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Info-activity of the immune system from the perspective of the informational model of the human body and living structures

Florin Gaiseanu *

Formerly with the Institute of Microtechnology Bucharest, Romania, and with the National Center of Microelectronic Barcelona, Spain, in the field of Science and Technology of Information.

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Abstract

In this paper it is demonstrated the informational nature of the activity of the immune system, and its role within the informational system of the human body, on the basis of the informational concept defined as matter-related information. This concept is derived from the observation that the interactions between the micro-material particles of the human body are under a permanent dynamic process, forming complex compounds or decomposing in constitutive components, with absorption and release of information. On the basis of this concept, it is possible to describe coherently on one hand the metabolic and genetic processes from informational perspective, for the body maintenance and its growth/development or the plasticity of parts of it, and on the other hand the info-relation between its components, based on the "language" compatibility and right communicational operability between micro-material informational agents carrying the information to the brain, the central managing operator/processor of the entire organism, and between them themselves. The identification of the specific distinct components of the informational system of the human body allows to describe it as a communication between brain and body, performed mainly by YES/NO binary-Bit-type mechanisms, both at the macro and microscopic level of the constitutive cells. The analysis of the immune system within this context and as a part of the informational system of the human body, allows to highlight that this activity can be described by the same concept of information, showing that the basic operative informational processes consists in combined genetic and communication mechanisms, as the informational model of the human body and living structures and its concepts predicts and demonstrates.

Keywords: Information; Matter-related information; Informational model of the human body and living structures; Info-compatibility; Info-genetic generator; Immune system; Info-operability; B-cells/T-cells; Surface receptors; Info-communication/genetically-assisted informational processes

1 Introduction

Information is an active factor everywhere in nature [1] and in our daily activities in industry, medicine, management [2-4] and in mass-media communications {5], but little is known about information in the human body and living structures [6]. Fundamental advances however have been reported in the recent years on this issue, precisely for a better understanding of the essential contribution of information in the structuration and functionality of the human body [7,8] and living structures [9-12]. Such advances firmly trace a new way/direction of investigation, which allows the deeper view of the communication phenomena/mechanisms and their essential importance/contribution in the structuration and functionality of the living organisms, highlighting the relationship between the body and mind [13,14], with all its favorable consequences on the problems dealt with related sciences, namely philosophy [15-16], psychology [17-20], neurosciences/neurology [21-24], geriatrics and gerontology [25-27], up to therapeutic rehabilitation treatments [28], information and info-modeling in plants [29,30] and animals [31], in biomedical engineering [32,33], biotechnology [34-36] and biometrics on COVID 19 control [37,38].

* Corresponding author: Florin Gaiseanu

Although managed basically by the brain, the immune system within the human body organism is distinctive by the distinctive contribution of various fix and mobile components, some of them – the immune cells, with individual but correlated mobility, able to circulate within the whole organisms and to intervene promptly in the local region where is in needed. Therefore, this system must to receive special attention concerning especially the functionality and coordination between its components. For this, in this paper it is investigated the activity of the immune system within the frame of the informational model of the human body (IMHB) recently developed [10], extended to the living structures, in particular to the eukaryotic cell [11,12], arguing and demonstrating that this activity can be fully understood by using informational concepts concerning the matter-related information by means of interactions between the micro-material components of the body, which are in a permanent dynamic process of info-communication. Within such a process, a special attention is dedicated to the compatibility between the communicating partners, and to the right interpretation of the communication message, for an efficient and right/correct communication, indispensable for the correct functioning of the cells and organism, and especially relevant in the case of the immunity system.

2 Information in the Human Organism and Informational Model of the Human Body and Living Structures

A key parameter which is to be introduced in this discussion is information. Taking into account the complexity of the immune system, approached and presented in the next section, the introduction of such a parameter is indispensable to approach first of all the “communication” between the various components of the immune system, otherwise not possible to be understood. Communication is already a presumption which can explain the coherent functionality of the immune system composed by such variety of structural and functional elements, but in the same time this is an informational concept, typically used in the science and technology of information.

If in the large sense, communication is a frequently used concept in our informational era, largely open to connections between various worldwide sources of information, geographically speaking by using various types – television/radio/press, smartphones, laptops/computers and all other large diversity of informational devices which make our life better and comfortable, communication between various constituents of an organism, in particular of the human body, is a little bit more difficult to be understood. And not only communication, which involves an informational/codification source – in accordance with the transmission mode, a transmission channel of the signals and a reception/decoding terminal of information (as defined by the information theory, for the first time developed and applied to the electronically systems [39]), but also the acquirement and release of information by structuration/destructuration mechanisms [10-12], as it will be briefly presented below, as a preamble of the assessment/investigation of the immune system from the informational perspective.

From the perspective of the science and technology of information, information is a result of a new event in an observed system, treated statistically in a binary (YES/NO-like) Bit unit terms, and can be expressed as certainty/uncertainty of its apparition. In a communication “language" (codification), the message launched by a source and transmitted through a specific channel, should be understood (decoded) accordingly by the receiver. Within the common communication process, if the communication between source and receiver is performed in distinct languages, the communication fails, if no a “decoding" system would be involved. But not only this would be a reason of failure: the distinct level of preparation and/or judgment (by own decision criteria, mentality and acquired reliable experience), makes the difference between the emitted/intentional and received/interpreted message [19, 40]. The right form of transmission/reception, so the compatibility between the two participants in an–info-communication process is fundamental for a right inter-connection and the subsequent results.

In the electronic systems, the communication between their composing parts is performed by electronic signals, codified/decoded accordingly with the desired/designed functions. With much higher level of complexity, in the human organism and living systems in general, the communication is performed by structural/material agents of various types and forms. However, the similarity between these two forms of communication is really helpful when is the case, to clarify the intimate mechanisms of communication in living organisms. This point is discussed as follows, by the introduction of the concept of matter-related information. The structuration/destructuration process with absorption/release of information could be understood by taking into account a simple system of two components A and B in interaction (“communication"):

- if whiting the frame of such an interaction the following process takes place to form a compound AB according to the schematic representation:

$$A+B \Rightarrow (AB\ (I)) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1),$$

then this is a process with absorption of information I, where (I) becomes a hidden (embodied) information;

- if a compound CD(I) containing the hidden information (I) is restructured in the composing components C and D according to the schematically represented process:

$$CD\ (I) \Rightarrow C+D+I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2),$$

then the hidden information (I) is released as I.

In terms of chemistry, the relations (1) and (2) are called reactions, but in terms of information science, these are considered informational processes, with absorption and release of information. In the living systems, as well as in the electronic communication processes, the source can be faraway of the receptor, like the communication by hormones is actually is. According to the above discussion, a correct communication is that in which the “language" is the same (compatibility), and the message emitted by the informational source is rightly decoded/interpreted/”understood” by the receiver.

A suggestive example of transmission of information as a fundamental process in the living systems, is represented by the chain of informational transcription-translation processes in the cells of various sequences of the gigantic molecule of the deoxyribonucleic acid (DNA) from genes [12], and schematically represented by the relations:

DNA => mRNA (RNA messenger) => tRNA (transport RNA in the ribosomes) + (amino acids) => Protein ……..(3)

where RNA and mRNA are the ribonucleic acid and messenger variant respectively, tRNA is a converted RNA species in the ribosomes of the cells in a new “language"-type system of 20 “letter” alphabet of the corresponding amino acids in human, to finally obtain proteins – the building bricks of the body. Specifically, the DNA sequences, “written" in a “language" of four “letter” alphabet of the nucleotides, which are adenine (A), guanine (G), thymine (T), and cytosine (C) in DNA, adenine, guanine, uracil (U), and cytosine in RNA, are taken/copied by mRNA and translated to ribosomes, where are converted in tRNA, and finally translated in cytoplasm for protein formation, with the contribution of various combinations of amino acids, according to the body necessities [14]. The basic nature of such an informational process is moreover revealed by the binary YES/NO-type relation between these micro-constituents units, working as “letters", because they can be coupled only by complementarity of their structures in DNA or RNA molecules, i.e. A unit can be combined only with T and C only with G in DNA, or A only with U in RNA and C only with G.

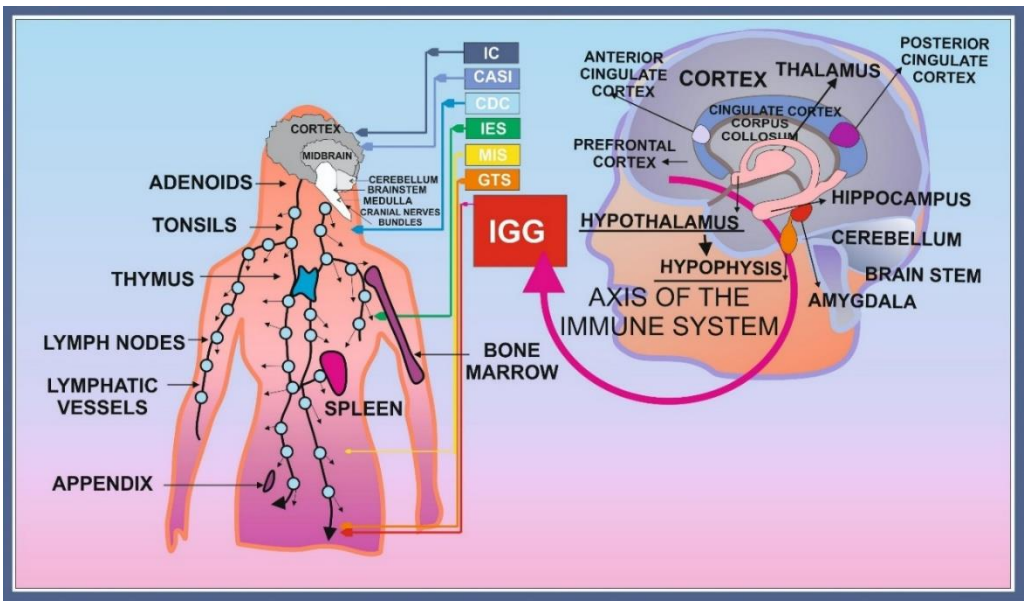

Figure 1 Schematic representation of the Informational System of the Human Body (central side), the relation with the body (left side) and with the central coordination in the brain (right side). A schematic representation of the Immune System is shown in the left side of the figure

Such informational activities in the cells for info-structuration of the organism, together with the info-communication processes between the distinct various constituents of the organism, with various distinct functions, allow the structuration of the entire body and its functionality and functions, shown at the macro level. What it is remarkable to note, is that the typical informational activities and functions at the cellular level are similar with the functions at the macro level of the organism as a whole, as it was recently revealed [11, 12], showing the basic informational common structure not only from the low to higher scale of complexity of the living organisms, starting from the single prokaryotic/eukaryotic cell to multicellular organisms, but also on the entire evolutionary scale, independently on their structural architecture and behavior. This show the essential contribution of information in the structuration and functionality of the living systems, on the entire evolutionary and complexity/organization scale.

With these specifications, we can distinguish the following informational systems in the human organism (Fig.1): (i) CASI (the center of the acquisition and storing of information – memory), connected mainly with the prefrontal cortex for short-term memory, with hippocampus for long-term memory and with sensorial network as an info-input; (ii) CDC (the center of decision and command – decision), connected mainly to 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, as an expression of the info-output attitude; (iii) IES (the Info-Emotional System – emotions), connected with the limbic system (hippocampus, amygdala, hypothalamus) and with hearth – the emo-sensitive feeder with nutrients for the tissues in momentary need, all of them connecting the organism to the external/internal reality for adaptation.

The other informational components of the informational system of the human body (ISHB) are: (iv) MIS (the maintenance informational system related to the metabolic processes), connected with the brain stem and expressed especially by the digestion; (v) GTS (the genetic transmission system – expressed by sexual activity as a genetic info-output), managed by hypophysis and hypothalamus; (vi) IGG (the Info-Genetic Generator), expressing/coordinating the genetic inheritance – the genetic info-input of the body, with development function depending on age and on the body circumstances, managed basically by hypophysis and hypothalamus too. From informational standpoint, these are programmed components of the informational system, assuring the maintenance/development of the body and genetic transmission to the offspring. A special role is assumed by IC (the info-connection center), which selects/distributes the information in a binary YES/NO – acceptance/rejection mode, according to the internal rules of survival and judgment criteria, advertising on the errors with respect to a right/trusting experience/orientation [8], supported by the anterior cingulate cortex (ACC) [21,41] (Fig. 1 right side). This behavior is demonstrated through experimental electro-encephalographic based results [42], indicating that ACC produces a 'distress signal' upon the detection of errors, conflict, and expectancy violation, called the error-related negativity (ERN). Posterior cingulate cortex plays also a role in the attention/orientation to the internal/external world and connection balance [43]. In terms of science of information [39], we have to remark that this could be assimilated with a corrector device at the receptor terminal against the induced errors on the communication channel/line, assuring the accurate interpretation/decoding of the signal, with respect to the reference/admitted values.

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

$$ISHB = (CASI + CDC + IES) + (MIS + GTS + IGG) + IC = OIS + PIS + IC \quad \ldots\ldots\ldots\ldots\ldots (4),$$

where OIS = CASI+CDC+IES is defined as the operative informational system for adaptation, and PIS=MIS+GTS+IGG is the automatic programmed informational system. With an automatic operability like PIS, IC manages the information in an automatic selective YES/NO manner to the prefrontal cortex, during the OIS connection to reality, serving therefore to a right error-free decision/orientation.

IC represents actually at the macro level scale the high coordination level of an efficient info-communication in the organism, fulfilling the condition of a reliable and correct orientation/info-interaction with the informational sources vs. the previous inherited/acquired memorized experience, i.e. the compatibility of "language" and trusting with respect to the species necessities, as discussed above. The IC function, particularly in the case of the immune system, is relevant for the immune cells, which must to act individually against the pathogen invaders, and orient toward the goal on the 3D map of the organism structure to the action location. These results are also a basic key to discuss and understand the activity of the immune system in the human organism from the informational perspective. Such an analysis is possible taking into account that the informational concepts used to explain and reveal the informational system of the human body (ISHB) are the same, allowing to extend the IMHB to any other living system, from the prokaryotic (specific for bacteria) and eukaryotic cells (specific for plants and animals), to the most complex organism (human), defining it as the information model of the human body and living structures (IMHBLS) [10-12, 14], which shows that the

information system of the human body and living structures (ISHBLS) is basically composed by the same constituents, with the particular specification that IES in this case is actually an info-reactive-sentience system (IRSS), allowing to any individual to “feel" reactive sensations induced by various informational sources, at any living level, as follows:

$$ISHBLS=(CASI + CDC + IES/IRSSS) + (MIS + GTS + IGG) + IC = OIS + PIS + IC \ldots\ldots\ldots\ldots(5)$$

In particular, the GTS in the eukaryotic cell is represented by replication/reproduction, IGG by transcription-translation, MIS by the metabolic processes, involving first of all mitochondria for energy production, CASI by the activity of the surface receptors, acting basically by YES/NO-type complementary mechanisms, CDC by chain cascade reactions in the cytoplasm, involving sometime the genes’ YES/NO activation/inhibition-dormancy, IRSS by the reactive sentience, IC by the specificity of the selective preferences at the surface receptors and decision reactions, as it was previously shown [11, 12] and in more explicit details below, necessary to demonstrate the info-activity of the immune system and its appurtenance to IGG.

3 Discussion: the Informational Activity of the Immune System from the Perspective of the IMHBLS

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, according to the age. The immunity system, working to defend the body against the foreigner micro-organisms and any other kind of intruders, is dispersed throughout entire organism by immunity cells through blood and lymphatic system, acting under the control of hypothalamus and hypophysis axis, as suggestively shown in the right side of Fig. 1.

The immunity cells, acting as informational agents of defense fight and as actuators/effectors, are generated the bone marrow (Fig. 1 left side). Because the dangerous micro-organisms can penetrate by any entrance way, invading/infecting the human organism, the defense processes should operate at micro level anywhere in the entire body. However, as this process should be controlled in every moment, it is indispensable to admit that all these defense components/factors should communicate between them for a coherent action, as a function of the localization of the involved population on the distribution map during the aggressive/defense attack [44]. The activity of the immune system should be therefore regarded and discussed basically as a function directed to watch/supervise and communicate/interchange of information between the co-participating partners, and the transmission of the decisional commands to the execution elements to actuate. Before to analyze/investigate the activity of the immune system from the informational standpoint, we have to observe that the communication processes between cells in multicellular organisms, in particular in human, allowing these cells to be “aware"/informed on their own /environmental status for an adequate decision and action [45], can be described as following: (i) the endocrine communication covers a long-distance range and is supported by hormones, which circulate in the blood/fluids circuits; (ii) the paracrine communication refers to a short-distance range and is performed by a diffusion process, like that of the neurotransmitters in the nervous synapses; (iii) the direct-contact communication consists in the informational transit through gap junctions, which are intercellular micro-channels or bridges between the neighbor cell membranes; (iv) the autocrine communication, distinctly from all above, is the communication of a cell with the cell itself, activating by such a self-communication a forward-feedback loop circuit, able to self-sustain for instance the growth of the cancer cells or inflammations by intervention of the grow factor, and the macrophage mechanisms of white molecules in the immune system. All these types of communications are involved in the activity of the immune system, especially the hormonal communication as described in the item (i), the nervously-driven in (ii), and autocrine self-communication in (iv). The involved fundamental driving role is played thus by the nervous system – specifically by means of hypothalamus and endocrine system, leaded by the hypothalamus-hypophysis tandem [46], both of them pertaining to IGG according to IMHB. Concretely, the hormones modulate the function of the immune system in response to activity arising within hypothalamus. This is done by a (iii)-type communication, operative especially at the nervous/hypophysis interface in the brain, the neuron activities stimulating the secretion of hormones in the hypophysis gland, which in turns drives the activities of all other glandes of the endocrine system [46]. The oxytocin and arginine vasopressors hormones are released for instance by hypophysis as a direct stimulation of the hypothalamus, by means of the nervous cells.

Hypothalamus is also interconnected with the brainstem (supporting the MIS activities according to IMHB), with the limbic system (amygdala and hippocampus – supporting IES activities) for the reception/transmission of the input/output information, and with thalamus (acting as a transitory hub for the sensory CASI system), especially to transmit the output information. All of these components contribute therefore to the modulation of the immune system [46]. Within the frame of the info-stimulating connection with the brain regions specified above and with the other associated glands of the endocrine system, hypophysis releases hormones for the stimulation of the bone growth (IGG), the production and secretion of breast milk and uterine contractions (female GTS), the production of ova and sperm by

the gonads (male and female GTS), or the production of components with analgesic (anti-pain) properties [46], and controls even some regulation processes of metabolism (MIS). Such multifunctional activities supply the evidences of how hypophysis is involved in the functionality of IGG, as it is defined by IMHB. The inter-relation with MIS is evidently necessary for the connection of IGG to matter and energy resources, for (re)construction/(re)structuration necessities.

As it can be seen in Fig.1 left side, the immune system is based on the activity of a vast network of cells, organs, various proteins and tissues components throughout the entire body, assuring the defense against invaders, be they toxic substances or living organisms, viruses and bacteria. The immune system therefore is able to discover/"know" and recognize differentially what are the danger products and micro-organisms (pathogens), adequately "decide" and transmit this decision to the execution elements to act for their inhibition and/or elimination. Such characteristics are proper to an informational system, based on cognitive, decisional and executive functions. The main components of the immune system are [46,47]: the hypothalamus/hypophysis as center of coordination – immune system axis in Fig. 1 right side, the lymph system (nodes and lymphatic vessels, Fig. 1 left side), the spleen (an organ where immune cells gather and work), the thymus gland (producing white blood cells called lymphocytes, active agents of surveillance and alarm against pathogens and body infections), the bone marrow (producing and stocking white and red cells), the tonsils (lymph nodes in the back of the mouth, filtering out bacteria and other germs to prevent infection), the adenoids and appendix, which are similar gateways agents against infections, and leukocytes – generically called white cells, spread in the blood and lymphatic system, which act as independent/alone cells. The lymph system consists in a network of nodes and vessels distributed (small arrows in Fig. 1 left side) inside of the entire body like the blood vessels, necessary to store and transport the lymphocytes (a species of leukocytes), specifically acting as natural killer (NK) cells, T-cells (thymus cells) and B-cells (bone cells) by means of the lymph fluid carrying agent. In terms of info-communication, the hypothalamus/hypophysis as center of coordination – immune system axis, represents the informational source, the molecules and hormones as info-agents of communication – the immunity cells, represents the receivers and actuators (info-executing systems), and the communication channels are represented by the lymph/blood vessels. In terms of IMHBLS, the immunity cells are also endowed with their own informational system, their own metabolism (MIS) and connection (CASI/IC)/decisional (CDC) operational components, allowing to understand and interpret correctly (IC) the received information (CASI), and even to modulate their body shape (MIS/IGG) for macrophage attack, or for other adaptive actions. The nodes are small operational "stations" of lymphocytes, concentrated especially in the neck, underarms, groin, and abdomen, where the immune cells gather and react when antigens (any substance including toxins, chemicals, bacteria, viruses, which provoke an immune response) are present. NK cells are lymphocyte that do not require activation in order to kill cells, rejecting tumors and cells infected by viruses through a programmed death process. The B and T cells assure the adaptive immunity as following: the B cells assure the antibody mediated immunity and T cell the cell-mediated immunity. B cells produce antibodies (white-like blood cells) used to attack the invading antigens, while the T cells destroy the body's cells invaded by viruses or cancer. The lymphoid are specifically the T, B and NK cells, representing practically the content of the lymph nodes and about 20-40% of body's leukocytes [48,49].

In terms of information and ISHBLS, from the above investigation results it should be observed that the immunity cells follow a process of evolution starting from the original place of bone marrow as undifferentiated stem cell (GTS), toward thymus, where they are maturated, toward the spleen and lymphatic system for distribution by blood and lymph in the entire body, differentiated by functions but still in a dormancy/standby/inactive state till the discovery of pathogens/antigens. In the first line of the defense is the nonspecific immune system, intervening urgently for the activation of the specific immunity defense. The main processes of activation and communication are performed by means of molecules, as informational agents, circulating by the fluid circuits of the body. The differentiation of the immune cells and their functions, allowing them to detect and decide the attack against the invader, under the central control of the components of the immune axis (the central information source), are actually informational processes, based on the matter-related information, assisted genetically by the central nucleus of the cells (IGG intervention), according to rel. (1). The body cells configuration/reconfiguration is typically performed therefore by structuration/restructuration processes with absorption/release of information, as expressed by rel. (2). These are info-communication processes in a DNA sequential language, as discussed in the previous section, for the "fabrication" by transcription/translation (IGG) mechanisms of various species of proteins, differentiated in specific functions: for building of the body cells and plastic modeling, for communication as informational agents, or for the formation/configuration of the surface receptors as micro-devices, which select the informational signal according to the programmed cell tasks (CASI/IC) for further decision (CDC/IRSS). The modulation processes are based actually by the genetic-assisted mechanisms of genes expression of the behaviors and traits, either inherited or acquired ones by epigenetic processes. It is demonstrated therefore that information and informational processes in the immune system play therefore an essential role both in the cell structuration and plastic modelling according to the cell tasks, and cell functions in the body, depending on the place, moment and interaction with the foreigner components and with the body itself. The immune cells are able to discriminate between body cells and intruders by interaction processes, and reconfigure their body accordingly (MIS/IGG), to eliminate them by phagocytic intervention. This is a consequence of a

decisional process, and of a transmission command to the execution/effector elements. Besides to boost immune responses, the phagocytes (white blood cells, with monocytes, macrophages, and neutrophils as variants), are able to "eat"/ingest the foreign micro-materials and remove the dead cells.

As independent, but inter-correlated living units of the immune system, these cells follow their own existence, according to the common basic rules of life revealed by IMHBLS, but fulfilling specific distinct tasks, as it is demonstrated in this paper. The immune cells of the human multicellular organism are perhaps the more evident and representative examples of the dynamic and rapid plastic/functional adaptation under interaction with their own body and especially with the environmental neighborhood. Analyzing from informational perspective the functionality of an eukaryotic cell – the smallest constitutive unit of the human, animal and plants body structures, it can be seen that this dispose of all informational components of the human body itself [12]. Indeed, the metabolic processes are managed by a MIS like that of the human body, automatically running specific chemical (informational) reactions on specific internal pathways and patterns in the cytoplasm body, engaging typical organelles like that ones in the human body: vacuoles are the "food reservoir" like the stomach, the mitochondria organelles work like a "lung" of the cell producing energy from glucose in interaction with oxygen, the Golgi apparatus is a "heart"-like/blood vessels distributer of fluids in the cell body, the endoplasmic reticulum and lysosomes operate as organelles with 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 replication/multiplication mechanism, the role of IGG by transcription-translation, CASI is represented by the activity of the network of surface receptors as sensors and nucleus, the informational master of the cell, CDC by decisional network of the reactive pathways in the cytoplasm, IES is better defined as the info-reactive sentient system (IRSS), and IC is represented by 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. Thus IC maintains the right significance/interpretation of information before to enter into the decisional chain response circuits, to avoid a wrong decision making by CDC. It is evident therefore, as demonstrated here, that a dysfunction of IC, inducing a bad interpretation of signal, leads to dysfunctions of the cells, manifested by allergic symptoms or diabetes, and disorders like cancer, asthma and arthritis [46], or even disorders of the central nervous system [50]. On the other hand, it is also evident that the reactivity of the immune system is a sentience response also (by IRSS) for the involved cells themselves at local level, and also at the macro/central level (IES) of the organism, by the effects of inflammations or by other associated symptoms.

In terms of information and ISHBLS, the innate (nonspecific) immune system assures mainly the physical barriers (skin, mucous membranes in lungs, intestine), antimicrobial secretions (stomach, mouth), cilia [51], macrophages and cytokines cells, small molecules which activate the immune system [48,52], serving therefore as triggering/communication informational agents. The immune response in vertebrate could be innate, learned already during the evolution of species and incorporated into the genetic info-structure of the cell, or adaptive immune system, individually learned/trained/acquired during a first interaction with a pathogen after an infection or vaccination. Learning is an informational process, a specific property of living structures, exercised by epigenetic processes, in which an information intensively or repetitively received by cell, is "imprinted" in the genetic system [53] (relations (2) and (3)), without losing of the characteristics of the species. As the immune system consists in distributed components in the body fulfilling different functions, T cells are also differentiated by functions, the most important from the operational point of view being the helper T cells (for cell maturation/education in thymus), and effector T cells, executing the immune operation. Each of these types of cells performs distinct functions, although each is composed structurally by similar components and organelles, being an example of how each of them organizes itself the own informational activity and structural tools for a suitable responsive/decisional behavior. B cell memory is another example of specialization, referring to the memory (CASI) of functionality/response/decision of the cell as typical one (CDC), after a first exposition to a pathogen in a natural or vaccination way [54].

In terms of IMHBLS, it is to be noted also that a critical first step in an effective immune response is the info-activation of cells of the innate immune system, i.e. monocytes, macrophages, dendritic cells, and neutrophils, each of them producing cytokines, which initiate the hypersensitivity response of the action cells, manifested by tissue inflammation, edema, or smooth muscle contraction. The neutrophils are the most important, indispensable, predominant leukocytes of the native immune system (about 70% of white cells), circulating through the bloodstream. Being highly mobile, these cells intervene the first in tissues of inflammations due to bacterial infection or of some forms of cancer (CDC), engulfing bacteria or microparticles (MIS/IGG) [55]. In the same terms of IMHBLS, the mechanism of detection and movement to the infected site (chemotaxis) is related to the ability of their surface membrane receptors (CASI) to detect chemical gradients of specific molecules, determining cell to direct and follow a suitable path (IC) toward the target. Macrophages are immune cells highly specialized in the removal of dying or dead cells and cellular debris (CDC executive tasks). Tissues where macrophages reside form a network throughout the entire organism [55]. They are formed through differentiation (IGG) of monocytes, one of the major groups of white blood cells of the immune system, which enter the

infected or damaged tissue or organ where develop, becoming macrophages (IGG/MIS). The cardiac resident macrophages participate in electrical conduction via gap junction communication (channel) with cardiac myocytes [56]. Macrophages show a broad range of communicating and recognition abilities through surface membrane receptors (CASI with the altered self-components of the host and of the microorganisms, followed by surface changes, uptake, signaling, and altered gene expression (IGG), contributing to homeostasis, host defense, innate effector mechanisms, and the induction of acquired immunity [57], highlighting the defining importance of the surface receptor (CASI/IC) implication in the inter-cells info-communication mechanisms and further consequences. Dendritic cells can be found especially in skin, nose, lungs, stomach and intestine, and migrate to the lymph nodes to interact with T and B cell for activation of the adaptive immune system (CDC). Dendritic cells are an example of continue info-communication with other cells, especially by cell-cell contact with lymphocytes, or at distance ((info-communication channels), via cytokines [58, 55]. Within such a communication process, the cell responsivity depends first of all on the selective specific availability, info-affinity and functionality of the surface receptors network (CASI/IC), which is a key for the further interpretation (IC) of the external signal at this informational input.

The acquired (specific) immune system works mainly with macrophages, B and T cells. The findings transposed here in terms of information and IMHBLS, shows furthermore that the key process of recognition is supported by complex inhibitory/activator (YES/NO – Bit-type) surface receptors [59], operating therefore like YES/NO-type informational micro-devices. The internal response is highly determined furthermore by the tissue context and cellular interactions that influence effector lineage fate decisions (CDC), engaging the cytoplasmic signal transduction, nuclear transcription factors (IGG), and mechanisms controlling gene expression (IGG). Specifically, by using the informational terms, the initiation and the transmission of information in leukocytes, which is one of the most complex transmission/decisional process (CDC), follows the following steps and associated mechanisms [60], (i) the initiation of the info-communication process by the binding of a specific ligand (signal), which can be cytokines or other molecules present in other cells, toward the corresponding surface receptor (CASI), consisting in general in one or more transmembrane proteins (always the tandem should be compatible, complementary (YES/NO) each other); (ii) the transmembrane cytoplasm reactive pathways (CDC) anchor the receptor chains in the plasma membrane, initiating the reactive transduction of the initial signal into a bulk intracellular information, typically by a cascade of reactions of phosphorylation or dephosphorylation (so in a YES/NO fashion, according to lMHBLS), with an end parkway in the cytoplasm itself, by the intervention of mediators such as calcium ions, for their sequestration in some special intracellular storage structures; (iii) however, as an effector/executing action is required, the intervention of specific proteins, which should carry out this action (like antibody immunoglobulin gama), fabricated by a transcription process described above is necessary (IGG – rel. (1)), and executed by the stimulation of the dormant/silent gene, so with the contribution of the genetic mechanisms. Such mechanisms illustrate specifically the transfer of information as described actually schematically by the relations (1-3), according to the informational model. The close info-communication between the T cells (helper variant) and B cells, stimulates B cells to fabricate antibodies (specifically immunoglobulin) and help natural killer T cells (NTK) to destroy the target – infected cells [61]. Memory T cells acting within the specific immune system, are generated from the effector T cells in thymus through epigenetic (IGG) modifications [61-64], so by means of a info-communication mechanism, similar with that described above, demonstrating again the informational nature of the activity of the immune system and its implications. Because the B memory cells can be formed only by communication with T helper cells, these cells appears later, acquiring migration properties toward spleen and nodes [65].

Implying the concepts of IMHBLS, which demonstrates the informational nature of the immune activityies it is to be also remark that besides the ability to memorize (CASI) of B and T cells and to produce the necessary reaction (CDC/IGG) against a specific antigen, a remarkable/key property of the immune system is to distinguish/identify the foreigners and the infected cells from the host cells (CASI/IC/CDC/IRSS) by a self/nonself (YES/NO) discrimination process (OIS intervention). This is complied by two ways: through the T cell-mediated-immunity, which does not involve antibody intervention, and through the implication of the B cell activity, by means of B-cell humoral immunity mechanism, with the involvement of antibodies, as presented above. The T-cell self/non-self-recognition mechanism is based also on the differential capability of the surface receptors (CASI/IC/IRSS/CDC) to distinguish selectively (IC) the various other cells or even peptide fragments of antigens (by intervention of cell surface glycoproteins), after the process of phagocytosis (i.e. the process by which the white blood phagocytes cells ingest/engulf (MIS/IGG) other cells or particles) [59]. These mechanisms demonstrate again that the central operability of the immune system is driven by informational processes, as a combination between genetic-assisted info-generation and communication mechanisms, assuring the local reconfiguration of the body structure and functionality by structuration/destructuration mechanisms, according to the necessities, as described by rels. (1-3) within the frame of the IMHBLS.

4 Conclusion

On the basis of the informational concepts of the IMHBLS and ISHBLS, it was demonstrated the informational nature of the activity of the immune system, and its appurtenance to IGG. It was shown that the approach of the human body and of the eukaryotic cells activity from informational perspective, within the frame of the IMHBLS, can be coherently described by the introduction of the concept of matter-related information, which allows to understand the operability of the body at micro and macro level. On this basis, it was shown that the interactions between the micro-material components of the human body, valid also, according to IMHBLS, for any other living structures, including the cell as the smallest living unit working independently or inter-correlated in human multicellular organism, are fundamental processes of communication, generating or absorbing information, by structuration/destructuration mechanisms. This insight allowed to coherently express the genetically-assisted processes of info-generation and communication, and to distinguish and define various components of the informational system of the human body and their relation with the brain – as a central info-manager – and the body itself, within the IMHBLS.

Analyzing the activity of the immune system as an integrated part of the informational system of the human body and living structures (ISHBLS), it was demonstrated that this acts as a part of the info-genetic generator (IGG), operating by the contribution of the genetically-assisted processes initiated via the communication through informational matter-related agents between the constitutive immune components themselves, i.e. with the central driving info-manager in the brain, and with the distributed components of the body. The key role in the immune processes and info-communication is played by the surface cell receptors as CASI attributed sensor/local memory, which can be configured/reconfigured by the contribution of the dormant genes (IGG), which are activated accordingly through a decisional CDC-assisted cascade of reaction response induced by an external signal received at the surface receptor (CASI), acting basically as an YES/NO informational micro-device, and maintained within a right task decision/action by IC. The right functioning according to the local tasks and goals of a cell is assured by IC, through selective action of the surface receptors and internal micro-reactions on the suitable reactive paths, avoiding anomalies of operability, which can generate dysfunctionalities like allergies and diabetes, or disorders like cancer, asthma, arthritis and even disorders of the nervous central system. The operations of the local immune system engage also info-sentient consequences involving IRSS/IES at the local and central informational systems by inflammations and or by associated symptoms. It was shown moreover that the immune cells could act as info-communicative and/or executing agents (killers and phagocytes cells), in a complex info-dynamic and multi-spatial informational activity, coherently managed by the central informational system.

Compliance with ethical standards

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Disclosure of conflict of interest

No any interest conflicts

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