

## Complexity in Medicine

### *La complejidad en Medicina*

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A few years ago we did not know about “complexity.” This orientation was the legacy that came to us from the Newtonian conception of the universe. In addition, that which did not lead to the understanding of the problem was framed by the “demon of Laplace,” that is, considered a deficit of knowledge. In the twentieth century, those always existing individuals with progressive concepts who, ultimately, consider that all knowledge can evolve, warned about a science stuck in a mechanistic conception. And this was not merely a change of system circumstance; it had a profound implication for the human condition, since it was necessary to gather the incidental and causative biological, psychic and social facts in a process called “man-being”, whose conscience establishes the subtle difference with the cosmos. Even Heidegger’s philosophy introduced itself into the existential anguish of the human being: the elementary matrix of being able to reflect on his life and not merely occupy it. To not understand this concept of complementarity in science implied discarding the possibilities of better results in research. Traditional science had shown satisfactory results in the reduced cause-effect problems, those we could call linear. On the other hand, in dilemmas with multiplicity of variables, the achievements were not in agreement with the resources invested in science for the solution of the diseases.

The change in the methods of science arose paradoxically in the formal discipline of physics, through the great revolutions with which it impregnated its atmosphere. From the first years of the twentieth century, with the theories of relativity and quantum, a foundation of unpredictable and haphazard behavior was created where once accuracies and certainties had reigned. And this did not occur in the realm of the “demon” only for lack of information, but also for the intrinsic behavior of the analyzed system. In fact, this different view of classical science had begun with thermodynamics in the mid-eighteenth century, which, with its laws of energy conservation and evolution towards disorder [entropy], led Darwin’s theory to the confrontation against the degradation of the processes of the universe, since the classical, objective

and deterministic physics could not explain why living beings grow and transmit information from the past which is subject to changes. Subsequently, the declaration of the third state systems (away from thermal and chemical equilibrium), and to which the living beings belong, found an explanation for their reorganization through the theory of dissipative structures. On the other hand, the instabilities that inhabited the behavior of the systems were based on meteorology. In them, small changes in their causes could provoke great variations. The sensitivity to the initial conditions, the “butterfly effect,” gave an explanation to the random development of the systems analyzed. On a weighing pan, the cosmos; on the opposite, consciousness. And this is the only one that establishes an asymmetry in the purely physical conception of the universe. This “human factor” makes science transcendent in its holistic conception.

Since the Renaissance, the Platonic point of view predominates. The world can be discovered and explained through formulas and mathematical equations, and the *Mathematical Principles of Natural Philosophy* written by Isaac Newton made its appearance becoming the cornerstone of the system. Newton’s studies used a scientific method in which the dynamic system under study was isolated. In addition, it was based on simple problems of few components and in the three-dimensional space of Euclid’s geometry. Another relevant aspect of this classical mechanics was the reversibility over time of these dynamic systems’ trajectories. This design considered that, if the initial conditions were known, it was possible to predict the results at a later time, adhering to the laws of mechanics. From that moment on it seemed that all the behavior of the universe could be deduced from the knowledge of fundamental laws. Order and prediction were the result in the conception of this world. This structure of the scientific method was later resized with the *Mécanique Céleste*, by Pierre Laplace, of deterministic conception. Systems of disordered, unpredictable, and haphazard behaviors were in his thesis the imperfection of knowledge.

Let us agree that Newton’s mechanics was applied in

the following centuries in various fields: physics, chemistry, biology. This orderly and determined world also contributed to the economic and social structure, but could not adequately describe electrical and magnetic phenomena. To explain them, during the nineteenth century, Michael Faraday and James Maxwell introduced the concept of field (the potential to produce a force in space), whose theory was called "Electrodynamics," and which understood that light is a magnetic field that travels in waves.

Paradoxically, a science based on the symbolism of mathematics such as physics, a formal discipline, shook the foundations upon which science itself was based during the twentieth century. Throughout that century, physics produced transcendental revolutions, such as the law of relativity, quantum mechanics, the uncertainty principle, the dissipative structures' theory, the catastrophes' theory, nonlinear equations, and Bell's theorem. These profound changes have allowed a better understanding of the surrounding world in all its aspects.

As a result of the advances in the theory of the atomic and subatomic particles which relegated the mechanistic view, the universe ceased to be a machine considered as a simple sum of components, to be part of a deeply interrelated system. We have deceived ourselves into believing that the vision of science built three centuries ago would lead us to accuracy and to a reality that was within our reach with the mere tools of the linear scientific method. During the twentieth century, we have witnessed the spectacular advance of physics, from order to chaos, from accuracy to uncertainty, from certainty to probability. Science was, with the passage of time, envisioning that the Newtonian mechanical universe was not valid for speeds approaching that of light or to understand the microcosm. The twentieth century changed the physical notions of the moment. There would be no concept of absolute space and time, solid elementary particles, causal nature of the phenomena or objective description of nature.

Classical medicine based on individual objects isolated from space, in a causal behavior, inserted in an absolute time and space and in the consciousness of the observer excluded from reality was no longer possible after physics, existential philosophy, understanding the subconscious, evolution, and ethology, developed in the last century. Newtonian physics allowed the progress of the problems with few, cause-effect, linear variables. The great medical problems that persist make it necessary to incorporate a new system, which should be based on integrating to the current molecular model the subatomic level, the consciousness, and the ecological habitat. These concepts can determine a total medicine in clinical practice, far from the strategy of remaining comfortable within a mechanical world with a fixed space and an absolute time, but far from understanding the real universe. Ultimately, this is what current physicists have discovered, preferring

the randomness of this world to the certainty of the imagination.

Sciences cannot be isolated. The interrelation between them is fundamental for understanding the problems. An approach of biology to physics is absolutely necessary. In fact this has allowed understanding the evolution of living matter, which before physical revolutions was thought to violate the second principle of thermodynamics. Today we know that this is not the case and that an open system organizes itself through a gradient. Science is linked to the cultural process.

The complexity sciences deserve this name, not because they are more complex than their classical predecessors, but because they deal with complex systems and complex systems hierarchies. From quarks to social systems, new organizational levels are formed. Each new level means a simplification of the systemic function and the corresponding system structure. It also means the beginning of a process of progressive functional and structural complication. Systems form a continuum in matter, in life and in history. The oldest levels present strong and consolidated links to the recent ones, which are weak and flexible.

The human being is not only a physical system. The sum of body and consciousness is much more than its parts. Pain has a reflexive connotation here, not merely instinctive. Subjectivity colors all his acts and imaginations. The "human factor" turns Medicine transcendent in its holistic conception. All parts of the organism are perceptive to its validity, although when dismantled we have not been able to find the *res cogitans*. Maybe, could not it be the real "demon"?

In the last third of the twentieth century, a plethora of researchers from various disciplines considered the need to incorporate the development of scientific transversality into Medicine. However, all those brave pioneering works faced the applicability of complexity in the doctor's daily work before the patient. Without that possibility, all this change of paradigm in Medicine became a theoretical sum of concepts that were insufficient to obtain practical translation. The meaning of the physical-medical conjunction was perhaps closer than intuited at the time of the incorporation of "complexity" into the clinic. The integration of the current molecular to the subatomic level and to the habitat was the path of sufficient reason. Now we have no doubt that without conscience, the individual and unique "human factor", Medicine has no destiny and the patient no consolation, both situations that lose their immanence. The sciences of complexity are not more complex than their predecessors. Their postulates try to explain the new organizational systems (continuum of matter, life, history) attempting to regulate and simplify the older ones with more rigid and stable links. Finally and of elementary character, with the humility of the relative, this Medicine based on the conjunction of the sciences only tries to return the "human factor" to the patient's bedside.