution from the perspective of the informational model of consciousness. *EC Psychology and Psychiatry J., 9*(5), 37-49. https://www.ecronicon.com/ecpp/ECPP-09-00692.php

Gaiseanu, F. (2020e). Information based hierarchical brain organization/evolution from the perspective of the informational model of consciousness. *Archives in Neurology & Neuroscience*, *7*(5), 1–9. doi:10.33552/ANN.2020.07.000672

Gaiseanu, F. (2020f). Info-relational cognitive operability of the posterior cingulate cortex according to the informational model of consciousness. *International Journal of Psychological and Brain Sciences*, *5*(4), 61–68. doi:10.11648/j.ijpbs.20200504.12

Gaiseanu, F. (2020g). Informationally-assisted equilibrium and health: Specific ACC contribution from the perspective of the informational model of consciousness. *EC Psychology and Psychiatry J., 9*(5), 37-49. https://www.ecronicon.com/ecpp/ECPP-09-00692.php

Gaiseanu, F. (2020h). Attitude as an expressible info-operational reaction to a perceived/purposed object/objective. *International Journal on Neuropsychology and Behavioural Sciences*, *1*(1), 12–16. doi:10.51626/ijnbs.2020.01.00002

Gaiseanu, F. (2020i). Multitask music-based therapy optimization in aging neurorehability by activation of the informational cognitive centers of consciousness. *Gerontology & Geriatrics Studie*s, *6*(3), 621-625. https://crimsonpublishers.com/ggs/fulltext/GGS.000639.php

Gaiseanu, F. (2020j). *Fizica constiintei si a vietii: Modelul informational al constiintei-Informatia in neurostiinte, biocomputeresi biosisteme* [Physics of consciousness and life: Informational model of consciousness-information in neurosciences, biocomputers and biosystems]. Omni Scriptum International Group.

Gaiseanu, F. (2021a). Evolution and development of the information concept in biological systems: From empirical description to informational modeling of the living structures. *Philosophical Studies*, *11*(7), 501–516.

Gaiseanu, F. (2021b). *Information in the universal triangle of reality for non-living/living structures: From philosophy to neuro/life sciences*. Academic Press.

Gaiseanu, F. (2021c). Information in biological structures and big data assisted prediction as informational biostatistics/biometric tool for pandemic COVID-19 investigation. *Annals of Biostatistics & Biometric Applications*, *4*(3), 1–3.

Gaiseanu, F. (2021d). Solution to the mind-body relation problem: Information. *Philosophical Studies*, *11*(1), 42–55.

Gaiseanu, F. (2021e). Information as an essential component of the biological structures and their informational organization. *Journal of Microbiology and Biotechnology*, *6*(2), 1–9. https://medwinpublishers.com/OAJMB/information-as-an-essential-component-of-the-biological-structures-and-their-informational-organization.pdf

Gaiseanu, F. (2021f). Advanced perspectives in biological researches: Info-operability of the cell and human/multicellular organisms. *Acta Scientific Biotechnology*, *2*(7), 1–5.

Gaiseanu, F. (2021g). Information, info-creational field, creativity and creation, according to the informational model of consciousness. *International Journal on Neuropsychology and Behavioural Sciences*, *2*(3), 75–80. doi:10.51626/ijnbs.2021.02.000017

Gaiseanu, F. (2021h). New investigation perspectives in psychology and behavioral sciences: Informational activity and psychological/behavioral expression of the cognitive centers of consciousness. *International Journal on Neuropsychology and Behavioural Sciences*, *2*(4), 99–102.

Gaiseanu, F. (2021i). Neuropsychological response to information of beauty/ugly brain circuits according to the informational model of consciousness. *International Journal on Neuropsychology and Behavioural Sciences*, *2*(2), 1–6.

Gaiseanu, F. (2021j). Pathological expression and circuits in addiction and mood disorders: Informational relation with the brain and info-therapy. *EC Neurology*, *13*(8), 1–12.

Gaiseanu, F. (2021k). Human as an informational device. *Archives in Biomedical Engineering & Biotechnology, 6*(1), 1-8. https://irispublishers.com/abeb/pdf/ABEB.MS.ID.000629.pdf

Gaiseanu, F. (2021l). New perspectives in biomedical engineering and biotechnology: Information in human and biological structures. *Archives in Biomedical Engineering and Biotechnology, 6*(1), 1-3. doi:10.33552/ABEB.2021.06.000633

Gaiseanu, F. (2021m). Evaluating attitude and behavior: An info-operational procedure related/supported by the cognitive centers of mind. *International Journal on Neuropsychology and Behavioural Sciences*, *2*(1), 1–5.

Gaiseanu, F. (2021n). *Informational model of consciousness and life, information as a constitutive element of the living systems: From philosophy to modeling and application.* Presentation at Romanian Academy, Science and Technology of Information. https://academiaromana.ro/sectii/sectia14_informatica/sti/info_even.htm

Gaiseanu, F. (2021o). Mental aggressive operability from informational perspective: A deterrence manifesto. *EC Neurology, 13*(4), 31-39. https://www.ecronicon.com/ecne/pdf/ECNE-13-00879.pdf

Gaiseanu, F. (2022a). Virus-inducing informational processes vs. cell antivirus info-sensitivity and implication of the biostatistics/biometric applications in the detection/prediction of the Covid-19 infections. *Annals of Biostatistics & Biometric Applications*, *4*(3), 1–5.

Gaiseanu, F. (2022b). What we know/need to know about information in plants and animals. *Journal of Biotechnology & Bioresearch*, *4*(1), 1–4. https://crimsonpublishers.com/jbb/pdf/JBB.000576.pdf

Gaiseanu, F. (2022c). Information in plants: The informational model of the plant cells and plant structures. *Cell Biology (Henderson NV)*, *10*(1), 31–40. doi:10.11648/j.cb.20221001.14

Gaiseanu, F. (2022d). Let's leave the prejudices: Plants are informational systems, living their life. *Advances in Agriculture, Food*. *Scientia Forestalis*, *10*(2), 1–5. doi:10.51268/2736-1799.22.10.076

Gaiseanu, F. (2022e). Information as a coherent/effective investigation concept/strategy to approach the Biotechnology Scientific and Technical Research. *Acta Scientifica Biotechnolog*y, *3*(1), 28-33. https://actascientific.com/ASBT/pdf/ASBT-03-0124.pdf

Gaiseanu, F. (2022f). The cognitive-sentient exploration of mediated reality: From proto-cognition/epigenetic informational processes to big data assisted prediction. In S. B. Shafer & A. Bennet (Eds.), *Global media's preternatural influence on global technological singularity, culture, and government* (pp. 193–213). IGI-Global. doi:10.4018/978-1-7998-8884-0.ch010

Gaiseanu, F. (2022g). Information-body relation and information as a solution of the consciousness problem in the biological structures. *Philosophy Study, 12*(5), 287-303. https://www.davidpublisher.com/Public/uploads/Contribute/62aa94b6238d1.pdf

Gaiseanu, F. (2023a). Information: From cognitive-sentient exploration of reality to predictive big data assisted informational era. *Romanian Journal of Information Science and Technology*, *26*(1), 78–99. doi:10.59277/ROMJIST.2023.1.06

Gaiseanu, F. (2023b). Cellular info-operability: Micro/macro-scale inter-communication in the immune system of the human/mammalian organism. *Annals of Biostatistics & Biometric Applications*, *5*(1), 1–7. doi:10.33552/ABBA.2023.05.000605

Goodw, M. M. D. (2022). *How the immune system works. Medically reviewed By Tim Newman.* https://www.medicalnewstoday.com/articles/320101

Gruntman, M., Groß, D., Májeková, M., & Tielbörger, K. (2017). Decision-making in plants under competition. *Nature Communications*, *8*(2235), 1–9. PMID:29269832

Hagen, S. (2012). *The mind's eye – How do we transform an ever-changing jumble of visual stimuli into the rich and coherent three-dimensional perception we know as sight? Rochester vision scientists are helping reshape our understanding of how the brain 'sees'.* University of Rochester. https://www.rochester.edu/pr/Review/V74N4/0402_brainscience.html

Jacob, E. B., Shapira, Y., & Tauberd, A. I. (2006). Seeking the foundations of cognition in bacteria: From Schröinger's negative entropy to latent information. *Physica A*, *359*, 495–524. doi:10.1016/j.physa.2005.05.096

Jiang, Y., & Xu, C. (2010). The calculation of information and organismal complexity. *Biology Direct*, *5*(59), 1–17. doi:10.1186/1745-6150-5-59 PMID:20937149

Kasman, L. M., & Porter, L. D. (2022). *Bacteriophage*. NCBI Bookshelf, StatPearls Publishing LLC. https://www.ncbi.nlm.nih.gov/books/NBK493185/)

Kondev, J. (2014). Bacterial decision making. *Physics Today 67*(2), 31-36. https://physicstoday.scitation.org/toc/pto/67/2

Lodish, H., & Berk, A. (2008). *Molecular cell biology* (8th ed.). W. H. Freeman.

Nick, P., & Schäifer, E. (1988). Spatial memory during the tropism of maize (Zea mays L.) coleoptiles. *Planta*, *175*, 380–388. doi:10.1007/BF00396344 PMID:11540759

Peil, K. T. (2014). Emotion: The self-regulatory sense. *Global Advances in Health and Medicine: Improving Healthcare Outcomes Worldwide*, *3*(2), 80–108. doi:10.7453/gahmj.2013.058 PMID:24808986

Peil, K. T. (2015). Emotional sentience and the nature of phenomenal experience. *Progress in Biophysics and Molecular Biology*, *119*(3), 545–562. doi:10.1016/j.pbiomolbio.2015.08.003 PMID:26272799

Rajaure, M., & Adhya, S. (2019). Molecular Basis of Phage Communication. *Molecular Cell*, *74*(1), 1–2. doi:10.1016/j.molcel.2019.03.015 PMID:30951649

Schrödinger, E. (1944). *What is life? The physical aspect of the living cell*. Cambridge University Press.

Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*. https://en.m.wikipedia.org/wiki/Genome

Shapiro, J.A. (2021). All living cells are cognitive. *Biochemical and Biophysical Research, Communications*, 134-149. . doi:10.1016/j.bbrc.2020.08.120

Shettleworth, S. J. (2010). *Cognition, evolution, and behavior* (2nd ed.). Oxford University Press.

Szilard, L. (1929). On the decrease of entropy in a thermodynamic state by the intervention of intelligent beings. *Zeitschrift fur Physik*, *53*, 840–856. doi:10.1007/BF01341281

Telewski, F. W. (2006). A unified hypothesis of mechanoperception in plants. *American Journal of Botany*, *3*(10), 1466–1476. doi:10.3732/ajb.93.10.1466 PMID:21642094

Tononi, G., Boly, M., Gosseries, O., & Laureys, S. (2016). The neurology of consciousness: An overview. In S. Laureys, O. Gosseries, & G. Tononi (Eds.), *The neurology of consciousness* (2nd ed., pp. 407–461). doi:10.1016/B978-0-12-800948-2.00025-X

Topsham, A. T., Taylora, R. E., Yanb, D., Nambarab, E., Johnstona, I. G., & Bassela, G. W. (2017). Temperature variability is integrated by a spatially-embedded decision-making centre to break dormancy in Arabidopsis seeds. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(25), 6629–6634. doi:10.1073/pnas.1704745114 PMID:28584126

Wraith, D., & Nicholson, L. B. (2012). The adaptive immune system in diseases of the central nervous system. *The Journal of Clinical Investigation*, *122*(4), 1172–1179. doi:10.1172/JCI58648 PMID:22466659

ADDITIONAL READING

Gaiseanu, F. (2022h). Info-activity of the immune system from the perspective of the informational model of the human body and living structures. *International Journal of Frontline Research in Life Science*, *1*(2), 1–12. doi:10.56355/ijfrls.2022.1.2.0025

Gaiseanu, F. (2023). From micro to macro complexity organization scale of the living organisms, their informational structure/functions are the same. *Annals of Biostatistics & Biometric Applications*, *5*(3), 1–12. doi:10.33552/ABBA.2023.05.000614

Gaiseanu, F. (2023c). What is mind, what is consciousness, and where this resides. *Philosophy Study, 13*(3), 103-120. https://www.davidpublisher.com/Public/uploads/Contribute/647027490c94a.pdf

KEY TERMS AND DEFINITIONS

Big Data: A computational domain of the artificial intelligence for analysis and systematical extraction of information from large/complex data sets which cannot be already processed by the traditional application software. Useful also in genomic analysis and predictions (Gaiseanu, 2020f).

Cognition: The process/ability of a biologic organism to perceive, acquire and store information/knowledge from external and internal sources and to understand/interpret them (Gaiseanu, 2019a, 2022d, 2022f).

Cognitive Sentience: The ability of the living organisms to explore reality, involving the informational system of the organism, as a tool of experience and knowledge for the perception/interpretation/understanding of information and informational sources, according to the organism's own criteria and needs for survival (Gaiseanu, 2019a).

Epigenetic/Epigenetic Processes: Modifications and associated operations in the genetic system due to persistent/repetitive/intensive changes/cues of the external conditions as informational sources, which do not involve, however, alterations of the genetic system of species, and are reflected in new features and behaviors of adaptation transmissible to the next generations (Gaiseanu, 2019b, 2019d).

Eukaryotic Cell: A unicellular organism, the basic unit of multicellular organisms – plants and animals, with a nucleus enclosed within a nuclear envelope and distinct various organelles with specific

functions. Superior on the evolutionary scale to the prokaryotic cell (like bacterium), which does not have a nucleus and organelles, but similar informational functions (Gaiseanu, 2020c).

Gene: A DNA genetic unit as part of the chromosome (a threadlike structure of DNA in the cell nucleus), which allows the transference of the genetic information from parents to the offspring (https://en.m.wikipedia.org/wiki/Gene).

Genome: The complete set of genes in every cell of the body containing the full set of DNA genetic instructions for the reproduction of an individual, its development and growth (https://en.m.wikipedia.org/wiki/Genome).

Matter-Related Information: Information operated and supported by matter configuration/reconfiguration and material transport agents in biologic organisms (Gaiseanu, 2020a, 2020c, 2021g).

Plasmodesmata (Singular: Plasmodesma): Microscopic channels which traverse the cell walls of plant cells and some algal cells, enabling transport and communication between them (https://en.m.wikipedia.org/wiki/Plasmodesma).

Prokaryotic Cell: The simplest—although complex—single cell organism, with similar functions to the eukaryotic cell, living automatically as bacteria and archaea **(**Gaiseanu, 2019c).

Sentience: Capacity/ability of human and subhuman organisms to experience feelings/sensations as a consequence of the interaction with information, interpreted in the superior organisms as emotions and in the inferior organisms as a sensitive reaction to information (Gaiseanu, 2019a, 2022f).

Virtual/Conceptual Information: Expressed specifically by language at human by means of the learned internal "dictionary" for the interpretation of reality, and through the symbols created by humans, in particular in the sciences, arts and engineering. In a large sense, virtual information is actually that (re)composed by the perception during the cognitive-sentient exploration of reality and during recalling of information from memory, so the subhuman organisms operate also with virtual information (Gaiseanu, 2021g).

Virus: Parasite sub-living structures without their own metabolic system, operating/substituting by the host cell informational one (Gaiseanu, 2022a). Bacteriophages (or phages) are the most abundant viruses on earth, extremely diverse in size, morphology, and genomic organization, that infect and replicate only in bacterial cells (Kasman & Porter, 2022), and which communicate on molecular bases (Rajaure & Adhya, 2019).