Open Access

Archives in Biomedical Engineering & Biotechnology

Iris Publishers

Research Article

Epigenetic Information-Body Interaction and Information-Assisted Evolution from the Perspective of the Informational Model of Consciousness

Florin Gaiseanu*

Principal Senior Researcher (Professor), Science of Information and Technology Bucharest (Romania), and Barcelona (Spain).

***Corresponding author:** Florin Gaiseanu, Principal Senior Researcher (Professor), Science of Information and Technology Bucharest (Romania), and Barcelona (Spain).

Received Date: June 28, 2019

Published Date: July 09, 2019

Abstract

Introduction: the objective of this investigation is to analyses the advances of understanding in the epigenetic processes and to extract conclusions concerning the information-based evolution from the perspective of the Informational Model of Consciousness (IMC).

Analysis of epigenetic mechanisms: it is shown that the study of the epigenetic mechanisms are of increasing interest not only to discover the responsible mechanisms of some diseases, but also to observe the acquisition and transmission mechanisms of some traits to the next generation/ transgenerations, without affecting the DNA sequences. These advances were especially supported by the spectacular progresses in the high technological tools like digital microfluidic techniques and semiconductor-based detection systems, allowing to apply sequencing methods of DNA and to observe its structural modifications. The specific typical steps of the epigenetic mechanisms are analysed, showing that these mechanisms could be fully described in terms of information, as signal transmission agents embodying or disembodying information in three different stages and under specific conditions, including especially the signal persistence as a main conditional epigenetic factor.

Results concerning the information-assisted evolution from the perspective of IMC: the epigenetic mechanisms are discussed as a function of each component of the informational system of the organism, consisting in memory, decisional operability, emotional reactivity, metabolic driving processes, genetic transmission, genetic info-generator and the info-connection explaining the special extra-power properties of the mind. It is shown that the epigenetic mechanisms could be related to the specific functions of each informational component, mainly exhibiting five levels of integration of information as matter-related information, culminating with the stable integration in the procreation cells and transmission to the next generation. The results were extended to explain the transgenerational adaptive processes of isolated population groups.

Conclusion: the epigenetic mechanisms discussed within IMC allow to understand the transgenerational adaptation as an information-assisted process.

Keywords: Information; Epigenetic mechanisms; Epigenetic transmission to the offspring; Informational components; Information-assisted evolution; Transgenerational inherited adaptation

Introduction

In a series of recently published papers it was shown that the informational system of the human organism operates by means of seven components referring to memory, decisional operability, emotional reaction, autonomic driving of the metabolic processes, genetic transmission and genetic info-generation [1-3]. A special component explains some extra-power properties of the mind, revealed during the near-death experiences [4, 5] and other similar phenomena [6-8]. Such an informational architecture of the human informational system permits to approach the analysis of the interaction between the received information from the environment and conclusions on the adaptation process of the organism [3,9]. This analysis is supported also by the increasing epigenetic studies [10-12], showing that some acquired traits during the life can be transmitted to the offspring by means of embodiment/disembodiment mechanisms of information [3]. The progress obtained in this field is an encouraging stimulant to approach also the evolution process due to the adaptation to changes of the environmental conditions [13]. Therefore, in this paper it is presented first of all an analysis of the epigenetic processes and the typical steps of such mechanisms. In a second section there are presented the results concerning the information-

assisted evolution from the perspective of the Informational Model of Consciousness (IMC), recently reported, as mentioned above.

Analysis of epigenetic (information-related) processes

The epigenetic science have been opening a new field of investigation in genetics, allowing valuable observations on the intimate mechanisms of the interaction of information with the material body [3], specifically on the environmentally induced phenotypes (observable properties of an organism produced by the interaction with the environment), which can be transferred to the offspring, without affecting the genetic sequences of the deoxyribonucleic acid (DNA). Such mechanisms are based on molecular factor transfer of information, by info - embodiment/disembodiment processes [3]. This concept refers to the interaction of information with the body, underlining that body matter, at the low scale level represented by cell and its molecular components, is actually a carrying agent of information, intrinsically incorporated inside of it. Therefore, such processes reveal actually the intimate interaction between the received information and body, so could be defined as info-body related processes. The term epigenetic itself is a product of two concepts, that of genetics, and that of epi, which means "around of" [13]. The investigations in the field of epigenetics have been increasingly improved by the implementation of the high technologies in the instruments of characterization, basically allowing the DNA sequencing procedures, like for instance the digital-microfluidic techniques [14], or semiconductor-based detection systems [15].

On the basis of such methods and techniques, epigenetic reveals the mechanisms of the regulation of gene expression, as a common process that acts during the differentiation of somatic cells, incorporating the informational response to environmental cues and stresses, which passes as overlapping modulations to the offspring constituted epigenetic inheritance [13]. On such way, the environmentally induced phenotypes can persist for one or several generations, due to the transmission of the incorporated info-response, that determine how DNA is read and expressed. These high technological advances have revealed the role of intimate mechanisms of epigenetic inheritance, among which the DNA methylation, histone modification and small RNA transmission are of a main demonstrated importance [3,13]. The epigenetic processes can explain both the personal acquired traits transference to the offspring [3] but also the adaptive effects of population groups living in the same conditions of environment, nourishment and stress. The adaptive effects of parental environment on offspring development, defined as adaptive transgenerational plasticity, are increasingly known in both plants and animals [16] with conclusions applicable for human adaptation and evolution [17].

In terms of information, the epigenetic mechanisms could be discussed taking into account three main categories of signals [3,11].

The signal which originates the interaction of the environmental perceived information with body itself is generally called "epigenator". Once the received information is converted into an internal integrated signal, implying the cell molecules, we should refer to this incorporated information as to a matter-related signal, and to such a process as to an info-embodiment process [3]. This informational signal initiates a molecular chain of interactions with the body cells, converting in this way the initiator signal in an intimate cellular response. However, in order to obtain an epigenetic response, this signal should be sufficiently persistent, allowing to really trigger the second step of the epigenetic process.

The matter-related info-signal induced by the epigenator into the cell is generally called "initiator". The epigenetic effects on the cells are obtained as a result of the initiator action upon the chromosomes, which are composed by DNA (30-40%), RNA (ribonucleic acid, 1-10%) and histones (50-60%), some proteins which anchor the double helix type DNA structure to avoid its damage. The proportion of these components varies not only for different species and for various tissues of the same organism, but even in the same cell, depending on the various stages of the cell cycle [3]. Although each individual nucleotide (repeating units of DNA polymer) is very small, a DNA can contain hundreds of millions, like in the human DNA structure, where the largest human chromosome with approximately 220 million base pairs (bp) would be of 85 mm long if straightened [18].

The epigenetic "maintainer" signal is the final step of the epigenetic process, which actually conserves the stable embodied information which can be transmitted to the daughter cells. The epigenetic info-signals [3] are represented mainly by DNA methylation (DNA methylation is the substitution of a methyl (−CH3) group to the carbon atom in position 5 of a DNA segment), histone modifications and variants nucleosome positioning, chromosome coating with (long) noncoding RNAs, and others [11,12].

The epigenetic mechanisms allow the body adaptation [17] and the transmission of the acquired information as traits of the parents to the next generation [3]. Although such mechanisms could seem to be quite complicated, some common characteristics could be observed, allowing a global description in terms of informational concepts. In terms of information, the epigenetic feedback for instance could be actually referred to an informational YES/NO-type biostable mechanism, like in the computation informational system, consisting in the operating mode over or under a certain "threshold" condition of a reaction [3,19].

Results

The above analysed data allow to refer to the information-assisted process of the organism evolution from the perspective of the recently developed Informational Model of Consciousness (IMC) [3,20-22]. According to this model, and taking into account two fundamental forms of information supporting the life dynamic processes and mind-body relation [23], i.e. the virtual (mind-operational) and matter-related (epigenetic and genetic) information [24], the following informational systems could be defined, as represented in Fig. 1: the Center of Acquisition and Storing of Information (CASI), assuming all the brain areas contributing to the external info-perception and info-acquisition (memory) (23,

24), the Center of Decision and Command (CDC), dedicated to info-processing, decision and body voluntary command, the Info-Emotional System (IES), attributed to the emotional reactivity to the input information, Maintenance Informational System (MIS), complying mainly with autonomic processing of matter as a support of metabolism, Genetic Transmission System (GTS), which is the info genetic transmitter, and Info Genetic Generator (IGG), carrying the inherited information from parents. A special informational system, defined as Info-Connection pole is responsible for the special mind properties, like near-death experiences (NDEs) and Religious and Mystic experiences (RMEs) [4-7] and other special phenomena like premonition and clairvoyance [1,8,25]. While the first six mentioned informational systems operate with a common, current information, the seventh IC is detectable and provides information under special extreme conditions, as pointed out above (Figure 1).

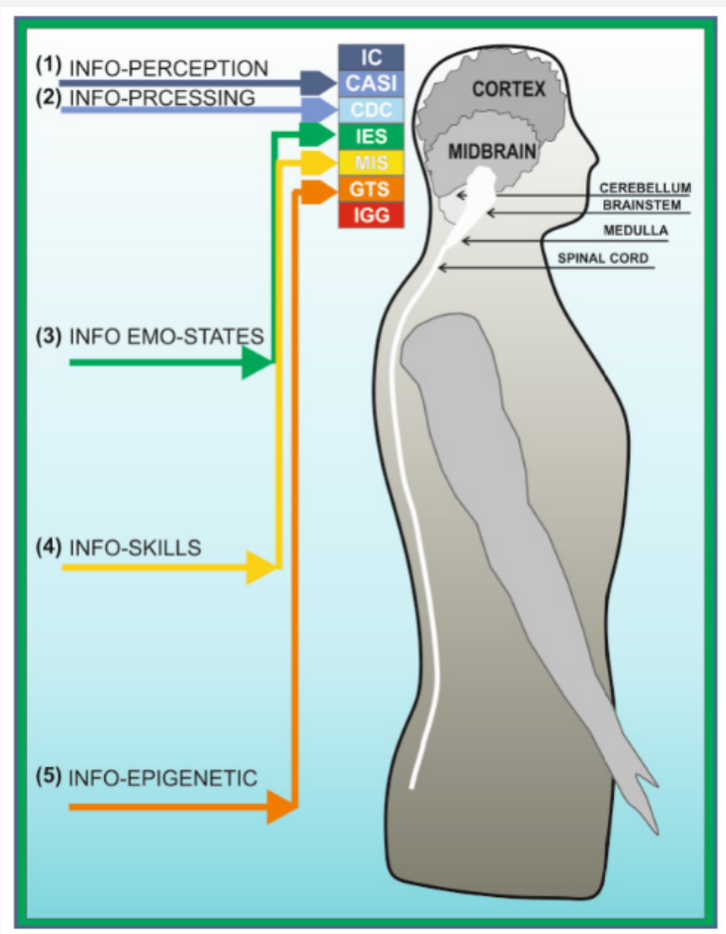

Figure 1: Schematic representation of the various steps (lines 1-5) of matter-related information degree by epigenetic processes. The gradient of gray colour suggest the degree of info-integration with a maximum in GTS.

On the basis of this model and taking into account the analysis of the epigenetic mechanism, the interaction between information and body cells according to the specific functions defined above could be discussed. The information and life experience as info-perception by CASI and IC is accumulated in memory (Fig. 1, line 1). This is a first step, consisting in the info-connection with the reality of the external environmental conditions. The received information by the body sensors is operated by the brain in two modes: short-time and long-time storing of information. The short-time memory cannot store too much information, this allows only the connection with the environment and the interpretation of the received information for immediate and primary tasks like recognition and orientation. Traducing this situation in terms of interaction of information with body specific cells, results that this interaction cannot be interpreted as a stable induced info-matter configuration. The low capacity to maintain this type of information is explainable by the necessity of a permanent info-connection with the ambient reality, if this ambient does not provides a really special informational interest. On contrary, when the information of a certain event is really important, then this information is fixed in the long-time, consolidated memory, where the relation between the memorized information and matter is stronger, allowing to the thought to retrieve it from memory in the operational and analysis field, characteristic for CDC.

Therefore, the information resulted from the info-perception process (Fig. 1, line 1) or from memory, can be operated by CDC through info-processing operations (Fig. 1 line 2). The working mode of the brain in CDC is to activate the stored information from CASI, to analyze the various types of information [2] and to decide on the basis of the decision criteria [26]. From this point of view, the

thought shows a vector-type behaviour, because it needs a specific address where should go and activate a specific information in the informational field of the stocked data. Ones CDC elaborates a decision, this is also stored in CASI and or is externally expressed by attitude.

The memory processes can be discussed in terms of epigenetic mechanisms [27], referring to the interaction between information and body matter, and the stability of the matter-related information in this stage of interaction [3]. Indeed, as it was recently revealed, certain derangements and dysfunctions in the molecular components of the epigenetic apparatus have been implicated, for instance in mental retardation, Rubinstein–Taybi and Rett syndrome and even in schizophrenia, this serious disorder of cognition, which is manifested by inability of normal behaviour in social situations and in the performing of the everyday cognitive tasks [28]. Diseases like anxiety, autism, depression, epilepsy, substance abuse, could be also added to this list [3] and can become hereditary [29]. Such investigations were promoted taking into account certain medical objectives, but the results suggest that actually not only the long-term memory is based on epigenetic mechanisms, but also the short-term memory too. The ineffective possibility to reveal the implication of the epigenetic mechanisms in the short-term memory could be justified by still unstable relation between the perceived information and the nervous cells, so undetectable by the present investigation means. As much as the information is insistently and repetitively accessed, as stronger becomes the relation between the received information and cell body, in other word, the integration degree of the information is more and more stronger under a stable configuration form, supporting IMC, which already stipulated the necessity of a repetitive process for memory consolidation [7].

IES operates with emotions, which according to IMC, are reactive info-signals activated as a consequence of the received information. These signals mobilize instantaneously the body specially to deal with unexpected situations. Such a property was earlier stipulated by IMC [3,7] and is supported by the neuro-connection in the brain, between the visual stream and the limbic system [30]. However, in CASI are also stored the associated emotions to the various events, so emotions could be also approached in terms of information (Fig. 1, line 3). The long-term interactions of a certain type of emotion with the cell body induce the formation on the cell surface of certain specialized receptors, which allow selective reception only of the appropriate signaling agents, known generically as ligands [26,31]. This is a similar mechanism with the info-transmission in the junction between two neighbor nervous cells by neurotransmitters, or in the drug-dependence processes [32]. Such type of transmission, related also with epigenetic mechanisms, gives rise to long-term emotional states, defined within IMC as emo-states and represented in Fig. 1 by the line 3. According to this discussion, IES can also integrate information by epigenetic type adaptation mechanisms, but also operates in an automatic reactive way.

A further automatic level supported by epigenetic mechanisms is represented by the acquired skills, marked in Fig. 1 by the line 4. These skills refer for instance to the ability to perform the automatic motor movements like that necessary to drive a car or a bike, or to play an instrument. Such skills are memorized also in a specialized area of the brain, so in CASI, and can be also regarded as an acquired chain of info-motor commands by cell epigenetic implications. During the large time along the species evolution, the metabolic processes, implying motor autonomic operations, were acquired a stable configuration by insistent and systematic repetition, if the external conditions were also maintained in a stable state. The transmission of such stable acquired skills by epigenetic processes are a valid start point to understand the organism development during a large-time evolution. This represents a high degree of info-matter integration, allowing the autonomic driving of the mechanical and physico-chemical involved processes of the metabolism. A combination between such type of automatic sequential chains are represented by the skills, which are triggered by a starting initial information, so then the entire chain will follow the same path, without the participation of the conscious mind. Such acquired skills could be therefore regarded as precursors of some stable acquired info-driven motion operations.

The genetic info-integration (Fig. 1, line 5), represents the highest level of interaction between the information and body cell, keeping the species information plus acquired epigenetic information in the DNA of the procreation cells. From the above analysis it can be deduced that the human organism acts like an informational "pump" for the adaptation of the body, transforming the acquired environmental information persistently perceived into epigenetically matter-related stable information inside of the cell. The organism "absorbs" as a pump the external information and converts it in a matter-related epigenetic information for its adaptive benefit. In other words, the information can "model" actually the organism and its functions, just by means of interaction mechanisms between information and body matter itself, which is able to sustain it like a "hard" dynamic support.

The studies of epigenetic mechanisms cover an increasing range of properties which are proved to be transferred to the offspring. Among these studies, the investigation of transgenerational adaptation is a promising way to understand the human adaptation to various ambient and nourishment conditions. However, an essential condition that the acquired traits of a certain population is that such conditions to be maintained also for the subsequent generations. This condition seems to be essential for the epigenetic mechanisms themselves as an intrinsic requirement, so that the intervention process to act for a successful stable acquisition. Although today the transgenerational transfer and stability of some of these properties are not fully demonstrated, an essential reason being the impossibility in the human case to trace the stability of the epigenetic effects for more than one generation, the premises seem to be strongly favorable to such a process.

We have to observe that one of the fundamental properties of the living structures, particularly of the human body complex structure, is the complementary associativity. The new information itself is acquired into CASI on the basis of association with another stable information already acquired [7]. The associative processes

are also a common way to obtain solid structures and observable effects on the atomic transport phenomena in semiconductors [33,34], as well as in the dynamics of the charge carriers into the semiconductor junctions [35]. In the human body, each composing organ fulfils certain function necessary to another one component or to the entire organism as a whole. Therefore, the associativity is a mandatory property contributing on a large time period to the increasing chance of survival than the separate components. Living itself is a demonstration how the entire system works in a common collaborative way to sustain the living structure against the potential environmental aggressive agents. Adaptation enters in the same category of survival requirements, with the condition that the ambient changing signals inducing the adaptation to be sufficiently low to maintain the integrity of the organism and to act for a sufficiently large time period as changing inducing agents. Indeed, looking to the intimate epigenetic process at the cellular level, this condition is well represented by the required properties of the "epigenator" and "initiator", as discussed above. The integrated effect at the macro level should be a reflection of the micro level behaviour.

An evident adaptive differentiation of the human species as a function of the distinct conditions, particularly that of the isolated population groups, is certainly represented by the distinct acquired languages. The communication of information is a fundamental requirement for human, who is a social being [25]. Survival is a major dominant commandment which successfully operates also in this case. This is reflected not only by the procreation necessities, but also for a better defense and protection of the entire group with respect to the nature vicissitudes. The maintenance efforts of the geographic territory providing the food products was a fundamental consequence. The multiplication by procreation of the same species inside of the same group, with the same acquired features, assured further support of group proliferation.

Conclusion

The increasing accumulating data yielded by the epigenetic studies, successfully supported by the high-tech new investigation tools like the digital-microfluidic techniques and semiconductor-based detection systems, provide the opportunity to approach on this new basis the life evolution, specifically that of the human species. Such studies, started especially to observe the distinctive differences between healthy and non-healthy cell structures, were extended to understand the traits transmission to the next generation and even the stability of the transgenerational epigenetic mechanisms. It was shown that at the molecular/cellular level, three main specific typical steps of an epigenetic process could be defined and described in terms of informational signals, i.e. epigenator, initiator and maintainer. This analysis allowed to distinguish five steps categories of epigenetic processes, as a function of the informational distinctive components of the informational system of the organism, defined as IC, CASI, CDC, IES, MIS, GTS and IGG. The specific characteristics of the acquired or existing driving information were discussed in each of these systems, pointing out the integration degree of information in each of them. An immediate and imminent conclusion is that the human organism acts as an informational "pump" absorbing information and converting it in matter-related hereditary information by means of epigenetic mechanisms, modelling in this way the body itself and its functional operation for optimal adaptation to the environment conditions.

The transgenerational transfer of acquired information by adaptation for survival of various human groups was discussed, showing that the stability of the epigenetic transference between generations is supported by: (i) low and non-destructive cues signals inducing the adaptation; (ii) persistence and stability of the external signal over the next generations. As a suggestive example, it was shown that the distinctive languages of various population groups are an evidence of such adaptation process.

It was shown also that the associativity of the components with complementary properties increases the chance of survival during the evolution from simple to complex living structures, as the human organism can demonstrate.

Acknowledgment

To my son Adrian for his special virtues and qualities and to his family. To all members of family who appreciate and love me.

In the memory of my exemplar and loved parents, the distinguished (Magna cum Laude) Professor Emanoil Gaiseanu and the distinguished (Emeritus) Professor Florica Gaiseanu, to my Brother and to All Members of my Family, who were part of my life.

Conflict of Interest

No conflict of interest.

References

1. Gaiseanu F (2018) Information: from Philosophic to Physics Concepts for Informational Modeling of Consciousness. Philosophy Study 8(8): 368-382
2. Gaiseanu F (2019) 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.
3. Gaiseanu F (2019) The Informational Model of Consciousness: Mechanisms of Embodiment/Disembodiment of Information. Neuro Quantology 17(4): 1-17.
4. Gaiseanu F (2017) Quantum-Assisted Process of Disembody Under Near-Death Conditions: An Informational-Field Support Model. Neuro Quantology 15(1): 4-9.
5. Gaiseanu F (2018) Near-Death Experiences and Immortality from the Perspective of an Informational Modeling of Consciousness. Gerontology & Geriatric Studies. 2(3): 1-4.
6. Gaiseanu F (2017) An Information Based Model of Consciousness Fully Explaining the Mind Normal/Paranormal Properties. Neuro Quantology 15(2): 132-140.
7. Gaiseanu F (2016) Consciousness as Informational System of the Human Body. Consciousness and Life Physics, Cosmology and Astrophysics Journal 16(1): 14-25.
8. Gaiseanu F (2019) Human/Humanity, Consciousness and Universe: Informational Relation. Neuro Quantology 17(5): 20-30.

9. Gaiseanu F (2019), Informational Model of Consciousness: From Philosophic Concepts to an Information Science of Consciousness. Philosophy Study 9(4): 181-196.
10. Dodd IB, Micheelsen MA, Sneppen K, Thon G (2007) Theoretical analysis of epigenetic cell memory by nucleosome modification. Cell 129(4): 813-822.
11. Shelley L, Berger LS, Kouzarides T, Shiekhattar R, Shilatifard A (2009) An operational definition of epigenetics. Genes Dev 23(7): 781-783.
12. Cortini R, Barbi M, Caré BR (2016) The physics of epigenetics. Rev Mod Phys 88(2): 025002-1 - 025002-29.
13. Lind MI, Spagopoulou F (2018) Evolutionary consequences of epigenetic inheritance Heredity 121(3): 205-209.
14. Fair RB, Khlystov A, Tailor TD, Ivanov V, Evans RD, et al. (2007) Chemical and Biological Applications of Digital-Microfluidic Devices. IEEE Design & Test of Computers. 24(1): 10-24.
15. Merriman B, Rothberg JM (2012) Progress in Ion Torrent semiconductor chip-based sequencing, Electrophoresis 33(23): 3397–3417.
16. Herman JJ, Spencer HJ, Donohue K, Sultan SE (2013) How Stable "Should" Epigenetic Modifications Be? Adaptive Plasticity and Bet Hedging. Evolution: 1-12.
17. Gluckman PD, Hanson MA, Spencer HG (2005) Predictive adaptive responses and human evolution. Trends Ecol Evol 20(10): 527–533.
18. Gregory SG, Barlow KF, McLay KE, Kaul R, Swarbreck, et al. (2006) The DNA sequence and biological annotation of human chromosome 1, Nature 441(7091): 315-321.
19. Furusawa C, Kaneko K (2013) Epigenetic Feedback Regulation Accelerates Adaptation and Evolution PLoS ONE 8(5): e61251.
20. Gaiseanu F (2016) Informational Subsystems of the Consciousness. The Science of Consciousness, Abstract Book, TSC 2016 TUCSON (Eds) The University of Arizona Center for Consciousness Studies and University of Michigan Center for Consciousness Science, by Stuart Hameroff, George Mashour.
21. Gaiseanu F (2018) An Informational Modeling of Consciousness and Cognitive Centers. Proc of the Human Project Brain (HPB) International Conference: Understanding Consciousness, a Scientific Quest for the 21st Century. 04-Models, simulation and emulation of consciousness, Barcelona: 21-22.
22. Gaiseanu F, Graur A (2018) Cognitive Centers Related Attitude: Application for an Iterative Evaluation Method in Music-Based Therapy Process. Abstract Book of the Conference on Science of Consciousness (Co-Chair Prof. Stuart Hameroff, The University of Arizona-Center for Consciousness Studies, Tucson, Arizona). Consciousness and Education Cognitive Development, Concurrent Session C27, 165: 2-7.
23. Gaiseanu F (2019) Informational Mode of the Brain Operation and Consciousness as an Informational Related System, Archives in Biomedical Engineering & Biotechnology 1(5): 1-7.
24. Gaiseanu F (2019) Informational Neuro-Connections of the Brain with the Body Supporting the Informational Model of Consciousness, Archives in Neurology & Neuroscience 4(1): 1-6.
25. Gaiseanu F (2019) Language Patterns and Cognitive-Sentient Reality: Certainty/Uncertainty in Cognitive-Sentient Exploration of Reality, Chapter in Media Models to Foster Collective Human Coherence in the PSYCH ecology, Ed. Stephen Brock Schafer, USA, IGI Global.
26. Gaiseanu F (2018) 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.
27. Bisrat WT, Mansuy IM (2017) Epigenetic Bases of Memory In: Sara SJ, Byrne JH, Kearning and Memory: a comprehensive reference, Amsterdam Elsevier 247-256.
28. Levenson JM, Sweatt JD (2005) Epigenetic Mechanisms in Memory Formation. NATURE REVIEWS NEUROSCIENCE 6(2): 108-118.
29. Goodman SH (1999) Risk for Psychopathology in the Children of Depressed Mothers: A Developmental Model for Understanding Mechanisms of Transmission. Psychological Review 106(3): 458-490.
30. Silverstein DN and Ingvar M (2015) A multi-pathway hypothesis for human visual fear signaling. A Front Syst Neurosci. 9: 101: 1-18.
31. Dispenza J (2007) Evolve Your Brain: The Science of Changing Your Mind. Health Communications Inc, Deerfield Beach, Florida.
32. Gupta S, Kulhara P (2007) Cellular and molecular mechanisms of drug dependence: An overview and update. Indian J Psychiatry 49(2): 85-90.
33. Gaiseanu F (2013) Contributions to the Modelling and Simulation of the Atomic Transport Processes in Silicon and Polysilicon and Applications. Proceedings of the Romanian Academy 4(4): 376-384.
34. Gaiseanu F (2017) Modeling 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.
35. Gaiseanu F, Sachelarie M, Sachelarie D, Esteve J (1997) Analytical Modeling of the Gold Diffusion Induced Modification of the Forward Current Density Through the p-n Junctions. Solid State Phenomena 37(38): 525-530.