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Cellular Info-Operability: Micro/Macro-Scale Inter-Communication in The Immune System of The Human/Mammalian Organism

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In this paper it is demonstrated the informational basis of the operability of the immune system of human/mammalian organism, composed by micro-scale mobile and macroscale stationary components, and the close correlation between the micro-scale mechanisms and macro-scale effects, based on info-communication running processes, an issue not yet understood till present. It is shown thus that the activity of the immune system of human/mammalians is based on the transmission and reception of information, between the mobile micro-components of the immune system-the immune cells, and between these cells and the central info - manager of information in the brain-the hypothalamus/hypophysis. This is a consequence of the info-operability of the smallest units of the organism - the cells, disposing of the same structure of the informational system like that of the multicellular organism, as demonstrated by the informational model of the human body and living structures. This common info-structural organization is a typical fundamental key for the functioning of the living organisms in general and immune system in particular, which assures coherently the activity of the individual immune cell, of the collective community of the immune cells, working together to comply the same goal - the defense of the local zone against the antigen invaders, and of the entire multicellular organism. The common informational basis explained within the informational model of human body and living structures, allows to demonstrate that the immune system is a component of the info-genetic generator of the informational system of human body, and that the info-connection is an essential component for a right and correct communication between the immune cells. The dysfunctions of such a communication could rise to micro and macroscale effects, manifested first of all by inflammations and allergies, by cancer, arthritis, diabetes and even by diseases of the nervous system.

Keywords: Information; Informational model of the human body and living structures; Micro/macro-scale; Statistic cell population; Info-genetic generator; Immune system; Info-operability; B-cells/T-cells; surface receptors; Info-communication; Info-connection

Introduction

Maybe the most suggestive and relevant example of dynamic info-communication between the low/marco-scale components of the human body is represented by the immune system. That is because this consists in a distributed network of various components in the entire organism, which can be classified in two main categories:

some of them fixed at macroscale dimensions, and others consisting in a network of mobile immune cells, circulating by means of the blood and lymph vessels, operating elsewhere is necessary, within the affected organism tissue by pathogen invasion. Although it is acknowledged in principle that the communication is a tool of

correlated intervention for the organism defense, the mechanisms of such a communication from informational perspective there were however not really defined and understood [1]. Important advances were however obtained on the explanation of the informational functioning of the human organism based on info-structuration/communication processes within the Informational Model of the Human Body (IMHB), which determines not only its structuration-both at micro and macro level, but also the behavior and functionality of various organs and micro/macro constituents [2, 3]. On such a way, it was possible to explain the info-correlation between the body and mind [4] and the corresponding neuro-communication [5], and it was possible also to advance and develop an Informational Model of Consciousness (IMC) [6], as well as of the corresponding adjacent mind properties [7-10], the macro-phenomenological effects of the informational processing in the brain, taking into account the corroboration of information from various informational cognitive centers [11], for decision making, expressed as attitude [12] and its evaluation [13], to explain the selective role of the anterior [14] and posterior cingulate cortex [15] in the exploration and evaluation of reality [16] with respect to the decision criteria [17], the neuro-equilibrium [18], mental aggressiveness [19] and mood disorders [20], and even to reveal the music-based therapy by activation of the cognitive centers defined by thy IMHB and IMC [21]. On the other hand, it was analyzed and developed an informational model of the living structures (IMLS), with reference especially to the eukaryotic cell, representative for the multicellular organisms-plants [22, 23] and animals [24], and also to bacteria (prokaryotic cell) – as unicellular independent organisms, by similarity [25]. The corresponding findings show that the living structures operate with information on the entire scale of evolution and organization based on a similar structure of their informational system, defined as informational system of the living structures (ISLS), revealing the common informational background [3, 25], with corresponding consequences in a better definition of the informational concepts and mechanisms, serving to discuss the running of the immune processes in the human immune system [26].

Despite all these advances, based on the successful application of the informational concepts in biological structures [27, 28], the understanding of the info-correlation between the micro and macro components of the human organism and by extension of the mammals, is still a critical issue of analysis, so more data on such an issue allowing to acknowledge the fundamental role of informational mechanisms and processes on functional behavior of the organism, focused from micro to macro scale and reversely, is still a non-approached or carelessly treated subject. In order to improve the understanding on this issue, and reinforce the concept of information as a determinant factor intervening in the functionality of the body, in particular of the immune system, in this paper there are analyzed and emphasized further characteristics and intimate informational mechanisms involved in this operational work, demonstrating the fundamental role of information in the inter-communication between the immune cells and collectivity, with macroscale effect. It is also demonstrated the appurtenance of

this system to a specific component of the informational system of the human/mammalian body defined as info-genetic generator, and the crucial role of the compatibility of the info-connection between the immune cells.

The Informational Model of the Human Body and Living Structures: Brain/Body Relations and Immune Micro/Macroscale Components

The discussion on the info-operability of the immune system and its micro/macroscale components in human and mammalian, is indispensable correlated with information and the information system of the human body and living structures (ISHBLS). This system is illustrated schematically in Figure 1, where:

- CASI – center of acquisition and storing of information, manages the sensorial network (info-input) and memory, connected with the prefrontal cortex (short-term memory), hippocampus (long-term memory) and cerebellum for motor-combined learned stereotypes and with thalamus as a sensory distributor hub, essential for awareness and consciousness state (Figure 1a,b); in eukaryotic (animals and plants) cell, CASI is represented first of all by the surface receptors specialized to bind only the ligands informational agents with complementary structure, in a YES/NO (Bit-type) informational manner [3, 25], and secondly, by the corresponding typical pathway to the genetic/epigenetic structure of the cell, where the informational reaction cascade initiated at the surface receptors can intervene to activate/memorize (YES) further information, or inhibit (NO) it (Figure 1c).
- CDC – the center of decision and command, manages the decision process especially in the cortex at human/mammalian, and within the pathway network in the cytosol of the eukaryotic cell, transmitting a reactive response to the external environment (info-output) (Figure 1b), expressed by motor-action/posture, and at human especially by vocalization (Figure 1a);
- IES – info-emotional system at human/mammalian is connected with the limbic system (hippocampus, amygdala, hypothalamus) (Figure 1a,b) and with the heart, the sensitive driving distributor of the nutrient fluid to every component/cell of the body, according to the momentary needs; in cells and inferior organisms on the organizational/evolution scale, this system is equivalent with an info-reactive sentient system (IRSS), which is perceived as a sensation/feeling/sentience effect of the received/processed information within any living structure [2, 29], such an emotional/affective/sentient process being manifested typically by spontaneous reactive movement, and evaluated in the individual organism as GOOD/BAD, with an acceptance (YES) or rejection (NO) effect, depending on the nature of information, according to the species and individual experience;
- MIS – maintenance informational system, manages the metabolic processes within the matter-related metabolic circuit/pathway in animals/cells respectively, generating

energy (E) from adenosine triphosphate (ATP) (basically obtained from glucose and oxygen-assisted processes – Figure 1c), and micro-components (minerals, proteins, fat, amino acids, etc.) for the structuration/restructuring of the body; in human/animals the MIS circuit (provided with input/output orifices/pores terminals in multicellular/unicellular organisms respectively), is connected with the brainstem and digestive

system and with the corresponding organelles in cells, i.e. lung-like mitochondria, stomach-like vacuoles, endoplasmic reticulum and lysosomes, working like pancreas and spleen for elimination of the degraded products, Golgi apparatus, as a heart-like blood vessels distributor of fluids in the cell body etc [3] (Figure 1a-c);

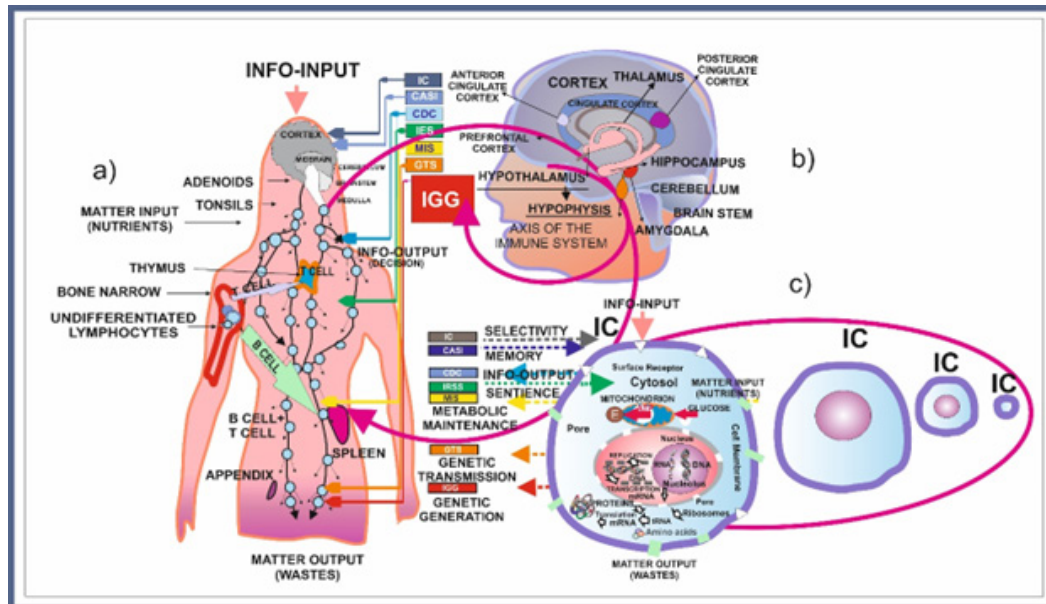


Figure 1: Schematic representation of the Informational System of the Human Body and Living Structures (ISHBLS), with reference to the central brain-body coordination (a), the components of the immune system and their distribution in the brain/body (a, b), and the informational structure of the eukaryotic cell (c).

- GTS – genetic transmission system, is connected with sexual organs in animals, assuring the reproduction both in animals and cell, driven basically by the replication process of the deoxyribonucleic acid (DNA) of the nucleus, which initiates the cellular division (Figure 1c);
- IGG – info-genetic generator, is connected basically with hypothalamus and hypophysis in human/mammalian, and drives the growth, structuration/restructuring processes and the defense of the organism (immune system shown schematically in Figure 1a,b), composed by mobile cells generated in the marrow bones, and distributed by blood and lymphatic fluid throughout the immobile structures, consisting in blood/lymph vessels and their nodes (cell stations), spleen, thymus and special singular organs like adenoids, tonsils and appendix, defending the entrance gates to the organism against the pathogens; in cells, IGG is represented basically by transcription-translation processes for the production of proteins, the bricks of the body, operating by informational mechanisms, which consists in the copy of various sequences of DNA in “four-letter alphabet” of the nucleotides by mRNA (messenger RNA), the transposition in a new language in ribosomes by tRNA (transport RNA), combined with some of

the 20 amino acids components in cytoplasm (Figure 1c) [2, 29];

- IC – info-connection system, is the most subtle component of ISHBLS, with not so evident, but fundamental function for the correct functioning of the organism, probably the most relevant in the operability of the immune system: this system maintains basically the received signals through a permitted informational “window” in suitable range, according to the inherited/acquired experience, allowing the correct/non deviated operation from the attributed task [29]. At human, this is experimentally evidenced by an EEG (electro-encephalography) error signal in the anterior cingulate cortex before a decision, advertising on such a deviation [30], and manifested by a spontaneous evaluation in social relations or problem resolution, and at animals by a correct individual/collective orientation during the migration of the birds, anticipation of a danger or bad weather, synchronized behavior of the school of fishes or of bacteria colonies [8, 29, 31]. In the multicellular organisms, IC is operative even from the info-input reception of the signal by a specific, firm selection (YES/NO) of a specific signal at the surface receptors (Figure 1c) and after, according to the inherited/epigenetically supported goals, and by the associate

network in cytoplasm, assuring the regular, right functioning of a cell, in agreement with the particular specific tasks within the local/general micro/macro-scale body context, as it will be further discussed below in the case of the immune system.

According to the above presentation, IMHBLS reveals the structure of the informational system of the human body and living organisms, showing that at the micro/macro-scale of dimensions, independently on the shape and living conditions, the living structures – from the eukaryotic cells and prokaryotic unicellular organisms, even if these ones does not dispose of well defined organelles, but dispose of the necessary functions, all of them operate with information in a similar way, based on the same informational structure and informational system, composed by seven main subsystems: CASI (memory and sensorial network-info-input), CDC (decision-info-output), IES/IRSS (emotions/sentience reaction), MIS (power, vivacity, self-status/health), GTS (genetic info-output), IGG (genetic info-input and body development), and IC (straight/right/trust/safe/reliable maintenance of the info-orientation/navigation, according to the specific individual tasks, within the permitted informational window of work). Another important conclusion is that information is a fundamental component of the living organisms, indispensable both for body structuration and its functionality. The micro-components of the body in the multicellular organisms – eukaryotic cell, operate on the basis of the same informational structure, assuring the functionality and body structuration, but with a higher level of organization, under the central management and coordination of the brain.

Micro/Macro-Scale Inter-Communication Between the Components of the Immune System of Human/Mammalian Organisms

As it is schematically represented in Figure 1a, the immune system is composed basically by stationary and mobile components: in the bone marrow and thymus (primary lymphoid organs) there are generated immune lymphocyte cells (native and adaptive agents, acting as NK-natural killers), which can circulate by the lymphatic and blood vessel network, and are accumulated preferentially and differentially in thymus (T-thymus cells), spleen (B-bone cells) and lymphatic nodes (T plus B cells) for further executive functions against the dangerous pathogenic invaders, be they living organisms or toxic particles. The tonsils are lymph nodes placed in the back side of the mouth, which filter out bacteria and other germs to prevent infection. The adenoids and appendix are similar gateways components with preventive role. The leukocytes - generically called white cells, are the immune agents spread in the blood and lymphatic system, forming a statistic population of surveillance and fighters/effector cells, prepared to intervene in the momentary and local site, as necessary. Basically, the immune system acts as an informational/executor system, because it is able to detect/discover ("know"/recognize) in a differential way the intruders, and to decide and command their inhibition/elimination: B cells make antibodies, a species of white blood cells used as effectors, while the T cells help to destroy the body's cells invaded by viruses or cancer. NK are innate cells, capable of immediate intervention, while T, B are adaptive cells of the immune system

which learn to fight only after a primary interaction with pathogens or vaccination, all of them representing practically the content of the lymph nodes and about 20-40% of body's leukocytes [32, 33].

As the immune system consists in stationary and mobile components non-"wire" connected, a fundamental question is how they assure a coherent actuation. According to IMHBLS, this question is clarified taking into account the info-operability of their components, which can communicate between them themselves and with the central coordinator-the immune axis of the brain, by matter-related chemical informational agents [2, 29].

The definition of matter-related information comes from the information-assisted structuration/destructuration processes, which are absorbent or releasing of information, as it was explained in detail elsewhere [29]. In terms of information, the hypothalamus/hypophysis immune axis as a macro-center of coordination is the central informational source, the small molecules and hormones acts as carrier info-agents of communication, the immunity micro-scale cells are the receivers and actuators (info-executing elements), and the communication channels are the lymph/blood vessels and lymphatic operational/storing online stations. The remarkable point revealed by IMHBLS is that the micro-scale informational agents themselves – the immune cells, acts as fully-equipped "intelligent" informational agents, possessing their own capacity of cognition and actuation, i.e. info-perception, info-processing, reactivity, info-communication and execution. More that, they are able to reconfigure plastically their body by means of the IGG's activity, expressed in informationally assisted transcription-translation mechanisms for protein fabrication. At this micro-scale level, the alone immune cells are similar with the autonomic satellites, info-connecting statistically with the central macro-scale center, which receives this mediated signal and elaborates an adequate decision for further actuation. Indeed, the immune cell, this micro-scale intelligent operator is equipped with own source of energy (MIS), receiving the nutrients by the food cordon of blood vessels, with a sensitive surface receptor/cytoplasm network for info-perception and memorization (CASI), with a selective administrator of suitable/reliable information according to the specific momentary tasks (IC), which is supported by corresponding activation of suitable surface receptors and comparative analyzers for correct understanding and interpretation of the received signal, with info-processors of information to make output decisions, and to transmit them to their body, able for own shape modulation (IGG) in the case of macrophage actions, according to the specific task. In conjunction with such a defense strategy, a higher density of local small stations with T and B cells – the lymph nodes, is spread on the most exposed or germs-sensitive body regions like neck, underarms, groin, and abdomen.

The activity of the immune system is controlled at the macro-scale level by the immune hypothalamus/hypophysis tandem, as it was mentioned above. This management activity could be not possible without the inter-communication between this center and the population of the immune cells, dispersed on the tridimensional (3D) map of the entire organism [1]. This objective is fulfilled by informational inter-communication between cells [34],

assured by hormones in endocrine communication at distance, by neurotransmitters in paracrine short range communication in the nervous synapses, by micro-channels/bridges through the neighbor cell membranes in the direct cell-cell communication, or by autocrine communication, consisting in the reception of own broadcasted signals in a positive feedback loop, inducing the micro-scale activation of the macrophage mechanisms of white cells and bad functioning of the cell, with negative macro-scale consequence like cancer growth, inflammations through the intervention of the grow factor, allergies, arthritis, diabetes and even diseases of the nervous system

From the perspective of information science, a right and correct communication between two partners is obtained if they use the same language, and if the level of understanding/interpretation (decoding of the initial codified message) is correct. The losses of accuracy on the transmission channel (noise), should be also taken into account. Transposing to the communication in living structures this model, discussed for the first time for electronic systems [35], it is to observe that the components of the inter-communication should be compatible each other, i.e. they should use the same kind of "language", and the codification/decoding should operate adequately. If the receiver does not interpret the received message correctly, i.e. within the permitted "tolerance" of the error limits, the result of the communication is disturbed/distorted. Within a common communication process between individuals, the term "tolerance" refers to their inherent, but acceptable differentiation of their mentality, culture and preparation, the kind and manner of judgment and to the decisional terms and criteria, which evidently could be different. At micro-scale level, the cells dispose of a certain range of communication channels by various types of surface receptors, which can be activated or inhibited. IC is the informational system which signalize the incorrect connection to the source, or inadequate interpretation of a signal, different of the right interpretation according to the inherited or systematically experienced, validated and accepted patterns during the life, by epigenetic adaptation proesses [36, 37].

Because the individual immune cells dispose only of a limited "visibility" on the local health state, although each of them can detect differentially the local irregularity, they transmit the corresponding data to the neighbor cells for comparison with the health normal state of the organism, and actually receive the feedback collective response, managing on this way the inflammation, in a kind of 'swarm intelligence' or 'crowd wisdom' manner, which would be actually an integral part of the immune computation of the health state, as it was recently proposed [38]. If such a hypothesis would be accepted as operational, this process can be compared with the activity of a learning machine, in particular with that of a new generation of artificial deep neural networks, used in the automatic driverless cars, responsible to make dynamic momentary and optimal decisions under a very high complexity of traffic, although each of them – the natural and artificial intelligent systems, works in their own manner. Even they are different systems, the degree of complexity could be evaluated comparatively, taking into account that such a learning machine can work at present with about 150 millions of parameters, while the natural system with even more

degree, knowing that a milliliter of blood contains about 2 million T cells, and each T cell expresses tens of thousands of proteins on its surface, exhibiting orders of magnitude more complexity than the most developed present learning machine [38]. However, from the point of view of IMHBL, the collective response could be actually a result of the exposition of the immune singular cells to the same source of information emitted by the central components of the immune axis in the brain, which operate the signals in a statistical mediated way, transmitting the feedback response to the cell collectivity. Therefore, not necessary a collective wisdom should be involved in this case. From the perspective of the IMHBL, the central role of the brain for the management of the immune system is really defining, both in the control of the gland network through hypophysis, and in that of the nervous system by hypothalamus, as mentioned above, and cannot be neglected. Indeed, as it was shown above, various types of communications are involved in the activity of the immune system, but the fundamental driving role is played by the hypothalamus/endocrine tandem [39] both of them pertaining to IGG according to IMHB. Concretely, the hormones as distance communication agents modulate the function of the immune system in response to the hypothalamus nervous stimulation of the hormone secretion of the hypophysis gland by direct communication at the nervous/hypophysis interface in the brain, which in turns drives the activities of all other glandes of the endocrine system [26, 39].

On the other hand, the inter-connection between individuals of the same species/category can be also effective, giving rise a collective common behavior. According to IMHBL, the role of IC system is also defining for the inter-communication between cells themselves. This communication is only effective on the basis of compatibility of the surface receptors, allowing the access to the same informational 'window' among the large range of informational signals, and the appropriate coding/decoding system/language expression and interpretation of signals, as indicated in the Figure 1c. Indeed, in partnership communication, two conditions should be fulfilled for a right/good communication, as mentioned above [16, 37], the same language (nature of the signal) should be used, and the message interpretation (significance) [40] to be appropriately transduced/decoded, according to the message significance transmitted from the informational source. These requirements are filtered/fulfilled and maintained by IC's individual system of the cells, according to own info-ability to couple to the informational source, in function of its preparation/individual experience, all of them over the native inherited tasks and functionalities imposed by the specific construction and destination. The notable performance of the immune cells consists also not only in the dynamics of info-reception/transmission of signals and their interpretation, but also in the fulfilling of the decisional activity by executive actions (involving IGG/MIS), manifested by their own body reconfiguration shown by macrophage cells, as a function of their own momentary tasks.

The activity of IC consisting in the analysis and comparison of the new information with the existing patterns inherited according add to the species properties and behavior (IG) [41], or epigenetically acquired during the life [17], are related with

the learning process (CASI), from the long-term memory to the memorization by epigenetic processes in the stable genetic system, trans-generationally transmissible [36]. Such memorized information is the result of the verification during innumerable, repeatable experiences by the present or anterior generation and accepted a valid, and guarded in the patrimonial mentality of the local collectivity. Such an educational process is actually the result of the adaptation to the local conditions and inter-relational activities, helping the life of entire collectivity/"colony", so the life of every of its individuals. IC was therefore generated by adaptation necessities, as a vigilance center necessary for every form of life, developed and expressible with more or less evidence, depending on the local conditions of adaptation of every species. One of the more traditional pattern acting as a reference is that of the alarm system, which is managed at human and mammal organisms by amygdala. The immune system is also a result of the necessity of defense against the micro-organisms, so that the IC system of every fighting units – the immune cell, located in the first front of this reactive defense, should be extremely active.

The informational model of human body and living structures is therefore capable to explain in this way the multifaceted forms of inter-dependence and inter-communication between the various components of the body, in cooperation to comply a common target, dedicated in this case to the organism defense. Such a remarkable property should not be surprising at all for the living structures, although at a first glance just seems to be. The evolution of the organisms from the inferior (unicellular prokaryotic/eukaryotic units) to more organized multicellular organisms on the evolutionary/organization scale by collective association in a unique body, but specialized by functions in corresponding organs, is actually a consequence of such an inter-communicative processes, generated by the stringent need of defense and better chance of survival of such organisms, as an adaptation effect. The immune system offers therefore an illustrative and remarkable example of the division of the tasks and collaborative work by specialties, under a common scope in the multicellular organisms, with favorable results for the entire collectivity, like other biologic categories in nature show: schools of fish, flocks of birds, and hives of bees, colonization of bacteria.

Conclusion

It was demonstrated the fundamental role of information in the activity of the immune system, by inter-communication between its micro-components at dimensional micro-scale, all of them working for the fulfilling of the same target, the defense of the organism against the micro-invaders, with effects at macro-scale level for health maintenance. It was demonstrated that the activity of the immune system is based both on the inter-communication between these components and with the central immune axis represented by the hypothalamus/hypophysis, managing statistically the mediated signals of the micro components at central macro-scale, which support the activity of IGG.

The IMHBSL is able to explain these processes in terms of information by using the concept of matter-related information, as a result of the configuration/reconfiguration of the micro-

material components of the body, transmitted by small info-carrier agents. The smallest components of the immune system, with a mobile circulation within the human/mammalian organism – the eukaryotic immune cells, dispose of a similar informational system like the organism itself. They are able to receive and release information and to make decisions, so to react at information, by inter-communication between them, in which the info-connection (IC) system plays a fundamental role. Such a communication can induce a collective response, consisting in the coherent behavior of the entire collectivity of the immune cells, able to act for the fulfillment of the same local scope, but the global immune coordination is performed by the brain. The collective behavior is spectacular but common in nature, a relevant example being the multicellular organism itself, where the multitude composing cells work in a perfect symphony to assure and maintain the coherent functioning and health of the entire body as whole. The dysfunctions of the info-communication between the immune cells between them and with the central immune axis provoke negative effects at the micro and macro scale, consisting in cancer, diabetes and other forms of diseases.

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Conflict of Interest

No Conflict of interest.

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