

# Epistemology of Quantum Biophysical Semeiotics. Entanglement, non-locality and deterministic chaos in human biological systems

by Simone Caramel

## Abstract

The phenomena of entanglement and non-locality in quantum physics and deterministic chaos in the classical world represent, from the epistemological point of view, relations and with nature, a fascinating challenge. With this work we wish to investigate, verify and investigate the presence of these behaviors in biological systems. In particular, in humans, in vivo, changes in the topological complexity of forms are observed, measured and interpreted, according to René Thom, using the clinical Quantum Biophysical Semeiotic method called reflex- diagnostic percussion-auscultation. These variations - space-time volumetric modifications of the forms - are measured in conjunction with appropriate energy stimuli on well-defined trigger-points. These stresses act on the local dissipative level of the structures, explaining the complexity of the investigated systems and its level of entropy, fractal dimension, endo- cellular free energy, ATP synthesis and production. The fractal dimension used in this research, which is a measure of the variations in the topological complexity of the forms, reveals the implicated presence of morphogenetic fields – implicated order, according to Bohm's causal interpretation of quantum mechanics, in an epistemology according to which the phenomena of non-locality and entanglement naturally follows - also called vital or information fields, as well as allowing to discern locally between physiological, pathological or pre-pathological stages of the investigated biological systems, for predictive purposes, therapeutic monitoring and pre-primary and primary prevention of the most serious mitochondrial degenerative disease.

## Introduction

For an epistemological understanding of the sense and the meaning of experimentally observed phenomena concerning remote correlation (or entanglement) and non-locality, both in quantum physics [1-3] and in some experiments of quantum biology [4-9], a closer look at the contribution given by the physicist David Bohm [10-14] can be helpful as a starting point.

Probably inspired by his studies on plasma [see *Appendix*], Bohm re-wrote and reformulated Schrödinger's equation by adding a fundamental parameter to it: quantum potential, which - according to his causal interpretation - turns quantum mechanics from a probabilistic theory into a deterministic theory.

In this way, an electron doesn't act randomly, but under the action of quantum potential, which leads information from global environment, through non-local, simultaneous and synchronic connections, among quantum systems.

On the basis of quantum potential, Bohm is able to introduce in physics for the first time the concept of information field, in which an electron is not governed by chaos, but is a specifically defined quantity, although it underlies continuous transformation, and is continually and constantly informed on its surrounding environment.

Quantum potential is configured as potentially active information. When an electron moves along its path, it does so on the basis of an information pack, and it reaches a certain kind of status. When such a status is registered in the macroscopic world, the information

gets active and what was originally a potential, turns into a factual event.

The information contained in quantum potential thus determines the outcome of quantum process<sup>1</sup>. The information, which denotes the complexity of a system [15], is the leading factor. We have here an active information, that is a low-energy form which enters and leads a higher energy. We have also an *energy form* which in-forms. Such energy has no form, it's potentially active everywhere, it turns into a factual event and it gets active whenever its form enters (into a) classical energy.

Information and forms were thoroughly studied, from a topological viewpoint, by René Thom, a forerunner of modern deterministic chaos theory, with the help of his catastrophe theory [16].

According to the French mathematician, the core problem in biology has a topological nature, since topology is the mathematical branch dealing with the passage from local to global<sup>2</sup>. Overall, all living phenomena might be seen as manifestations of a geometrical object: the morphogenetic field – also called vital field –, which is similar to gravitational or electromagnetic field. Living beings can therefore be conceived as structurally stable particles or aspects of such a field, and its phenomena, for example symbiosis, parasitism, sexuality etc. are interactions and (structural) combinations among those particles.

Thom's purpose was to geometrically describe this field, to define its formal properties and its evolution laws<sup>3</sup>, as well as the stability of each human being and of each structurally stable form.

In this kind of approach, which is very similar to David Bohm's, we re-discover the etymological meaning of information: something that gives form within a process of explication from an implied order (*information field or morphogenetic field – genesis of form*) to an explicated, visible order of forms. Any information is first of all a form or, the other way round, any geometrical form can be an information vehicle.

Within the set of geometrical forms conveying the same information, it is important to define the measure of the topological complexity of a form, in particular the qualitative measure of information (*its graduated quantitative measure not being important*).

One of such measures is entropy<sup>4</sup>, which is related to topological complexity of forms:

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<sup>1</sup> Let's consider the example of a radio wave whose form transports a signal, for example a a disk-jockey's voice. The sound energy being heard from the receiving radio does not come from this wave, but from the device's battery. The subtle and hidden energy is essentially unformed, but it takes a form from the information contained in the radio wave. This information is potentially active anywhere, but it gets active and factual only when its form enters the electrical energy of the radio. Its analogy with causal interpretation is clear. The quantic wave transports information and is therefore potentially active everywhere, but it gets active and factual only if and where this energy enters the particle energy. An electron must therefore have a complex, although hidden, structure, which must be at least comparable with a radio's structure. This reveals us that classical Newton's mechanics is a special case of Bohm's mechanics, local reality is a singularity of non-local reality, linear reality is a singularity of of non-linear reality. Particles' paths chaotically fluctuate and are predictable only through statistical probability distributions. Bohm therefore gives a causal but not strictly determined interpretation.

<sup>2</sup> Obtaining local information starting from the global is not profitable, considering the complexity of biological systems.

<sup>3</sup> The ultimate nature of this field pertains instead to the metaphysical domain.

<sup>4</sup> In relation to deterministic systems with non-linear dynamics and to the complexity of their equilibrium (structured orders, topological complexity of forms) entropy is the uncertainty measure or factor in such systems or, to express it differently, it's the amount of the average information we obtain as a result of our observation. In particular, the presence of entropy tells us that the observation of a specific system keeps generating information all along an arbitrarily long-time interval. As a result of this we can infer that - although the position of a system can be observed with the utmost precision - uncertainty will ever persist about its future course, even if the dynamic rule governing the system is known with the highest precision. Entropy equal to zero means absence of chaotic behavior, which is typical of linear or periodic systems, whose features are respectively fix point equilibrium or limit-cycle equilibrium, that is full and exact predictability: no new information of any quality will

the higher a topological complexity of a form, the higher its entropy. Within this syllogism, complexity can be considered as information<sup>5</sup>: deterministic chaos theory teaches that entropy is comparable with the information factor contained in a system, and when this value is equal to zero, its complexity is also at zero.

Several studies on non-linear dynamics in the physiology of biological systems [17-20] highlighted that, other than intuitively theorized by Thom, highly complex forms can stand perturbations of a certain amplitude far better than less complex forms.

Some universal parameters facilitate the structural stability of forms and of their complex equilibria called strange attractors, such as the golden ratio  $\Phi$  and Feigenbaum's delta  $\delta$  [21, 22], so deterministic chaos is a marker, it is what we expect in physiological stages.

The presence of deterministic chaos in non-linear dynamics of biological systems is a symptom of a physiological behavior. For example: in microcirculation it facilitates stability and adaptability to perturbation, distributive efficiency and efficacy of, say, blood flow, improvement of tissue oxygenation, flexibility and efficiency in error control, economy in managing big state changes with the lowest energy waste [23-25].

Within this domain, let's try to have a better insight in phenomena such as entanglement and deterministic chaos and their correlation. Some researchers have recently discovered a relation between these aspects of classical physics and quantum physics which were considered as not correlated with each other. The results of their analyses suggest the possibility to use controllable quantum systems to study some of nature's fundamental aspects [26-29].

These studies reveal that a low level of entanglement always corresponds to a low level of deterministic chaos, and, in turn, a high level of entanglement is always accompanied by a high level of deterministic chaos - meaning that these two phenomena are strongly correlated. The linking element is thermalization<sup>6</sup>, which is represented by the driving forces behind this particular search [30-31].

Other studies [32-35] show that fractal forms emerge as macroscopic manifestations of underlying coherent quantum dynamics (morphogenesis) and their evolution (metamorphosis) goes through particular paths, whereas any changes in border conditions can induce diverging paths (non-linear dynamic evolution!). Elementary components dynamics manifest as a flow of evolving forms on the physical level. The coherent condensation of long-period correlation wave quantum brings forth specific forms with self-similar fractal structures, their evolution and fractal dimension, the vacuum structure. The metamorphosis process comes out of a dynamic rearrangement of symmetry.

In the same direction, there are a few other remarkable studies in physics which focus on matter condensation systems and their corresponding quantum correlation & deterministic chaos phenomena as well as the so-called entanglement entropy [36-38].

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appear all along the arbitrarily long time interval considered.

<sup>5</sup> Plants absorb through their chloroplast the highest complexity from light, that is energy; whereas animals extract through their retina the correlations among forms, or the information they need to get food and therefore their energy. Complexity seems to be describable directly through singularity.

<sup>6</sup> In molecular physics, thermalization is the act and effect of reducing (thermalizing) the kinetic energy of particles to levels comparable with thermal perturbation energy of the environment (thermal particles). In statistical mechanics, thermalization is meant as the set of phenomena intervening in fluid evolution (and, more in general, in macroscopic systems) causing their relaxation towards a state of thermodynamic equilibrium.

Summing up, several experiments confirm Bohm's and Thom's epistemological layout: morphogenesis is to be found in any information-rich quantum implied order. This information has qualitative features similar to those which were observed in complex dynamics (deterministic chaos) and structures (fractals) in the classical world and it gives form to the single parts of the sensitive and visible world, leading its metamorphoses.

Signs of entanglement, non-locality, deterministic chaos and fractals are manifest both in the quantum world and in the classical world and, on their borderline, in the processes of form genesis and change. Such complex and structured order can be physically found even in biological systems, both from a functional and from a structural viewpoint, whenever energy stimulations or changes are induced - such as the above mentioned thermalization. This is the domain expressly pertaining to Quantum Biophysical Semeiotics, whose studies and investigations are based on a cross-knowledge learning approach.

## **1. Quantum Biophysical Semeiotics**

Quantum Biophysical Semeiotics (QBS) observes the behavior of human biological systems, in particular from their functional viewpoint, and measures their dynamics and variations based on objective, precise and well-defined parameters.

Its data are real clinical observations measured at patient's bed; they are unconfutable facts, which won't be discussed here any further, since they were already dealt with and discussed from their physio pathological, diagnostic, pre-primary and primary viewpoint in several scientific studies [39-43]. The real data evaluated with QBS bed-side method are in perfect harmony and correlation with their corresponding clinical data obtained through image and laboratory diagnostics.

The convenience of a clinical data evaluation by means of QBS resides in the swiftness and cheapness of its method, which allows to clinically obtain in a few seconds and with no cost the same information that you would obtain from the traditional diagnostics, which demands an average longer waiting time and surely higher costs.

QBS also allows from the very first patient's examination to canalize the traditional clinical diagnostics process towards a precise direction, thus orienting it optimally and avoiding any useless exams or to progress by trial or by exclusion, with clear benefits in terms of cheapness and of time and asset optimization. From a clinical viewpoint, QBS does not replace traditional diagnostics, which always should be followed, but it enlightens its path, its decisions and behaviors, by promoting efficacy, efficiency and optimization in terms of costs/times/benefits/results.

QBS's original and fundamental added value is its possibility to evaluate firstly pre-clinical data in people considered as clinically healthy - who nevertheless might reveal the presence, from birth, of some genetic predisposition (ground or constitution) to specific pathologies (in particular, degenerative mitochondrial pathologies) - and secondly the evolution state of their potential congenital risk (Real Risks).

The present study wants to further explore QBS from an epistemological viewpoint, trying to understand, give significance to and interpret the nature of these data, how they can be measured, why they are present, what triggers them - through a transdisciplinary approach involving several scientific disciplines, such as genetics, genomics, physics,

biology, chemistry and mathematics applied to systems with non-linear dynamics.

QBS data emerge as a reflex following a particular manoeuvre where a well-defined point (trigger-point) of the body correlated to the parenchyma of the biological system to be investigated is stimulated with one hand (for ex. by digital pressure or cutaneous pinch). Simultaneously, the other hand gently hits a different part of the body by means of the ancient auscultatory percussion technique. Sensorial auscultation allows measuring possible changes compared to basal behavior values (Auscultatory Percussion Reflex Diagnostics). Stimulating a specific point on the body simultaneously arouses volume changes in any other part (organs and bowels of the human body) and significant functional changes in any human and animal biological systems (such as in microcirculation and in micro vases) which can be measured, parametrized and evaluated with a precise diagnostic meaning by physicians [44-46].

Simultaneity and non-locality of the observed phenomena highlighted by QBS show strong analogies with non-locality and entanglement which are typical not only of the subquantum microworld, but also of the classical world, as recently observed through the instruments of quantum biology [54- 57]. The phenomena of entanglement and quantum coherence have been observed not only among photons, but also among little diamonds [47], in chlorophyllin synthesis of seaweed [7], in the green sulphurous bacterium [48], in DNA mutations [49], in enzymatic activities [50], in the visual activities of the retina (photo-transduction) [51], in the theory of smell vibrations [52], in magnetoreception [53].

By taking Aspect's experiment [2] as a starting point, we shall now try to check by means of QBS whether biological systems also show an effect that may be ascribed to quantum entanglement. In the quantum world, the information takes on a "non-local" dimension. In fact, two electrons which are separated and moved away from each other (dis-entangled) show exactly the same behavior, no matter what action or alteration is applied on either of the two, just as if they were still in contact. This means that they preserve the capacity of a simultaneous communication despite their distance. This apparently odd behavior may easily be explained if we assume the existence of a "non-local" reality beside the already known local reality we live in.

Let's take for example Lory's experiment [58], which is based on the fact that "all" the subatomic and therefore atomic and molecular components which form a cell, as well as the cellular set or parenchyma, are connected to one another and to "any" other component of the same embryological nature.

The QBS methodological system could demonstrate that the digital pressure applied on the parotid or a sublingual salivary gland of one "monovular" twin sister (this experiment was first made on two twin sisters) "simultaneously" causes microcirculatory activation, type I, associated, in the pancreas of her twin sister, no matter the distance between them, no matter if the distance is in terms of meters or kilometers [59]. The pancreas used in fact to be known and defined as the intestinal salivary gland.

Let's take another example, always based on QBS diagnostic method. Intense digital pressure on precordium, as in Caotino's Sign [39, 46], simultaneously causes a variation in the topological complexity of the stomach, if the physician applies auscultatory percussion on a section of the big gastric curve of a cardiopathic subject or a subject with Congenital Real Risk of Ischemic Cardiopathy.

If the physician takes heed to any other organ or viscera (for example on spleen, lungs, liver, bile duct, blind duct, kidneys, adrenal glands), similarly he will register when

applying pressure on precordium in the same subject, the simultaneous variation of the topological complexity of the auscultated form (organ or viscera): this is due to the fact that all biological systems simultaneously react to the initial stimulation.

This means that there's a time (synchronic) and space (ubiquitarian) correlation which may be explained by the phenomenon of entanglement. This correlation can be perceived in the movement of an iceberg along the ocean surface: lots of his parts are on the surface, seem to be moving and to communicate with one another mysteriously and simultaneously, even if they are separated from one another (explicated order); but what actually happens is that the iceberg has a submerged unitary body (implicated order) that leads what appears to be moving separately, but in a connected manner, on the surface (check Picture 1).



*Picture 1. Similarly to an iceberg moved by the ocean waves, consisting of a dynamic part which is submerged, united, implicated, invisible and indistinct, and of a part which is over the surface, i.e. explicated, visible and separated, the variation in topological complexity manifests overall and simultaneously in all the sensible elements of the explicated order (such as stomach and liver) – a behavior similar to quantum entanglement and quantum non-locality – as a consequence of an energetic stimulation (ex. on precordium) acting on the information and morphogenetic field (implicated order) and promoting metamorphosis: the information turns from potential into factual, active information which in-forms, that is gives a (new) form.*

From a biological viewpoint there's an underlying unity (ex. microvascular-tissue unity) governing the behaviors of the observed systems. The next step is to measure variation of topological complexity of such forms and give them a meaning (ex. physiopathological, diagnostic meaning, etc.).

## **2. Entanglement and deterministic chaos in human beings: clinical and experimental evidences of Quantum Biophysical Semeiotics**

Morphogenetic fields [16] which are intimately correlated with information fields [11, 13] seem to be behind [32, 33] morphogenesis and metamorphosis (variation) of forms; an indistinct underlying unit governs genesis and variation of the distinct and separated forms (variation of topological complexity of forms) of the classical, sensible, visible, explicated world. Some forms – both quantum and classical forms – sometimes behave in a particularly correlated way, as if they were communicating simultaneously, although far away from one another (entanglement), but they actually emerge from a common unitary source. So separateness is just merely an apparent condition.

Let's take a look at the growth of a tree all along spring time and let us imagine we ignore that trees have a trunk and roots. If we were able to merely see the metamorphosis of its bows and gems first turning into leaves and then into flowers, we would say that all these variations in topological complexity of forms apparently separated from one another are correlated (entangled), are mysteriously communicating and simultaneously growing in harmony and beauty – this we consider, since – because of our initial assumption - we aren't

able to see the unity underlying and governing those variations. At the same time, the tree bows are harmonized according to dynamic processes of their own that are intimately correlated with period doubling – one of the most frequent transitions to deterministic chaos, governed by constant fundamental universal factors such as Feigenbaum's delta and the above mentioned golden ratio.

The presence of entanglement and of deterministic chaos in biologic systems [7-9, 36-38, 49-57] is interesting, but not sufficient to understand their correlation and the physio-pathological meanings, in medicine in particular.

It is known that biologic systems have a dissipative<sup>7</sup> nature, and a series of studies highlight that they contain chaotic-deterministic physio-pathological dynamics, yet they occasionally can have conservative features. Energetic stimulations on particular points of biologic systems, such as to cause topological variation of forms, should be dosed within a specific range (in dyne/cm<sup>2</sup>), so as to increase the level of endocellular free energy and of ATP, but at the same time maintain the dissipative feature of the stirred, thermodynamically open system. This is in fact a necessary condition to grant that complex non-linear dynamics can be observed, in particular in microcirculation and in micro vases, which have a strict relationship with the corresponding parenchyma and the local mitochondrial activities [23-35, 60-73].

In physiology, Quantum Biophysical Semeiotics highlights the co-existence of entanglement and deterministic chaos in biologic systems - recently discovered even in mitochondrial and nuclear genes, in mitochondria [74], in endoplasmatic reticulum [75], and in the web of nutritional capillaries. This confirms other researches [27]: local reduction of entanglement means lower complexity. The other way round: a higher entanglement means an increase of deterministic chaos.

The purpose of this article is to explain how these phenomena are linked to one another. In particular, in physiology, the epistemological foundations of QBS highlight the key role that information (uncertainty, entropy, that which gives form) plays in giving efficiency, stability and dynamic equilibrium to biologic systems. This is testified and demonstrated by the simultaneous presence, in physiology, of universal constants such as the above mentioned Feigenbaum's delta  $\delta$  and the golden ratio  $\Phi$ .

This information, which is synonymous with complexity, acts simultaneously and non-locally, exploiting the entanglement in order to be and act synchronically and in all directions, hierarchically, at all levels, starting from the genome (e.g. mitochondrial genome) [82, 83].

Quantum Biophysics Semeiotics aims at collecting signs. The collected signs are a real, objective, factual manifestation of reflexes, coming out of a particular dynamic diagnostics based on the ancient method of auscultatory percussion of organs and viscera.

What type of reflexes are they? They are movements [44, 46] of organs and viscera aroused by pressure on particular reference trigger-points which are correlated with the biologic systems we wish to examine. These reflexes, testifying the movement of an organ or viscera, a variation of these forms, are the explicitation of a signal [76] or, rather, of a field [77], that simultaneously in-forms, gives form, gives new form to the pressed organ or viscera, and at the same time unfolds the in-formation contained, which concerns the parenchyma and tissue we're stimulating and investigating.

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<sup>7</sup> Open systems working in a state opposite to thermo-dynamic equilibrium, by interchanging, with correlative systems and the environment, energy, matter and information, whose features are spontaneous emerging self-organizing formation of ordered complex and/or chaotic structures, such as in Bénard's cell, in cyclones, in lasers, in ecosystems, in life forms.

To make an example: pressure on any precordium point<sup>8</sup> increases tissue acidosis which worsens until a certain threshold is reached after reflex latency time; when this threshold is reached, a signal<sup>9</sup> [76] already potentially present in the whole body<sup>10</sup> is triggered and detected by physician with a stethoscope allowing him to identify a variation in tone and intensity of the sound being listened<sup>11</sup>.

The information is hidden out, yet potentially active anywhere, although still implicated, and this information is revealed, gets visible, comes to light by means of the pressure stimulation which turns it into a factual, active, explicated information.

Such information is both qualitative and quantitative. It is in-formation, meaning it gives form to strange chaotic attractor<sup>12</sup>, it's an equilibrium of a dynamic non-linear physiological system, and at the same time it "gives form" to microcirculation and its corresponding parenchyma, and it "takes form" from the corresponding mitochondrial genome, which is variegated, differenced from part to part, from tissue to tissue of the same organism, due to the phenomenon of mitochondrial heteroplasmy<sup>13</sup>.

Once activated, this in-formation physiologically stands for the presence of deterministic chaos and of fractal structures (function and structure being two poles of the same equation), and origins from a hidden out biologic information field [77] which is itself naturally and physically pulsing with fractal features.

In physiology, this information stands for non-null entropy - i.e., from an absolute viewpoint, positive entropy and measure for deterministic chaos, uncertainty and unpredictability, which are the qualitative features of deterministic chaos, together with sensible dependence on initial conditions – all this within a superior and complex structured order with virtuous features: unity, density, compactness, flexibility, learning, excellence, cheapness, efficiency, minimum energetic consumption, excellent space exploitation and energetic distribution (e.g. of blood and oxygen).

The co-presence of non-locality and entanglement, which are extraordinary properties in biologic systems as investigated by Doctor Stagnaro, allows an efficient communication, distribution and connection of in-formation in and between biologic systems. This is the quantic, implicated substratum allowing local explicated visible reality, which is typical of dissipative systems with physiologically chaotic dynamics and fractal structure.

In his causal interpretation to quantum mechanics, David Bohm stressed that

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<sup>8</sup> Skin projection of the cardiac muscle.

<sup>9</sup> Instead of talking about a signal activation it would be better to say, according to Bohm and Thom, that the information relating to the information or morphogenetic field is activated.

<sup>10</sup> The common way of thinking might lead us to think that the signal spreads overall and simultaneously in all biological systems according to the commonly intended local reality, i.e. all through the body. Yet studies reveal that entanglement and non-locality are always present, and the signal does not travel within a space & time dimension, but rather it's already overall there, although still not activated, still not factual. And following stimulation, this signal turns from potential into factual, that is into an active information that acts on the form, causing a variation in the topological complexity of forms, a metamorphosis of all forms, and in particular of the form we're observing and measuring – e.g. the stomach.

<sup>11</sup> In case of an intense stimulation – 1000 dyne/cm<sup>2</sup> – on precordium, if the tissue acidosis threshold is reached simultaneously, the appearance of aspecific gastric auscultatory reflex, Caotino's Sign or Congenital Real Risk of Ischemic Cardiopathy is also simultaneous.

<sup>12</sup> Strange or chaotic attractors stand for an equilibrium condition in a non-linear dynamic system which differs both from a fix-point condition and from a periodic or quasi-periodic condition. Strange attractors, in particular, are related to geometric fractal features of the equilibrium with complex dynamics.

<sup>13</sup> Heteroplasmy is the presence of more than one type of organellar genome (mitochondrial DNA) within a cell or entity. It's an important factor to consider to evaluate the seriousness of mitochondrial illnesses. Since most of eukaryotic cells contain several hundreds of mitochondria with hundreds of mitochondrial DNA copies, it is common to mutations to affect only some mitochondria and leaving most of the others unvaried.

Quantum Potential, a weak energy but yet rich in information about implicated order, is able to lead visible highly-complex processes, where information turns from potentially active into factual, and this entanglement-disentanglement process from an implicated to an explicated order and the other way round occurs billion of times per second.

Entanglement is a permanent condition, both under physiological and non-physiological conditions, although in a lower percentage in the second case. The parameter that allows us to neatly distinguish between physiological and non-physiological biological systems is not the presence or absence of deterministic chaos, i.e. of a sufficient qualitatively meaningful information. If information is present, it will give form, that is it will in-form, by physiologically renewing the creative biological process. If information is absent, that is entropy is equal to zero, it means that the biological system has lost its physiological parametric range. In such conditions, the chaotic attractor is no longer present, but declines towards simpler, less complex orders ranging from quasi-periodic to periodic until fix-point equilibria (where a chronic illness sets in).

Measures of deterministic chaos are for example entropy (amount of uncertainty or information), fractal dimension, LCEs (Lyapunov Characteristic Exponents), symbolic maps, network analysis and others.

Within chaos theory, entropy can be defined as the amount of information (or uncertainty) of a "system" over time. From an absolute viewpoint, a chaotic system has positive entropy, meaning it continuously gives us new information. In the apparent disorder there's a hidden out complex order which continually renovates. Conversely, entropy equal to zero means an amount of information equal to zero.

Fractal dimension refers to structural features of dynamic equilibrium, but it's intimately related to entropy, so it is in all respects an index of the presence or absence of deterministic chaos in a system with non-linear dynamics.

QBS clinical method allows local observation and measurement of function and structure of microcirculation, which are intimately correlated with their corresponding parenchyma and genome, in particular the mitochondrial one, as well as measurement – by means of fractal dimension calculation – of the variation of topological complexity of forms correlated to the reference trigger point.

Every fractal dimension value corresponds with a specific type of non-linear dynamic equilibrium (fix point, limit cycle, strange attractor). A physiological variation of the topological variation of forms is marked with a fractal dimension equal to 3.81, which represents a strange attractor-type equilibrium.

Conversely, the tendency towards equilibria of lower complexity (e.g. limit-cycle ones) denotes predisposition (QSB constitutions) to mitochondrial illnesses in their corresponding pre-clinical evolution stages - QBS Congenital Real Risks - (e.g. diabetes mellitus type 2, cardiopathy types, all forms of solid and liquid cancer, neurodegenerative pathologies like Alzheimer, SLA, Parkinson, etc.) or ongoing illnesses (e.g. tendency to fix point), although still silent and asymptomatic (Table 1).

FRactal Dimension (fD)	EQUILIBRIA	STATE OF HEALTH
$fD = 1.0$	Fix point	Chronicity. Chronic and acute pathology
$1.0 < fD < 1.9$	Limit cycle tending to fix point	Patology. Tendency to chronicity. Variable severity of disease evolution
$1.9 < fD < 3.0$	Limit cycle	Initial implementation, tendency to disease. Potential pathology (i.e. CAD IRR)
$3.0 < fD < 3.81$	Limit cycle tending to strange attractor	Tendency to physiologic condition (potential phase)
$fD \geq 3.81$	Strange (chaotic) attractor	Physiologic condition. Healthy state.

Table 1.

In general, a certain intrinsic variability (chaotic dynamics) denotes a normal physiological condition in biological systems, whereas the loss of such variability and the onset of a more regular behavior are signs of compromised health and the presence of an illness [70].

In particular, vasomotion in microangiology physiologically shows dynamics of a deterministic chaotic type [23-25, 66-73]. Conversely, physiology shows several examples of a loss of chaotic dynamics in physiologically compromised functions – particularly in cardiovascular and neuronal systems.

This emerges from several studies on oscillatory dynamics, for example of HRV [69-71] and EEG [78, 79], which converge on some fundamental aspects: the basic clinical information is coded in space-time oscillations; the complexity degree reflects the capacity by the system to react and adapt to perturbations; complexity reduces as an illness progressively worsens.

Several studies on microcirculation [23-25, 66-72] show that vasomotion is a chaotic process that can provide a high flexibility degree to dynamic regulation of microcirculatory perfusion rather than represent an epiphenomenon, as expected in a non-linear system. The complexity of chaotic vasomotion is not sensitive to flow and pressure, yet it might be regulated by an external control – which was in fact detected in GH-RH by Doctor Stagnaro [80].

Chaotic reactions can be stabilized to periodic or fix-point behaviors by using simple techniques based on pressure feedbacks. It's interesting to observe that slight pressure in Clinical Microangiology [45] allows identifying chaotic oscillations; conversely, if pressure increases to moderate-medium, a periodical/sinusoidal behavior sets in.

If deterministic chaos improves blood-flow [23] in capillaries, chaotic vasomotion dissipates perturbations quicker than the periodical one, and therefore gives high stability to microcirculatory perfusion.

About vasomotion's role in tissue oxygenation, evidences show that the oscillatory flow in capillary bed (caused by vasomotility) ensures a better tissue oxygenation compared to a regular flow (steady-state). For example: chaotic nature of vasomotion in the skeletal

muscle improves the efficiency of tissue oxygenation by comparing it with periodical forms of vasomotion [25].

By analyzing clinical and experimental evidences and clinical data gathered at patient's bed with Quantum Biophysical Semeiotics by means of Clinical Microangiology we can similarly conclude that QBS signal - which represents the morphogenetical field and is everywhere and simultaneous – contains information. Information (coming from implicated order) is that which gives form to a classic structured order. In nature in general, and in biological systems in particular, the (explicated) order is physiologically complex, chaotic, fractal. Complexity reduces if such systems have a tendency towards illness. In particular, micro vases physiologically oscillate, under rest condition, according to a deterministic chaotic scheme and consist of a fractal structure.

QBS parameters which identify the space-time metamorphosis of forms (e.g. of the stomach) that are sensorially observed (by means of auscultatory percussion and auscultatory percussion reflex diagnostics) reflect the information contents (entropy) of the corresponding signal, of the hidden coded information.

In QBS, information is physiologically complex, fractal. The information amount of the signal reduces and tends to zero progressing towards illness (e.g. QBS signal progresses from quasi-periodicity to periodicity until fix point).

Overall, QBS allows measuring the variation (metamorphosis) of topological complexity of forms (according to David Bohm's and René Thom's theoretical background), meaning it allows decodifying the information contained in the signal, or rather in the biological or morphogenetic information field, so as to promote a pre-clinical and clinical quick and free of charge diagnosis which supports an efficient pre-primary and primary prevention on subjects finely selected (Single Patient Based Medicine) [81].

### **3. Conclusions**

Several scientific studies show that entanglement and deterministic chaos are co-present both in quantum physics and in the classical world.

If we want to explore these behaviors from an epistemological viewpoint, the reference studies are the ones provided by David Bohm – as to quantum physics – and René Thom – as to the classical world. Both their contributions promote an harmonic background where a hidden, underlying, implicated reality - called information field by the American physicist, or morphogenetic field, by the French mathematician – superintends and governs the genesis of forms (morphogenetics), their topological structured and complex order, their evolution and variation in time (metamorphosis).

Under this epistemological viewpoint, for the first time in history, Quantum Biophysical Semeiotics allows exploring and measuring morphogenetics and topological variation of forms (metamorphosis) that oscillate in the biological systems of the human body, both in physiology and in pre-pathological to pathological stages. It also places them in a pre-clinical and clinical physio-pathological, pathogenetic and diagnostic frame that has extraordinary

implications for pre-primary and primary prevention of the most serious illnesses, in particular degenerative illnesses with a mitochondrial origin.

Variation measurements of topological complexity of forms – which reflect the functional oscillations of non-linear biologic systems with non-linear deterministic chaotic dynamics –, are the entropy, or similar measures such as fractal dimension adopted by QBS, which recover the etymological qualitative meaning of information: that which gives form.

Clinical and experimental evidences obtained through QBS confirm the co-presence in human beings, of entanglement and deterministic chaos in physiology, whereas when the correlated degree of entanglement and deterministic chaos reduce, non physiological stages (constitutions, real risks of pathologies, declared pathologies in their several evolution stages) will appear.

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***Doctor Sergio Stagnaro followed, accompanied and approved all scientific contents of this article.***

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## Appendix. Causal interpretation of David Bohm's quantum mechanics

David Bohm started his research by investigating the behavior of plasmas, which are gas containing positive high density electrons and positive high density ions. Examples of plasmas are lightnings, the northern lights and stars. He soon realized that, once electrons become part of a plasma, they stop appearing as individual particles and start behaving as if they were part of a larger interconnected whole, a sea of particles which appear to be live, intelligent and self-conscious due to their clear "self-regulation" features, allowing them to harmonically arrange as in an orchestra. When two electrons negatively charged are totally isolated, their interaction extends to a great distance. Yet, in a plasma an enormous number (we are speaking here in terms of hundreds of billions) of other electrically charged particles re-arranges to shield this interaction on a vast scale. As a result, each electrically charged particle of plasma interacts with the nearby ones only on small distances (local reality, space – time). Yet, the long-distance interaction still hasn't disappeared. Such long-distance interactions (non-local, synchronic and simultaneous reality) cause plasma to behave coherently. Seen from a certain distance, a plasma appears as a series of collective oscillations which imply a very high number of particles "dancing in an intelligent plasma". Yet, at high magnification, only the seemingly casual motion of individual particles is visible. It's interesting to notice that a quantum correlation exists between brain and plasma, 99% of the universe consisting in plasma, - for example the lightnings and the sun -, and that plasmas form an helix similar to the one existing in DNA. Bohm formulated a dual mathematical description of plasma summing up both view points: the individual and the collective one. One description - collective coordinates – concerns collective vibrations, whereas the other – individual coordinates – explains the free motion of individual particles. Since both descriptions are part of a whole, the collective motion of the whole is enclosed in the seemingly casual individual motion and vice versa.

According to the causal interpretation of quantum mechanics proposed by Bohm, quantum potential<sup>14</sup> guides the electron along a precise trajectory which is potentially<sup>15</sup> identifiable, but gets updated minute after minute. Unlike what happens to electrical and magnetic potentials, quantum potential only depends on form, not on distance<sup>16</sup>.

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<sup>14</sup> The features of quantum potential are similar, if not equal to, quantum void or zero-point field defined by standard quantum theory (existence demonstrated by Casimir – 1948).

<sup>15</sup> If we presume that the structure of the electron is not punctiform, as commonly idealized by dominant physics, but of a certain complexity, as asserted by René Thom and supposed by the same David Bohm, then, according to chaos theory, if their trajectories are complex, although deterministic, i.e. defined by precise yet unknow laws, they are by definition intrinsically uncertain and unpredictable due to the connotative feature in systems with chaotic dynamics of sensible dependence on initial conditions, i.e. due to continuous implicated-explicated feedback, according to Bohm's setting. For this reason there's a basic determinism, the trajectories of the electron can be potentially determinable, but this determination is actually not possible.

<sup>16</sup> Entanglement and non-locality naturally follow from this particular feature.

This means that even if its energy is weak<sup>17</sup>, quantum potential can strongly influence particles. This concept is clearly different from Newton's ideas, as it implies that even features far from the environment<sup>18</sup> can strongly influence particles.

Bohm's approach helps in giving sense to and solving some paradoxes in quantum physics such as wave-particle duality<sup>19</sup> and Einstein-Podolsky-Rosen (EPR) paradox<sup>20</sup>.

Classic physics and quantum mechanics from the Copenhagen school find it hard explaining counter-intuitive phenomena such as non-local reality and entanglement from an epistemological viewpoint. How do these particles communicate? They certainly can't communicate by sending out signals which are supposed to be travelling at light speed. The only supportable epistemological hypothesis, which was also confirmed by Einstein, is that particles forcibly react to hidden, still unknown variables.

David Bohm argues that such hidden variables are to be found in quantum potential.

He suspects that the reason why subatomic particles stay in touch, no matter how far they are from one another, is that their separateness is only apparent. The whole theory

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<sup>17</sup> Metaphorically speaking, The human being is like a ship proceeding in the mist by means of his engine power, yet it safely reaches the harbor thanks to its radar signal.

Now, engines represent classic mechanics, whereas the radar signal represents quantum potential.

The ship is *pushed* along the sea by its powerful engines, but it's *guided* through along the correct route by means of its radar signal.

If we just consider the radar's energy, we will notice that it is extremely weak, almost imperceptible, most of the time unheard. Yet, radar signals are rich in information and that very information is the element that shows the direction to be followed. Similarly, the energy of quantum potential is weak, yet that energy is highly informative and can *in-form* (give form to) a raw energy still unformed.

<sup>18</sup> Quantum potential is comparable to a wave that can jolt a cork cap floating in a lake even when that cork cap is far from the wave source.

<sup>19</sup> One day, Bohm told a little story that can help us grasp how deceptive duality and separateness can be. Here's the story he told: Imagine an observer who cannot look directly into an aquarium containing one single fish. Now, imagine that the only means he has to find out what the aquarium contains is by watching by two cameras, one placed in front of the aquarium and the other situated aside, at 90° of the first direction. When the observer watches the object shown on each separate monitor, he might be misled into thinking that each monitor shows a different fish – and this idea would be reasonably supported by the fact that the images of the fish taken by the two cameras are different, since they are caught at different angles. Yet, if the observer keeps watching the two images on the monitors, he will notice some kind of relationship between the two fish. In fact, when the fish on one camera starts to move, the fish on the second camera will simultaneously move, too, although their appearance keep being different. Not knowing it's the same and only fish, he might believe that the first fish is communicating with the other at that very moment.

The electron can in fact be imagined as a wave coming from the universe and collapsing inwardly until it appears as a particle and then it re-expands outwardly until it appears as a wave. The fundamental reality thus becomes an opening-closure process, and its particles are just abstractions of such a process. The dualism between wave and particle is therefore only apparent and illusory: there's rather a dynamic process at work constantly interconnecting microcosm to macrocosm and taking place billions of times per second.

<sup>20</sup> Quantum potential also gives an explanation for Einstein-Podolsky-Rosen paradox, a refined mental experiment made by physicist John Bell, which was then experimentally confirmed by physicist Alain Aspect. If we take an elementary particle, for example an electron, without a spin (rotation property) and we divide it into two parts, one part should necessarily have a +1/2 spin and the other part a -1/2 spin (due to spin conservation law which should give zero as a result). If we then move these two particles at a certain distance away from each other (but lower than 300 000 km) we can observe that, once the spin sign of a particle is inverted, the sign of the other gets inverted, too. To a certain extent, we can say that the two particles will communicate with each other by sending out signals to each other, thus respecting the spin conservation law, according to light speed). Conversely, if these two particles are pushed to opposite directions so as to be at a great distance from one another (for example a million kilometers away) and we again change sign to the spin of one particle, the other particle will simultaneously invert its sign, too, meaning that they continue to respect the spin conservation law. Yet, this fact infringes one of the fundamental principles of the relativity theory, i.e. the assumption that light speed is well-defined, limited and equal to 300 000 km per second. So the solutions to this riddle are twofold: either the relativity theory is completely wrong or we have to postulate that a non-local reality exists, i.e. that particles do communicate simultaneously and synchronically with one another, no matter how far they are from one another, both in terms of space and time. In 1982, Alan Aspect experimentally demonstrated the exactness of Bell's theorem and therefore the existence of non-local reality.

about implicated order is founded on the following intuition: at some deeper level of reality, these particles are not individual entities, but extensions of the same and only fundamental organism. Just let us think about an iceberg floating on the ocean: several of his parts appear on the surface and move simultaneously (entanglement, non-locality)<sup>21</sup> although separated from one another – explicated order. Yet, the iceberg is actually made of one single submerged body – implicated order<sup>22</sup> – that leads all the parts appearing on the surface.

Bohm associates the idea of an implicated order<sup>23</sup> - the one that leads reality through – to the image of a hologram<sup>24</sup>, as this analogy perfectly represents the concept of unfragmented totality.

Each part of reality contains information on any other part within it, so that each area in space and time reflects the structure of the universe. The entire whole is contained in each of its parts. According to Bohm, holo movement is a movement (process) that triggers implicated order. The movement generated by holo movement in each region leads information through every other part of reality.

Bohm defines implicated order as a different concept from non-local reality, an invisible leading pre-space of the holographic universe<sup>25</sup>. The implicated world, which is hidden, creates the phenomenic reality as we perceive it.

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<sup>21</sup> Causality is paralleled by synchronicity, whose principle says that the terms of a meaningful coincidence are linked by a relationship of simultaneity and meaning (C. G.Jung, Synchronicity).

<sup>22</sup> Quantum potential acts in the implicated order. How should we imagine such an order? Let's take a piece of paper and fold it into several parts, then after cutting it in one spot, we unfold it back to its original extension: we will notice that the re-opened sheet has several forms inside, all symmetrically separated. These separated forms have actually been produced by the same cutting in the folded paper. This cutting stands for the implicated order, whereas the separated forms that appear when the sheet is unfolded represent the explicated order.

<sup>23</sup> The same implicated order resounds from a far more extended energy field which corresponds with pure potential. The term 'implicated' stems from Latin verb '*implicare*' – derived from '*plicare*' (*to fold*) with prefix '*in*', which meant '*to fold inwardly*'. So, reality taken as implicated means that every part of it recalls any of its other parts. There's a constant process at work changing from implication to explication backwards and forwards, where subatomic particles constantly dissolve in the implicated order and then crystallize in the explicated order.

<sup>24</sup> Holography is a photo technique which registers interfering figures generated by the superposition of two laser beams, one reflected by the object involved and the other coming from the source itself or from a reflection mirror. Hologram is the holographic sheet which can produce 3D images, and which is impressed by interfering figures produced by holography. If we break the the sheet obtained into several pieces, each little fragment will contain the information needed to project the whole 3D image of the object itself – each part of the object containing its entire whole.

<sup>25</sup> Bohm suggests that every region in space and time contains the entire order of the universe. The implicated order itself has been discovered in the complex movement of electromagnetic fields as well as in the form of a light wave. Such a movement of light waves is available everywhere and contains at its core the entire universe of space and time in any region. This process of contraction (implication) and expansion (explication) not only happens in the movement of electromagnetic fields, but also in other (protonic, electronic, etc.) fields. These fields obey to quantum-mechanical laws which imply discontinuity and non-locality. The totality of the contraction & expansion movement can go far beyond what was revealed during the observations made. Bohm calls such totality a holomovement. Everything emerges out of an expanding holo movement, which later folds in again in a contracting movement (implicated order). The process of folding-in is called implicant (contractive), and the process of folding out is called explicant (expansive). The implicated and explicated orders are one indivisible totality continuously flowing in and out. Each part of the universe is interconnected to any other parts but in different degrees.

According to Newton's physics, if a system is deterministic and we know the equations governing its evolution in time, we can measure its status with highest precision. Conversely, in classical interpretation of quantum physics, by observing the subatomic world we discover concepts such as indeterminateness, unpredictability, casualty, probability waves. How can we be freed from such dichotomy?

Unpredictability is a feature peculiar to systems with complex or chaotic dynamics, it doesn't depend on knowledge, measure and observer. Similarly, the uncertainty related to the principle of indeterminateness is an objective datum, Planck's constant being universal.

Chaos is deterministic, meaning that subtended laws exist which determine particular trajectories and orbits, yet due to Heisenberg's principle we cannot simultaneously know position and moment of a single entity: for this reason we rely into statistic distributions of probability. Non-null entropy is a marker for the presence of deterministic chaos and it measures the uncertainty rate or the variation (increase) rate of information in a dynamic system. Uncertainty is therefore an intrinsic feature, it has no stochastic nature: deterministic chaos has nothing in common with randomness<sup>26</sup>.

There exists a background causality which is well implemented by Bohm's interpretation of quantum mechanics. Its analogy with chaos theory is very strong. Bohm argues that this background causality is brought about by quantum potential (which adds its presence to classic potential) that determines and guides the trajectory of the electron. The electron is no longer considered as a simple particle, a point without a structure, but rather as a highly complex reality influenced and guided by quantum potential in a very subtle way. The information conveyed as a quantum wave leads the energy of the electron. The apparent wave-particle dualism is therefore caused by the complexity of quantum potential.

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<sup>26</sup> We have to be clear about this point, as argued René Thom, one of the pioneers in studies about deterministic chaos dynamics and his catastrophe theory: "Several authors offensively glorify randomness, noise, fluctuation; all of them make randomness both responsible for world organization (through «dissipative structures», according Prigogine), and for life appearance and thought development on the earth. The fascination about randomness is a symptom for an anti-scientific attitude and view. What is randomness? The only possible definition can't but be negative: random is called a process which cannot neither be simulated by any mechanism nor described by any formalism. To state that «randomness exists» therefore means to take an ontologic position that consists in accounting for the reality of natural phenomena which shall never be described, and therefore never be understood. Darwinism has introduced an illegitimate use of randomness in the scientific domain. Some authors (among whom P. Suppes in conferences held in November 1979 at Collège de France) focused on quantum indeterminism – which itself is based on a never demonstrated hypothesis by which particles are dots – in order to provide a scientific explanation for the existence of randomness. Let us therefore forget about the word "randomness"! The use of the term "uncertainty" according to the original Heisenberg's thought (which was later falsified and modified to support the hypotheses of the actually dominant physics) is correlated with unpredictability and uncontrollability. Particle A has a well-known position and moment as well as a specific trajectory, which nevertheless isn't, and cannot be, exactly known by the experimenter.

In conclusion, quantum mechanics exclusively based on probability is not wrong, yet it is incomplete, to use Einstein's words; it has a validity only to a certain extent and within certain domains, but it leaves many unsolved questions. It should be integrated with what comes before, i.e. with first principles, that make it explicit and explicated – to use terminology of an implicated and hidden order that subtends the explicated order theorized by David Bohm. Quantum mechanics should be completed with what comes before our observations so far, i.e. with what causes those subatomic clouds of (illusory and deceptive) probability: first principles, hidden and often unknown laws that cause them.

David Bohm has developed the causal interpretation of quantum mechanics (hidden variables) and, in his wake, Dutch Professor Gerard 't Hooft, Nobel prize 1999 for Physics, is now studying quantum gravity as a dissipative deterministic system. A background determinism exists, but it doesn't match with the one imagined by Laplace and Newton. Saint John Henry Newman, philosopher and theologian, wrote: "Without first principles we can't have any conditions; probability presumes and requires the existence of true certainties" ("Grammar of Assent", JH Newman).

According to Bohm, the discovery of chaos theory has demonstrated that new directions can be run, and that statistic and probabilistic laws can be treated as off-springs of causal laws.

Such a correspondence between chaotic and quantum behaviors legitimates a new school of thought, where chaotic and quantum determinism can be related to each other, turning them into a quantum-chaotic determinism allowing for a background causality as well as subtended laws and schemes which lead everything that happens in nature, but where (according to specific features of deterministic chaos) there exists a sensible dependence on initial conditions and complexity and (according to quantum aspect) entanglement, non-locality and constant feedback in the dynamics of apparently probabilistic behaviors of observable events, where uncertainty and unpredictability are intrinsic properties (and not the fruits of randomness). Under such conditions, free will is admitted and allowed for, since retroaction dynamics (feedback) are possible, which act both in the observed events, both in the space existing between deterministic law and the event that is happening, both in the subtended scheme or law, by changing initial conditions. Unpredictability and uncertainty are legitimated by a potential causality – a potential cause subject to the changing of initial conditions in systems, and of free will, where it exists.