Philosophy Study, May 2022, Vol. 12, No. 5, 287-303
doi: 10.17265/2159-5313/2022.05.006

Information-Body Relation and Information as a Solution of the Consciousness Problem in the Biological Structures

Florin Gaiseanu
Science of Information and Technology Bucharest (Romania) and Barcelona (Spain)

This paper approaches two main philosophical questions concerning the biological structures, from unicellular to multicellular organisms: one of them (i), referred to the information-body relation, as an extension of the mind-body relation at human, and another one (ii), to the consciousness problem, concerning the existence and nature of consciousness (if any), at the inferior organisms on the complexity scale, as this concept is known at humans. As philosophy benefits of the privilege to use data/concepts from other sciences to obtain philosophical conclusions, there were included detailed descriptions of some key biologic mechanisms, analyzed from informational perspective, necessary just to support/demonstrate/reinforce the informational nature/substrate of the mentioned relations. The analysis of the close relation between information and body, related to the structuration and functional properties of the biological organisms, from cells to multicellular structures, shows that all of them are able to "embody/disembody" information during/by structuration/destructuration processes of matter, in particular that of DNA/RNA/proteins, their functions appearing as a result of their informational capabilities to internally manage the inter-connection with environment, primarily due to their permanent dependence on the food resources and adaptation/survival needs. The experimental and theoretical studies, revealing/documenting on one hand the automatic management of maintenance metabolic processes, the reproduction, and growth/development, and on the other hand the adaptive decision-making/sentient processes as a responsive reaction to the environmental cues, show/support the consistency of the informational model of the human body and living structures on the entire biological scale, providing support to the informational solution of the stated problems (i) and (ii). A distinct attention is paid to plants, which are organisms without nervous system, but which show/manifest also informational capabilities to detect/react to information and to modulate their behavior accordingly. The question if the living organisms possess a pseudo/proto-consciousness level as a consequence of the informational activity of their body, distinct from human, but active in any biological structure under certain conditions is furthermore discussed, and a reliable definition of rudimentary pseudo/proto-consciousness level is given/described and compared with other empirical/theoretical concepts.

Keywords: information in biological structures, informationally-driven processes, structuration/destructuration, growth/differentiation/maintenance, functionality/informational structure, info-intra/inter-communication, cognitive

Conflict of Interest: No financial or conflict of interests.

Acknowledgment: To Adrian Gaiseanu and Ana-Maria Gaiseanu, with love; To the Romanian Academy, to all those willing to understand and acknowledge the fundamental role of information in living structures, and the Romanian contribution and priority in this field; To this Journal, for the professional publication; In memoriam to my loved parents, Emeritus Professors Emanoil and Florica Gaiseanu, and my brother, Professor Constantin Gaiseanu.

Florin Gaiseanu, Ph.D., Research Professor, Science of Information and Technology Bucharest (Romania) and Barcelona (Spain).

centers, proto/pseudo-consciousness problem

Introduction

Since thousands of years, the human and humanity try to understand the nature of life and consciousness, but surprisingly, even in our century, these questions remain not yet elucidated. The most part of the scientific community acknowledges that only the physics and chemical laws are not sufficient to describe the life processes, and even less the life as a specific phenomena, compared with the non-living structures. As consciousness is also a phenomenon which human can detect and describe, expressible by language and behavior (Peper, 2020), but not measurable by non-subjective methods, it seems to be really difficult to determine if there would exist various degrees of consciousness in animals, or in other living structures like plants, doomed to remain fixed in the soil to which they belong, without an obvious expression and manifestation of their behavior as a response to stimuli. The recent studies in this field are commonly based on the viewpoint that we can refer to consciousness at animals, basically because they dispose of a nervous system as a sensitive tool for connection with the environment (Sattin, Magnani, Bartesaghi, Caputo, Fittipaldo, Cacciatore, Picozzi, & Leonardi, 2021). The question if plants are really able to decide if/how to adapt their structure/functions depending on their local conditions, with a certain level of consciousness, is still a discussible question (Rivera-Serrano, 2021), and on this issue can be evoked pro (Raja, Silva, Holghoomi, & Calvo, 2020; Debono, 2013; Segundo-Ortin & Calvo, 2021; Hiernaux, 2021) and contra arguments (Mallatt, Taiz, Draguhn, Blatt, & Robinson, 2021; Taiz, Alkon, Draguhn, Murphy, Blatt, Hawes, Thiel, & Robinson, 2019).

A new line of investigation promotes information as a basic constituent of the biologic structures, determining their growth and development, maintenance, reproduction, and the inter-relation/interconnection with the neighbor environment and with themselves (Gaiseanu, 2021a). However, although information is a highly conveyed concept nowadays in our current domestic and professional activities, this concept is not yet perceived as fundamental, when the biological structuration and functionality is concerned and even some scientists are still sceptic/late to understand/admit the specific role of information in structuration/functionality of the biologic organisms, with specific results like growth, differentiation, reproduction, self-organization/maintenance, and self info-management. Substantial advances have been recorded/reported however in a number of recent papers, showing that information intervenes not only in the structuration of the human (Gaiseanu, 2021a; 2021b), and living structures (Gaiseanu, 2020b; 2021b; 2021c; 2021d; 2021e; 2021f, 2022a) but also of matter itself (Gaiseanu, 2021g). The application of this concept to the human functionality contributed to spectacular results in the understanding of the relation between the body and mind, a millenary problem still debated nowadays by philosophy (Gaiseanu, 2021h), of the sharp definition of the attitude and its quantification (Gaiseanu, 2020c, 2021i), of the distinct informational reactions to beauty and ugly concepts in neuropsychology and behavioral sciences (Gaiseanu, 2021j; 2021k; 2021l), of the mental equilibrium (Gaiseanu, 2020d), aggressiveness (Gaiseanu, 2021m), and mood disorders (Gaiseanu, 2021n), of the neuro-rehabilitation by informational therapies in geriatrics treatment (2020e) and informational procedures. Information is therefore part of our reality, even we perceive it or not. As a continuation of this line of investigation, in this paper is approached the question of consciousness on the entire living scale, from unicellular to multicellular organisms and human, focusing attention on the intervention of information mechanisms in body structuration and functionality, which finally promotes an independent and creative

adaptation to the environmental conditions, within the particular “window” of connection/interpretation of the informational panorama of reality, specific for every species and individual.

Information-Body Relation: Informationally-Driven Processes of Growth/Structuration/Maintenance of the Biologic Organisms

The traditional philosophic view on the mind-body relation is to separate these two forms of existence taking into account their different consistencies: while body is understood as a material/consistent, even solid state structure, mind is a non-material supported structure, a virtual form of reflection of reality. This simplistic form to treat this problem is a consequence of the poor understanding of the micro-structural substrate activity in the material bodies, leading to macroscopic phenomena, in living and even in non-living structures. The solid-state physics approach exactly this tender spot, in particular concerning the behavior of semiconductor materials (Gaiseanu, 2013; 2017a), rising to the plain light the intensive internal micro-structural activity in macroscopic otherwise solid/“inert”/rigid structures (Gaiseanu, 2022b; 2022c; 2022d). The spectacular advances in our informational era which we enjoy of today, are the results of these spectacular micro-structural activities in the microelectronic circuits in our informational devices, where information is carried out by electrons and holes, these binary (negative/positive) elemental informational carriers (Gaiseanu, 2013, 2017a). Surprisingly probably for some of us, although from the macroscopic point of view, these are solid systems, super-flowing intensive down/upstream of information operate inside of them. This is maybe a suggestive starting standpoint to initiate the contemplation on what happens in human and living organisms, to understand actually the relation between body functionality and “mind” like/informational phenomena.

The living organisms on the entire scale are informational systems, animated/driven by information (Gaiseanu, 2021a; 2020b). However, in opposition with the artificial informational devices, the living organisms are self-organized structures, able to manage themselves their growth/development and maintenance on the entire life cycle. Moreover, different from our informational devices which are electrical systems, information in living organisms is rather carried by chemical agents instead of electrical elements, although in animals the nervous system engages also an ionic transport along the axon of the nervous cell (Gaiseanu, 2021o). In plants, there are also active Ca^{2+} and other conduction channels, which favor a faster reaction to informational stimuli (deBono, 2013), as it is shown to be the case in carnivore plants, which trap their victims by an electrically-assisted mechanism (Gaiseanu, 2022e).

The growth and development are information-assisted processes. Indeed, these are achieved by the replication and transcription/translation process in the eukaryotic cell, the life unit of animal and plants and prokaryotic cells like bacteria (Gaiseanu, 2020a). The living organisms therefore are able to construct, growth and structure themselves, according to the design project of the species, on the basis of instructions contained by the molecule of the deoxyribonucleic acid (DNA) in genes and genome, in the nucleus of the eukaryotic cells. Replication of the cell is a process initiated by the splitting of the DNA molecule in two symmetrical parts, consisting in the strands of the DNA molecule, and the completion of each of them with the complementary nucleotides, to form two new identical mother-daughter molecules. The key of the informational process is that the DNA molecule contains the “embodied” information (Gaiseanu, 2019a), expressible by combinations of four distinct nucleotides—adenine (A), thymine (T), guanine (G), and cytosine (C), which attach each other by complementarity, i.e. the nucleotide A only with T, and G only with C, to form chemical bonds called base pairs, which connect the two DNA strands. These nucleotides are the “letters” of a

four-type “alphabet” which form furthermore “words” by various combinations, communicated to proteins, the construction units of the organism, by the transcription and translation process. This consists in the copy by an enzymes-assisted process of various sequences of DNA by the messenger ribonucleic acid (mRNA), which transfer the information to protein in combination with the transfer RNA (tRNA) processed in a specialized organelle, which is the ribosome (Rubio & Hopper, 2011), with role of adaptor with other “word”-type components—the amino acids, the building blocks of proteins.

So, the cells dispose of an additional informational machine—ribosomes, that reads one language (DNA received information) and operates in another (amino acids assisted conversion). The structuration of the biologic organisms is supported by four categories of main organic components (Gaiseanu, 2022e): fats, carbohydrates (energetic basis), amino, and nucleic acids (info-components). While bacteria and plants can synthesize all the 20 amino acids needed by the building structures of the body and info-communication to proteins, the mammals, as well as human, can synthesize only 11, so the completion with other nine should be obtained from the external sources (food) (Gaiseanu, 2020e; Nelson & Cox, 2005). The amino acids are part of the informational mechanism within the building process of the proteins, driven by ribosome, as a continuation of a primary info-communication in a four-letter-type alphabet from various DNA sequences of DNA genetic structures, by means of mRNA, this time in a 20-letter-type alphabet, forming practically a huge variety of combined “words”. The ribosome therefore is an efficient informational “device”, allowing an input info-operability in a mRNA/DNA nucleic “language” of 4-letter alphabet, and an output in a new combined language, by the participation of the amino acids.

The accurate transmission of information from the genes and genome during the replication is a fundamental task for reproduction of the cell, because small mistakes or changes like point mutations can induce sometimes far-reaching consequences (Ahern & Rajagopal, 2013). The informational “machine” of the cell is not limited thus to replication process itself, which plays a vital role for the cell and multicellular organisms. It continues to self-guard the accuracy of the DNA copy (so of the cell “blueprint”), and the integrity of the DNA molecule during and after this process, acting by means of the mismatch repair mechanisms (Ahern & Rajagopal, 2013). Such informational mechanisms are incredible rigorous, from scan-type processes of the new DNA for mistakes detection, to the surgical removal of incorrect areas and their rectification, for errors fixing: thus, the mismatch repair improves the error rate of DNA from about one in 107 nucleotides to hundred-fold to one in 109 nucleotides (Ahern & Rajagopal, 2013). According to the above discussion, a genetic transmission system (GTS) and an info-genetic Generator (IGG) can be defined on each living structure, in cells supported by replication and transcription/translation processes, respectively.

Every process described above, and actually all processes performed by the cell and multicellular organisms, need energy, necessary to run the living functions and structuration. The cell and multicellular organisms are self-organized informational systems (Gaiseanu, 2021a; 2021b; 2020b), which assure their energy by metabolic (automatic) processes—enzyme-catalyzed reactions, comprising: (a) the conversion of food (nutrients, water, air) in energy; (b) the achievement of the micro-material components (i.e. proteins, lipids, nucleic acids, carbohydrates) for the structuration/restructuration of the body constituents, each of them with specific functions; (c) the intra/intercellular transport and the elimination of the wastes. The metabolic processes run as catabolic/anabolic (YES/NO-type) reactions, to release/absorb energy by the breakdown of the compound chemical bonds, and synthesize (structuration process) compounds (such as proteins, carbohydrates,

lipids, and nucleic acids). The breakdown of the food compounds (carbohydrates, fats, proteins) in animal cells, and of the glucose as a result of photosynthesis in the chloroplast in cell plants, is a process releasing energy by oxidation in mitochondria, followed by elimination of wastes (uric acid, various molecular rests, water, dioxide carbon) (Gaiseanu, 2020b), like in the human multicellular organism (Gaiseanu, 2021c). The basic reaction releasing energy consists in the conversion of the adenosine diphosphate (ADP) into adenosine triphosphate (ATP), and a key switching YES/NO parameter is the ratio (ADP)/(ATP) between these two reacting components, so that when the concentration of ATP is insufficient, the ATP synthesis is initiated, whereas when this is sufficient, the conversion is stopped (Gaiseanu, 2020b; 2021a; 2021b).

The mitochondria (in plants and animal cells) and chloroplasts (in plants), the energetic/metabolic "factory" of the cells, are informationally driven by their own DNA, showing the importance of these organelles for the organism functioning (Alberts et al., 2015). The mitochondria organelles (carrying out oxidative phosphorylation), and chloroplasts (carrying out photosynthesis) in animals and plants respectively, dispose thus of an additional center of informational management, besides of the nucleus of the cell. Extensive researches on this matter (Alberts et al., 2015) show that, presumably, both organelles originated from a stable endosymbiotic relationship (living of an organism in another), between the primitive eukaryotic cell and a prokaryotic cell (bacterium). As the efficacy of the mitochondrial DNA replication and DNA repair processes is substantially lower than that of the corresponding processes in the cell nucleus, the damages accumulated in the genome of mitochondria over time explain the aging and diseases of the cells and multicellular organisms (Alberts et al., 2015). On the other hand, noting the high informational activity and functions driven by genetic processes in/near nucleus and mitochondrion, and transposing them to the multicellular organisms, in particular to human, we have to observe that the "second brain" operating within the solar plexus in human body, follows actually the complex informational processes necessary for digestion and metabolic tasks, which are supported at the microscale by the eukaryotic cell at mitochondrion, which dispose of a second genetic system for the management of such processes. This additional argument shows again the unitary behavior of life info-structure on the entire evolutionary scale. From the above discussion, we can define a maintenance informational system (MIS), fundamental for the energetic and micro-structural needs of the organisms on the entire evolutionary/complexity scale.

From the above presentation, we may understand that the structuration in the biologic organisms is an information absorbing process, while the destructuration is an information releasing process (Gaiseanu, 2021b). This could be suggestively expressed by the relation:

$$A+B+I \Rightarrow (AB)(I) \tag{1}$$

where A and B are the components of the reaction, and information is represented by I, which is "embodied" (Gaiseanu, 2019a) into the composed structure. Information can be released from a compound C by a further disembodying process, of the form:

$$C=(DE)(I) \Rightarrow (D+E)+I \tag{2}$$

where D and E are the material components and I the disembodied information previously embodied into compound structure, on the form (I). Reactions (1) and (2) are unidirectional in the living organisms.

The proteins comply actually with various functions in organism, assuring the body building process, and also the transmission of various other instructions/messages for differentiation, metabolic or reactive processes to other components of the body, according to the local necessities. Specifically, the differentiation process in animals is strongly dependent on the regulatory role of proteins and corresponding DNA sequences, i.e. on

informational processes. In a simplified view, it can be noted that the phenotype traits of an organism are controlled by specific regions of the DNA (genes), responsible to transmit each of them instructions to a certain protein, which manifests a certain trait. Such an activity is regulated in time, so not all the genes are expressed all the time, the cells may alter/suppress/inhibit their patterns of gene expressions, or initiate them for the regulation of protein production, as needed in some periods of development, or as a decisional reactive response to various external cues (Ahern & Rajagopal, 2013), within the frame of a permanent info-dynamic process of YES/NO-type of reaction chains. As each cell type is defined in multicellular organisms by specific genes patterns, the cell differentiation during the growth or post-growth processes is based on the switch (YES/NO-ON/OFF mechanisms) from one type of pattern expression to another, as a consequence of a communication process within a gene regulatory network, with an information input and an output gene expression (De-Leon & Davidson, 2007). Such a communication is carried out by specific molecules (growth factors) and is controlled by cell signaling mechanisms from cell to cell, typically following a transduction process as follows: (i) a chemical signaling agent (ligand), emitted by a cell, (binds to)/activates (by enzymatic intervention) a receptor of another cell (specifically with a complementary structure), like a YES/NO info/Bit-type binary connection; (ii) this is a selective process, performed according to its competences with respect to other competing cells; (iii) the previous process induces catalyzing reactions on other proteins, which subsequently can trigger eventually inhibition/activation of transcription factors, responsible for differentiation in the target cell. Because all cells of species dispose of the same genome, the epigenetic processes play a crucial role in regulating the decision to adopt a specific growth process, driven by gene expression (Knisely & Scott, 2009).

Enzymes play a fundamental role in the metabolic processes by the acceleration/regulation of the rate of chemical reactions, as a reactive response to the external information, both from the environment and other cells. The metabolic reactions follow reaction pathways, in which an initiating reaction process triggers a subsequent cascade of processes. The reactive pathways are well defined due to the intervention of specific mechanisms driven by scaffold proteins, which control the sharp differentiation to avoid the interferences with other pathways (Alberts et al., 2015). We have to observe therefore that these pathways work like microcircuits in our informational devices, but in opposition with that, the information is carried by various chemical agents and reactions, while in the microelectronic circuits by electrical agents—negatively/positively charged electrons and holes (Gaiseanu, 2013; 2017a). Actually, as it was recently argued (Gaiseanu, 2021c; 2021d), the living organisms work like informational devices. We have to observe that in both devices, the working processes are based on complementary/opposed mechanisms/transport agents, as a consequence of the similar properties of silicon (basic electronic material support of the microprocessors) and carbon (basic support of the living systems), sensitive to chemical elements from left and right side of the group IV of the periodic table, which they belong to.

Therefore, when we discuss about the body of a living organism, we have to regard it as a complex system, much more than an inert mechanical structure, absorbing (rel. (1)), processing (chains/interacting reactions (1) and (2)), and sharing/communicating information (rel. (2)) by informationally-driven processes. We have to take into consideration a large range of informational processes, carried out by informational agents, continuously transmitting and receiving information, transduced into distinct and useful acts. Two main conclusions are to be extracted from this analysis: (A) the body is not at all an inert material with only a role of mechanical support, this is an active informational communication medium, this is actually an informed-matter

structure; (B) the living organisms are bipolar information-matter/energy systems, operating information by connection to information and matter, like informational devices (Gaiseanu, 2013; 2017a; 2021c; 2021d). The time has therefore come to carefully reconsider, recognize, and accept information as an active constituent element of living matter and to treat it as such, through the concepts of information science and technology. Such an approach helps the scientific and technical investigations on two main directions, with positive/deep consequences in biology and biotechnology: the understanding of the working mechanisms of the biological structures, and the advance in the development of the artificial structures with intervening role in biosystems as exploring, predictive, interpretative, mimetic, or substituting components.

Functional/Informational Structure of the Biologic Organisms and Consciousness Problem

The conservation of the informational model which the living structures is based on, followed on the entire evolutionary scale by all of them, is a fundamental requirement for the survival, as we are going to discuss along this section. This model of such a self-organizing structural and functional behavior with many millions years ago, “discovered” by countless repetitive natural experiments, starting from the first form of living structure till nowadays, has been maintained the same. The informational and functional system is basically the same for all forms of life, with diversifications concerning the shape architecture, as a function of the adaptation necessities, induced/assisted by information via epigenetic processes and/or mutations. This system was verified as reliable along millions of years of practice, showing structural and functional stable properties, within the local conditions of environment. The question how was possible such a long-term survival and adaptation leads to the following response: by info/sensitive-detection, memory and decision making processes.

The decision making is a natural process in the living structures, necessary for the survival. First condition of the survival is the finding of the material resources (foods). As the biologic organisms are based on a dynamic system far way from equilibrium, its maintenance depends first of all on the permanent connection with the material resources. For this, the animals should explore the surrounding state of their environment to discover and acquire them, whereas the plants need to compete for the resources, both for light/energy or nutrients. A second requirement is derived from adaptation to the environmental changes, which comprise both resources and danger risks. Therefore, an immediate requirement for all living structures, from the unicellular to the more complex multicellular organisms, is to dispose of an informational system, not only to detect it, but also to make decisions, as a function of circumstances.

Cells are therefore sensitive, complex informational “devices” (Gaiseanu, 2021c; 2021d), which detect/receive various (stochastic) signals from the environment, perform an internal sentience/interpretation and a decisional process by own biochemistry, and produce a reactive response (Gaiseanu, 2021a; 2021b; 2020b). Therefore, the informational system of the living structures should be selective and decisional, according to own decisional criteria/needs/(“a priory”) experience. The concept of “a priori” should be understood here having origin both in the species experience, stably memorized in the genetic system, and the own acquired experience within the interaction with the environment (Gaiseanu, 2019b). The strategy of the decision making to comply with such requirements at the biomolecular level, could be characterized in stochastic/probability terms and comprise of three basic statements (Perkins & Swain, 2009): (1) cells must infer from noisy signals the probable informational utile signal, and anticipate future state of their environment; (2) they must weigh the balance between costs and benefits (so analyze according to own criteria (Gaiseanu, 2020b) of each potential response, given that future (i.e. the decisional goal/objective (Gaiseanu, 2020c; 2021i)).

Among the decision criteria should include the competitive and/or collaborative interaction with the external factors and other individuals, in the last case as a cooperative response in multicellular organisms, including even the self-sacrifice for the common good. The living structures should therefore dispose of the capability to detect/select/sense signals and decide in interaction with the environmental changing/stochastic conditions. The sense/sentience is probably more difficult to be understood, but if we compare it with a hanger sensation for instance in the human organism, which is actually a result of an imbalance of the ATP/ADP concentration, qualified as GOOD/BAD, according to the coincidence with the satisfying/unsatisfying needs of the cells, we may deduce a similar process in unicellular organisms. An input/received information could therefore be qualified in a similar GOOD/BAD (YES/NO) way, by means of a info-reactive sentient system (IRSS), depending if this information moves the critical/equilibrium point of a biochemical reaction to one side or in another opposite one. As a matter of fact, and according to the above discussion, it is intuitively obvious that the unicellular organisms should sense some basic characteristics, at least the presence of nutrients in their environmental neighborhood (Ahern & Rajagopal, 2013). The danger "feeling" is one of the main sentience detectable signals, necessary for the defense of organism, one of the most ancient probable in all organisms, and present in human beings and subhuman organisms by the activity of amygdala, so the particular version of IRSS in these organisms is represented by info-emotional system (IES), managing the emotions. In the opposite site of the emotional axis is the wellbeing and associative tendency (love), when all the needs of organism are satisfied. The GOOD/BAD comparison is supported by the center of acquisition and storing of information (CASI) and center of decision and command (CDC), closely related each other and with IRSS, for an optimal decision making, necessary for adaptation. The open "windows" through the living organisms detect and evaluate/interpret the external reality, represented by info-connection (IC), specific for every species, even for every individual, according to own experiences and inherited abilities. In human, the filtering/selection of information among the large diversity coming from external/internal sources is fine tuned/operated according to mentality/trust criteria provided/learned from parents, community, society (Gaiseanu, 2017b; 2019c).

Info-Connection (IC) center is thus specialized in selective orientation among the multitude of informational signals, on the basis of specific inherited/info-acquirement decision criteria of each species, in particular at human represented by belief/mentality, according to the local cultural/social conditions (Gaiseanu, 2019c; 2017b). In cells of the multicellular organisms, this center is manifested/related by the main informational duties according to the needs of organism and specialized/assigned main tasks to a certain type of cell. At individual level, IC comprises also the intuitive prediction, as need of certainty vs. uncertainty in confrontation with the exploration of reality, developed specifically in each species and individual (Gaiseanu, 2017b; 2018b; 2021d), according to the local conditions (Harari, 2017). This is actually the window of information through each species and individual "looks"/perceives and interprets the world (Gaiseanu, 2022e). The central role in cells is played by nucleus, the holder of the information of structural and functional properties of species, and also of the acquired information, adding new traits to individuals by epigenetic processes (Gaiseanu, 2019d). This is a gradual process, consisting in the integration of insistent/repetitive information in the functional/structural architecture of cells and multicellular organisms (rel. (1)), inter-generationally transmissible, which modulate the DNA molecules, but without modifying the species heritable structure, assuring actually the progressive adaptation to the local environmental conditions and thus evolution. This process can be suggestively described as a gradual transition/absorption of information by the

specific formation of new acquired pathways/patterns in cell and multicellular organisms, starting with the perception of information in CASI and finalized in GTS, according the following process:

External Info => CASI => CDC => IRSS (IES) => GTS ==> IGG (3)

of the next generation. In animals the central informational processor is the brain, and a pivotal role in plants is played by roots apices (Baluška et al., 2004; Gaiseanu, 2022e). This is a suggestive example of "intelligent" adaptation, according to the specific living substrate: while most animals have the head—the most sensitive/detector/analyzer system in air/water, where they commonly live, plants "prefer" to keep it in soil, where they have to seek/absorb/compete for the nutrients, raising the other organs—stem ("neck") and sexual (flowers/seeds) and metabolic organs (leaves) in air, where they absorb light and can "collaborate" with pollinators (Gaiseanu, 2022e). The root apex transition zone, seems to make timely decisions and solve problems concerning the optimal orientation (Baluška et al., 2004; Debono, 2013), so it is often compared with "like-brain" center, contributing/managing also the lung-like respiration system, as a "heart"-like pumping of water and nutrients, maintainer of the physiological/hormonal balance/info-communication, by means of auxin-like "neurotransmitter" and plasmodesmata-like neuro-gap-junctions, throughout the entire plant (Alberts et al., 2015).

CASI/CDC is revealed in plants by their detection/reaction to humidity/humidity gradients, light/light intensity, temperature/temperature gradients, gravity/electromagnetic fields, and by their network of mechano-perception sensors for the perception of numerous mechanical signals, like gravitropic, thigmomorphic, thigmotropic, self-loading, growth strains, turgor pressure, xylem pressure potential, and mechanical vibrations of sound (Telewski, 2006). Plants are sensitive to light not only for metabolic necessities, but also affecting the plant tropism and memorizing/decisional making processes allowing choosing between variant alternative (IC/IRSS/CDC) (Nick & Schäifer, 1988), plasticity, germination, flowering, and shape development, based on the light modulation of auxin signaling between the organs and root (Halliday, Martínez-Garcıía, & Josse, 2009), vertical growth/shade tolerance/lateral-avoidance (Baluska et al, 2018), learned by association with other acquired information (Gagliano, Renton, Depczynski, & Mancuso, 2014; Gagliano, Vyazovskiy, Borbély, Grimonprez, & Depczynsk, 2016), as it was earlier shown (Gaiseanu, 2019d). Plants react more slowly in comparison with animals, but the carnivore plant *Venus flytrap*, like other similar 600 species is provided with a rapid motor response (CDC/EE – the execution elements), appropriate to catch/hold/devour/digest animals (MIS) (Suda et al., 2020), showing in this case more "intelligent" behavior than their victims—the inferior ranking animals, even they are endowed with a nervous system (Gaiseanu, 2022e).

Although the general common belief is that the decision-making and learning are characteristic qualities only of the animals, experimental evidences show that the non-neural organisms are also decision making structures, including singly nucleated cells (Dexter, Prabakaran, & Gunawardena, 2019); the intra and inter-communication within and between cells in the multicellular organisms is performed by informational signaling, carried out by electrical or chemical agents (Ahern & Rajagopal, 2013; Alberts et al., 2015). This process comprises an information source (a cell emitting a signaling agent), a channel of transmission (fluid components and/or nervous system in animals) and receiver (target cell), which may interpret the message and develop a decision, according to the internal decision criteria, similar with an electronic informational/transmission/communication system, earlier considered as a basic example to develop the

information theory (Shannon, 1948).

In the multicellular organisms, the intercellular info-communication is an imprescriptible process for the coordination activities of the organism as a whole, and the activity of every part of it, composed by specialized cells with specific functions, responding to everything, from the metabolic necessities to injury, threat, the availability of a mate, or from the "acknowledgement" of the moment when they should store food and break it down, when they should divide themselves, or even when they must die (Ahern & Rajagopal, 2013). The cells are selective, receiving/accepting the appropriate molecular agents, if they are sufficiently small to diffuse through the cell membrane, to attain an internal receptor and trigger a response reaction and/or a cascade of reactions, or can bind a specific linked surface receptor, typically a protein, if the signaling molecule is larger, with intracellular response effect in reactive pathways, sometimes amplified or operated in a switching (ON/OFF-YES/NO) form (like the switching transistors in our computing systems) (Gaiseanu, 2013; 2017a), including, but not limited to, alterations in metabolic pathways or gene expression in the target cell (Ahern & Rajagopal, 2013).

Additional advances were made to reveal the molecular mechanisms involved in decision making at the microstructural level of the cells. In a recent study (Yamada, Whitney, Huang, Eck, Garcia, Rushlow, 2019; Gaiseanu, 2020b), as it was shown recently, the cells use to make decisions as a response to the external cues, about what genes they activate (in short regions in DNA adjacent to genes called enhancers), when and how much, within a regulation process (New York University, 2019). Such a function, similar with that in the logic circuits, which consists in the reading the cell's environment and integrating those inputs into a defined gene activity response, is achieved by the activation of the so called enhancers (New York University, 2019). Such research results, contributing to the understanding of the informational activity of the cell, can be also directed to manipulate the segment of DNA that acts as a tiny microcircuit to make this single decision (New York University, 2019) in biotechnology/biocomputing fields.

The cell migration, in particular in body development of the multicellular organisms, in the tissue repair or immune surveillance processes and in cancer aberrant invasion, is an essential decision making process, induced by external cues like chemical signals, mechanical forces, structural features (Ngalim, Magenau, Le Saux, Gooding, & Gaus, 2010) and hydraulic pressure (Zhao et al., 2019), determining the direction, speed of migration, and feed-back interaction with other cells. As mentioned above, the cell decision making is an informational process, which can be described by information theory. The cell adapt itself to the micro environmental conditions by the "embodiment"/coding of the available information, within the frame of restructuration processes, into genetic, epigenetic/transcription/translation "codes" for phenotypes responses, which can become reliable vs. noisy signals by the coupling of intracellular signaling pathway networks (Reppas, Jorswieck, & Hatzikirou, 2017).

The cell decision making as a process whereby the cell reacts to the environmental received information, assuming different "fates", according to the characteristics of the signal message, but without involving genetic change, is a universal function of life at various scale of organization, from viruses, bacteria, yeast, lower metazoans to mammals, as a key feature besides the environmental sensing and cell-cell communication, underlying pattern formation and development (Balázsi, Van Oudenaarden, & Collins, 2017). The decision making in cells frequently relies on networks with positive/negative feedback circuits, making the decision to be stable or reversible, respectively. The sensing feature refers also to the way whereby the cell itself "feels" information, as a regulatory process of the decision and adaptation (PEIL, 2014; 2015). Any unicellular

organism, even the smallest prokaryote living cells, displaying otherwise sophisticated regulatory networks (Shapiro, 2020; 2021), or any cell from a multicellular organism, in particular the human, with trillions of cells that form the body, has the ability to detect and respond to a wide range of input information, relied on a large set of signaling proteins to process this information and make decisions accordingly, which do not participate in metabolic/growth/maintenance processes, but only in "keeping tabs" on/detecting the external environment and responding to cues by activation/deactivation of the appropriate cellular processes (Laub, 2016), as a switching (YES/NO) relay. Viruses are parasite sub-living structures, which have not their own metabolic system, but are still DNA-based informational systems, operating/substituting the host cell informational one (Gaiseanu, 2021q; 2022f).

These results are underlying premises not only to better understand the human mind and consciousness, as a collaborative effect of the cognitive properties revealed/founded by the informational model of the human body and living structures (IMHBLS), but also to extend the informational solutions to the "mind"-like/body relation and the applicability of consciousness concept to biological structures. Indeed, at human and in a lower proportion in the rest of the living organisms, according to their info-complexity development, the informational system of the human body and living structures (ISHBLS) is reflected in the cognitive properties of all the biologic organisms by cognitive centers, corresponding to the activity of the informational components as:

$$\begin{aligned} ISHBLS=(CASI+CDC+IESS(IES))+(MIS+GTS+IGG+IC) = OIS + PIS \Rightarrow (memory) + \\ (decision\ making) + (sentience\ (emotion)) + (biologic\ multiplication/sexual\ behavior) + \\ (inherited\ predispositions) + (main\ selective\ criteria) \end{aligned} \quad (4)$$

manifested by the external/internal behavior/responsivity in function of the nature of the external informational stimuli. In relation (4) OIS and PIS represent the operative and programmed informational systems, respectively: OIS is an adaptive system, connected with internal and external informational sources, and PIS supports the informational processes for maintenance of the body and reproduction. While OIS captures and interprets messages from inside/outside world for short-term adaptation, PIS can integrate the insistent/intensive/repetitive information for long-term adaptation of the species by epigenetic mechanisms, within a grandiose process of evolution.

In the human being, consciousness is a result of the informational activities of the informational system of the human body, expressed/represented according to relation (4) by seven cognitive centers suggestively called Iknow (memory), Iwant (decision), Ilove (emotion), Iam (self-status/vigor/power), Icreate (biological creation), Icreated (genetic inheritance), Ibelieve (mentality/trusting criteria) (Gaiseanu, 2019a). Consciousness illuminates the mind with the informational panorama of the surrounding situation, creating the personal interpreted/integrated image/impression of reality, according to our own interpretation capabilities, life experience and judgment criteria. The perception of reality is a result of the activity of our common senses, which constitute the window from which we connect to reality and "see"/interpret it (Gaiseanu, 2021j; 2021k). As the structure of the informational system is the same on the entire scale of complexity of the biologic organisms, we have expected that consciousness, although different and with more poor attributes like at human, should exist at any organism. The integration of information in our brain, hierarchically organized (Gaiseanu, 2020g), is given by thalamus, but in cells information is also integrated, the diversity of the cell response is given rather by the combination between signals, than by the high number of signaling molecules (Alberts et al., 2015), so the integration process of information is operative also there on the detection/decisional/sentient pathways, according to the

cell biologic patterns and tasks. In animals, consciousness is detectable by figure expression and behavior, much more evident than in plants, which do not need mobility to seek the nutrients, like animals. Even so, plants are also engaged in competition for foods and living conditions (light, territory allowance, defense solutions), as it was experimentally demonstrated, so they are also informational active organisms, needing/finding solutions to their concrete/specific local problems, detected and solved differentially by OIS, the operative/adaptation informational system, able to modulate PIS for adaptive response. However, consciousness as operating in human being cannot be automatically transposed to animals and plants, because the degree of development and complexity of the informational system, although with similar constitution, is different. Moreover, a comparison between informational capabilities between plants and animals cannot be an effective/conclusive result only based on the existence or not of a nervous system, because the informational communication is effective in each of them, as it was discussed above. The “intelligent” behavior in carnivore plants for instance could be considered more effective in comparison with insects, although without an obvious nervous system-based communication.

However, the basic common constitution of an informational system, driving the life of any living species and individual, allow us to define a pseudo-consciousness for any living structure, from a proto/primary consciousness of unicellular organisms (Gaiseanu, 2022i), to the most complex multicellular organisms, as a consequence of the informational activity of the informational components, orchestrated/co-operating as a function of the local conditions and the endowment with personal tools for observing/interpreting reality and problems by own permitted/developed IC-delimited window, to allow creative solutions for the survival. By pseudo-consciousness we have to understand here a consciousness different from that of the human being, with limited/lower attributes and characteristics, specific to the development/complexity level in own reference system of each living organism and species. Each species explores and interprets reality in its specific fashion, although similarities can be of course evoked between closer species of the same animals or plant kingdom, like between mammals for instance. All living organisms dispose of their own capacity to lead their own life. Each species and individual perceives and interprets reality according to their capabilities, “feeling”/perceiving/deciding in own fashion by means of OIS in personal coordinates and reference system, which we probably cannot ever really know. The common informational structuration of all living organisms, as discussed above, gives as sufficient reasons to admit the existence of a certain degree of consciousness, in certain circumstances (OIS activated) for any species, all of them engaged in the connection with reality and with their own body for adaptation and survival, so consciousness, in a sense defined here, based on the seven registers of connection with reality, is a specific characteristic of life. In comparison with this definition, taking into account the contribution of seven informational activity revealed by ISHBLS, and based on documented studies and experimental and theoretical results, the introduction of the concept of a minimal level of consciousness (Hiernaux, 2021; Mallatt et al., 2021), related only to theoretical calculations based on integration theory (Mallatt et al., 2021), which is any way under debate (Mørch, 2019), cannot be a reliable argument to justify the existence of consciousness (Mallatt et al., 2021), simply because is fully based on hypothetical theoretical calculations. Moreover, according to our definition, a minimal level could be different even from cell to cell, depending on individual/species duties/tasks, environmental conditions and specific info-connection endowment tools.

Conclusions

Besides the body structuration processes through embodiment/disembodiment of information (by structuration/destructuration mechanisms absorbing/releasing information) in DNA/RNA molecules, there were presented additional results on information-assisted structuration like the ribosomal intervention in the communication processes and DNA/RNA info-intervention in mitochondria organelles of eukaryotic cells, reinforcing the understanding of fundamental role of information in the living structures and the high accuracy/precision of the informational processes assisted by repair mechanisms, compared/comparable sometime with working processes in informational devices. The presented results reveal/reinforce the high/fundamental driving/commander role of information in the biological organisms, with or without a nervous system (cells, plants in the last case), both in the structural and functional aspects, strongly supporting the Informational Model of the Human Body and Living Structures (IMHBLS) on the entire evolution/complexity scale, with evident advantage for understanding the functional working of the biologic organisms, based most of them by the Bit-type operability. The analyzed results reveal/demonstrate also the unitary character of the informational properties on the entire living evolution scale, as a fundamental feature of the biological organisms, and the close/determining relation between structuration and informational manifestation/behavior in such dynamic systems, representing a background solution of this philosophical problem. It was shown that the functionality of the biological organisms is derived from their capability to self-structure their body, not only as a mechanical support, but also to endow it with the specific info-sensitive tools and driving/informational processes for exploration of reality, for detection/decision making/sentience/reaction, induced in correlation with the local external conditions.

Plants are non-mobile/non-nervous multicellular organisms, composed by eukaryotic cells like animals, with chloroplasts organelles able to prepare glucose in their own specialized organic components (leaves), but able to lead their life and solve their own living problems, like all other living structures, including individual cells and unicellular organisms. Each of them is connected to reality through own specific IC-defined window, by means of its own endowment equipment of observation and interpretation, reacting according to own individual/species capacity and needs. All of them are equipped with an operative informational system, which can be used for short-term adaptation, including modulating their programmed informational system for long-term adaptation. Plants are able to restructure their root trajectory as a function of circumstances, to compete for resources, and to defense themselves, demonstrating the same informational structure like all other organisms. Both the prokaryotic and eukaryotic cells of plants and animals are operational in the same fashion, operating on the basis of an informational system with seven components, IC determining the preferential/constructional selectivity as informational window of info-detection/interpretation, according to the specific functionality and tasks within the unicellular or multicellular system.

A pseudo-consciousness can be defined for any living structure, with or without nervous system, as a consequence of the activity of the informational system of each living structure, with specific degree of development and complexity, from proto/primary consciousness level of the unicellular organisms to consciousness of human, as it is commonly interpreted in the last case. According to the above analysis, the following conditions are necessary to be fulfilled for the activation of pseudo/proto-consciousness: (a) IC should be activated for connection with the external/environmental reality (no “sleeping” state); (b) OIS should be activated for the seeking of a solution to a local/momentary problem; (c) the integration of information in a

panoramic reality perceived through IC individual/species window, should be integrated into a unitary perception, condition which seems to be fulfilled even at the lowest life level, represented by eukaryotic/prokaryotic cell.

As living organisms dispose of informational system composed by seven informational components, with common/similar characteristics for all of them, (pseudo/proto)consciousness could be considered a specific characteristic of life itself.

References

Ahern, K., & Rajagopal, I. (2013). *Biochemistry free and easy* (3rd, ed.). Hingham: DaVinci Press. Retrieved from https://biochem.oregonstate.edu/content/biochemistry-free-and-easy

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

Balázsi, G., Van Oudenaarden, A., & Collins, J. J. (2011). Cellular decision making and biological noise: From microbes to mammals. *Cell, 144*, 910-925.

Baluska, F., Gagliano, M., & Witzany, G. (Eds.). (2018). Cham, Switzerland: Springer.

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.

Debono, M. W. (2013). Perceptive levels in plants: A transdisciplinary challenge in living organism's plasticity. *Transdisciplinary Journal of Engineering & Science, 4*, 21-39.

De-Leon, S. B. T., & Davidson, E. H. (2007). Gene regulation: Gene control network in development. *Annu. Rev. Biophys. Biomol. Struct., 36*,191-212.

Dexter, J. P., Prabakaran, S., & Gunawardena, J. (2019). A complex hierarchy of avoidance behaviors in a single-cell eukaryote. *Current Biology, 29*(16), 4323-4329.

Gagliano, M., Renton, M., Depczynski, M., & Mancuso, S. (2014). Experience teaches plants to learn faster and forget slower in environments where it matters. *Oecologia, 175*, 63-72.

Gagliano, M., Vyazovskiy, V. V., Borbély, A. A., Grimonprez, M., & Depczynsk, M. (2016). Learning by association in plants. *Scientific Reports, 6*, 38427.

Gaiseanu, F. (2013). Contributions to the modeling and simulation of the atomic transport processes in silicon and polysilicon and applications, proceedings of the Romanian academy, series A. *The Publishing House of the Romanian Academy, 4*(4), 376-384. Retrieved from http://www.acad.ro/sectii2002/proceedings/doc2013-4/15-Gaiseanu.pdf

Gaiseanu, F. (2017a). Modelling and simulation of the impurity diffusion and related phenomena in silicon and polysilicon systems in microfabrication and micromachining technologies. *Annals of the Academy of Romanian Scientists, Series on Science and Technology of Information, 10* (1), 41-78.

Gaiseanu, F. (2017b). An information based model of consciousness fully explaining the mind normal/paranormal properties. *Neuro Quantology, 15*(2), 132-140.

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.

Gaiseanu, F. (2018b). Near-death experiences and immortality from the perspective of an informational modeling of consciousness. *Gerontology & Geriatric Studies, 2*(3), 1-4.

Gaiseanu, F. (2019a). The informational model of consciousness: Mechanisms of embodiment/disembodiment of information. *Neuro Quantology, 17*(4), 1-17.

Gaiseanu, F. (2019b). 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.

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.

Gaiseanu, F. (2019d). 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.

Gaiseanu, F. (2020a). Informational structure of the living systems: From philosophy to informational modeling. *Philosophy Study, 10*(12), 795-806.

Gaiseanu, F. (2020b). What is life: An informational model of the living structures. *Biochemistry and Molecular Biology, 5*(2), 18-28. doi:10.11648/j.bmb.20200502.12

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

Gaiseanu, F. (2020d). Informationally-assisted equilibrium and health: Specific ACC contribution from the perspective of the informational model of consciousness (invited paper). *EC Psychology and Psychiatry Journal, 9*(5), 37-49.

Gaiseanu, F. (2020e). Multitask music-based therapy optimization in aging neurorehability by activation of the informational cognitive centers of consciousness. *Gerontology & Geriatrics Studies, 6*(3), 621-625.

Gaiseanu, F. (2020f). *Physics of consciousness and life: The informational model of consciousness—Information in neurosciences, biocomputers and biosystems.* GlobeEdit: OmniScriptum International Group. Retrieved from https://www.amazon.com/Fizica-Conştiinţei-Vieţii-Informaţional-Neuroştiinţe/dp/6139421705

Gaiseanu, F. (2020g). Information based hierarchical brain organization/evolution from the perspective of the informational model of consciousness. *Archives in Neurology & Neuroscience, 7*(5), 1-6. doi:10.33552/ANN.2020.07.000672. Retrieved from https://www.academia.edu/42766202/Information_Based_Hierarchical_Brain_Organization_Evolution_from_the_Perspective_of_the_Informational_Model_of_Consciousness

Gaiseanu, F. (2021a). Information as an essential component of the biological structures and their informational organization. *Journal of Microbiology & Biotechnology, 6*(2), 1-9.

Gaiseanu, F. (2021b). Evolution and development of the information concept in biological systems: From empirical description to informational modeling of the living structures. *Philosophy Study, 11*(7), 501-516.

Gaiseanu, F. (2021c). Human as an Informational device. *Archives in Biomedical Engineering & Biotechnology, 6*(1), 1-8. doi:10.33552/ABEB.2021.06.000629

Gaiseanu, F. (2021d). 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. (2021e). Advanced results in biological researches: Informational structure and info-operability of the living systems. *Journal of Biotechnology & Bioresearch, 3*(3), 1-4.

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 in the universal triangle of reality for non-living/living structures: From philosophy to neuro/life sciences. *Philosophy Study, 11*(8), 607-621.

Gaiseanu, F. (2021h). Solution to the mind-body relation problem: Information. *Philosophy Study, 11*(1), 42-55.

Gaiseanu, F. (2021i). 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. (2021j). 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.

Gaiseanu, F. (2021k). 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. (2021l). Neuropsychological response to information of beauty/ugly brain circuits according to the informational model of consciousness. *International Journal on Neuropsychology and Behavioural Sciences (IJNBS), 2*(2), 55-59.

Gaiseanu, F. (2021m). Mental aggressive operability from informational perspective: A deterrence manifesto. *EC Neurology, 13*(4), 31-39.

Gaiseanu, F. (2021n). Pathological expression and circuits in addiction and mood disorders: Informational relation with the brain and info-therapy. *EC Neurology, 13*(8), 24-35.

Gaiseanu, F. (2021o). 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. Retrieved from https://skeenapublishers.com/journal/ijnbs/IJNBS-02-00017.pdf

Gaiseanu, F. (2021p). 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. (2021q). 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. doi:10.33552/ABBA.2020.04.000592

Gaiseanu, F. (2022a). Information as a coherent/effective investigation concept/strategy to approach the biotechnology scientific and technical research. *Acta Scientifica Biotechnology, 3*(1), 28-33. Retrieved from https://actascientific.com/ASBT/pdf/ASBT-03-0124.pdf

Gaiseanu, F. (2022b). Technology for the accurate preparation of silicon capacitive pressure sensors with biomedical application. *Biomedical Journal of Scientific & Technical Research, 42*(4), 33790-33796. Retrieved from https://biomedres.us/pdfs/BJSTR.MS.ID.006777.pdf

Gaiseanu, F. (2022c). Accurate procedure to calculate the stress induced by technological processes in the silicon capacitive pressure sensors for biomedical applications. *Biomed Journal of Science & Technical Research, 43*(4), 347748-34752. Retrieved from https://biomedres.us/pdfs/BJSTR.MS.ID.006926.pdf

Gaiseanu, F. (2022d). Analytical modelling of the boron diffusion and etching process for the accurate design and fabrication by bulk micromachining technology of the silicon capacitive pressure sensors for biomedical applications. *Biomed Journal of Science & Technical Research, 43*(4), 347831-34838. Retrieved from https://biomedres.us/pdfs/BJSTR.MS.ID.006937.pdf

Gaiseanu, F. (2022e). Information in plants: The informational model of the plant cell and plants. *Cell Biology, 10*(1), 31-40. Retrieved from https://www.sciencepg.com/journal/paperinfo?journalid=111&doi=10.11648/j.cb.20221001.14

Gaiseanu, F. (2022f). Virus-inducing informational processes vs. cell antivirus info-sensitivity and implication of the biostatistics/metric applications in the detection/prediction of the COVID-19 infections. *Annals of Biostatistics & Biometric Applications, 4*(3), 1-5. doi:10.33552/ABBA.2022.04.000593

Halliday, K. N., Martínez-Garcıía, J. F., & Josse, E. M. (2009). Integration of light and auxin signaling. *Cold Spring Harb Perspect Biol, 1*(6), a001586. doi:10.1101/cshperspect.a001586

Harari, Y. N. (2017). *Homo Deus: A brief history of tomorrow*. New York: Harper Collins Publishers.

Hiernaux, Q. (2021). Differentiating behaviour, cognition and consciousness in plants. *Journal of Consciousness Studies, 28*(1-2), 106-135.

Knisely, K., & Scott, G. F. (2009). *Developmental biology* (8th ed.). Sunderland, Mass: Sinauer Associates. ISBN: 978-0-87893-371-6

Laub, M. T. (2016). Keeping signals straight: How cells process information and make decisions. *PLoS Biol, 14*(7), e1002519. doi:10.1371/journal. pbio.1002519

Mallatt, J., Taiz, L., Draguhn, A., Blatt, M. R., & Robinson, D. G. (2021). Integrated information theory does not make plant consciousness more convincing. *Biochemical and Biophysical Research Communications, 564*, 166-169.

Mørch, H. H. (2019). Is Consciousness Intrinsic?: A Problem for the Integrated Information Theory. *Journal of Consciousness Studies, 26* (1-2), 133-162(30).

Nelson, D. L., & Cox, M. M. (2005). *Lehninger principles of biochemistry* (4th ed.). New York: W. H. Freeman and company.

New York University. (2019). Biologists uncover new rules for cellular decision-making in genetics. *Science Daily*, April 11, 2019. Retrieved from www.sciencedaily.com/releases/2019/04/190411131548.htm

Ngalim, S. H., Magenau, A., Le Saux, G., Gooding, J. J., & Gaus, K. (2010). How do cells make decisions: Engineering micro- and nanoenvironments for cell migration. *Journal of Oncology*, Volume 2010, Article ID 363106. doi:10.1155/2010/363106

Nick, P., & Schäifer, E. (1988). Spatial memory during the tropism of maize (*Zea mays* L.) coleoptiles. *Planta, 175*, 380-388.

Peil, K. T. (2014). Emotion: The self-regulatory sense. *Global Adv. Health Med., 3*(2), 80-108.

Peil, K. T. (2015). Emotional sentience and the nature of phenomenal experience. *Prog Biophys Mol Biol., 119*(3), 545-62.

Peper, A. (2020). A general theory of consciousness I: Consciousness and adaptation. *Communicative & Integrative Biology, 13*(1), 6-21. Retrieved from https://doi.org/10.1080/19420889.2020.1713967

Perkins, T. J., & Swain, P. S. (2009). Strategies for cellular decision-making. *Molecular Systems Biology, 326*, 1-15. doi:10.1038/msb.2009.83 horas

Raja, V., Silva, P. L., Holghoomi, R., & Calvo, P. (2020). The dynamics of plant nutation. *Scientifc Reports, 10*(19465), 1-13.

Reppas, A. I., Jorswieck, E. A., & Hatzikirou, H. (2017). On the principles of cell decision-making: Intracellular coupling improves cell responses fidelity of noisy signals. In *bioRxiv*. Retrieved from https://doi.org/10.1101/125864

Rivera-Serrano, E. (2021). Plants: Are they conscious? In *BBC science focus magazine.* Retrieved from https://www.sciencefocus.com/news/plants-are-they-conscious/

Rubio, M. A. T., & Hopper, A. K. (2011). tRNA travels from the cytoplasm to organelles. *Wiley Interdiscip Rev RNA, 2*(6), 802-817.

Sattin, D., Magnani, F. G., Bartesaghi, L., Caputo, M., Fittipaldo, A. V., Cacciatore, M., Picozzi, M., & Leonardi, M. (2011). Theoretical models of consciousness: A scoping review. *Brain Sci., 11*(535), 1-58. Retrieved from https://doi.org/10.3390/brainsci11050535

Segundo-Ortin, M., & Calvo, P. (2021). Consciousness and cognition in plants. *WIREs Cogn Sci., e1578*, 1-23.

Shannon, C. (1948). A mathematical theory of communication. *Bell System Technical Journal, 27*, 379-423, 623-656.

Shapiro, J. A. (2020). All living cells are cognitive. *Biochemical and Biophysical Research Communications, 564*, 134-149.

Shapiro, J. A. (2021). Cell cognition and cell decision-making. Retrieved from https://www.huffpost.com/entry/cell-cognition_b_1354889

Suda, H., Mano, H., Toyota, M., Fukushima, K., Mimura, T., Tsutsui, I., Hedrich, R., Tamada, Y., & Hasebe, M. (2020). Calcium dynamics during trap closure visualized in transgenic Venus flytrap. *Nature Plants Letters, 6*, 1219-1224.

Taiz, L., Alkon, D., Draguhn, A., Murphy, A., Blatt, M., Hawes, C., Thiel, G., & Robinson, D. G. (2019). Plants neither possess nor require consciousness, *Trends in Plant Science, 24*(8), 677-687.

Telewski, F. W. (2006). A unified hypothesis of mechanoperception in plants. *American Journal of Botany, 93*(10), 1466-1476.

Yamada, S., Whitney, P. H., Huang, S. K., Eck, E. C., Garcia, H. G., & Rushlow, C. A. (2019). The drosophila pioneer factor zelda modulates the nuclear microenvironment of a dorsal target enhancer to potentiate transcriptional output. *Current Biology, 29*(9), 1387-1393. doi:10.1016/j.cub.2019.03.019

Zhao, R., Afthinos, A., Zhu, T., Mistriotis, P., Li, P., Serra, S. A., … Konstantopoulos, K. (2019). Cell sensing and decision-making in confinement: The role of TRPM7 in a tug of war between hydraulic pressure and cross-sectional area. *Science Advances, 5*, eaaw7243.