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EDITORIAL

# The twentieth century: The century of progress and medicine

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## Introduction

*"Progress is the realisation of utopias"*

*Oscar Wilde*

The recently-ended twentieth century is considered as the century of progress thanks to the outstanding scientific conquests accumulated in such a turbulent manner, and in a range that goes from the knowledge of several fundamental laws of nature, Einstein's relativity, the quantum theories, the theory of information, the science of complexity, the discovery of DNA with the evolution of molecular biology and the definition of the human genome in 1999, to previously inconceivable diagnostic-therapeutic conquests.

However, according to several scholars like John Horgan in his book "The End of Science", this has given rise to a crisis in science due to the loss of fixed, determinist, and universal rules, with the prevailing of an indeterminist vision of the universe and an impetuous and rapid development of technology that prevents science from keeping up with, or providing an explanation for, the technological progress achieved.

According to others – like Ilya Prigogine (1917–2003), a renowned Belgian of Russian origin, born in Moscow, Nobel Prize winner for chemistry in 1977 for his discoveries in the field of thermodynamics, philosopher, and theorist on complexity – though, this just represents the beginning of a new era of science.

Among the numerous revolutionary events that have occurred over the last hundred years, the most predominant ones that have actually dominated the scientific scenario with all their deriving consequences, have been acquisitions in the field of quantum mechanics with the atomistic revolution, the advent of the information theory with globalization of communications-information, and the development of the science of complexity.

## Quantum mechanics

As far as quantum mechanics are concerned, up until the end of the nineteenth century it was a widespread belief that science was capable of solving all problems. Thanks to knowledge gained in the field of physics and chemistry, it seemed possible to pursue the truth. This illusion was plunged into crisis when at the beginning of the twentieth century, Ernest Rutherford (1871–1937) – New-Zealand physicist, father of the nuclear theory, and Nobel Prize winner for chemistry in 1908 – destroyed the paradigm of thermodynamics with his scientific experiments and totalizing explanations of the world, causing the idea of atomism to rear its head again from a remote past.

This idea in fact brought to mind several famous Greek philosophers like Democrites (460–370 BC), initiator of atomism, and Epicurus (341–270 BC) who carried this theory forward. On the basis of Democrites' theory, which preceded current scientific confirmations by more than twenty-four centuries, all things are born and die from the vortex of atoms, and they differ one from the other, both in shape and the way in which the atoms themselves aggregate. Moreover, according to Epicurus, the universe consists of elements called atoms that cannot be split any further and come in varying shapes and sizes and all move at the same speed.

The success of the atomist revolution, not always used for the benefit of mankind, consequently gave

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rise to an image of matter consisting of tiny components, atoms and molecules all held together by natural electrostatic forces when in a liquid or solid state. It could therefore be assumed, as upheld by Jacques Monod (1910–1976) – Nobel winning biochemist for medicine in 1965 – that life is a casual accident, an assembly of simple parts. Given the essential simplicity of the atomic-molecular components and their interactions, in a not too distant future all problems regarding matter, including those of the human organism, could be analyzed and solved by the technology of a sophisticated computer.

For this reason, molecular biology is now in a dominating position due to having its paradigms firmly rooted in the atomistic theory of contemporary physics. The consequence of this positivistic and mechanistic vision of medicine, upheld principally by molecular biology, represents an obstacle to the humanization progress of medicine to a certain extent.

Since ancient times, the doctor – initially in his role as a witch doctor and later as shaman, clairvoyant, magician, alchemist, philosopher, healer, and finally scientist – has been the key figure who has provided advice and therapies on the basis of knowledge of the art of medicine. With the advent of the atomistic revolution that hypothesizes the origins of the biological world in a casual manner, without the presence of self-organizational methods, man's aspiration to live a healthy life and to die peacefully with the aid of experts in Aesculapius' art, once satisfied, would be replaced in diagnosis and theory by a kind of robot lacking in any kind of humanity. Extraneous to the desperate plea of his patient, not only for a cure but also for a spiritual hand to rise up out of an emotional situation that could probably dissolve, or at least relieve the chains of his illness, the doctor would only be an executor of protocols and guidelines, and increasingly more frequently, following the mechanization of medicine, he would be replaced by more or less intelligent machines.

This state of affairs has been superseded by the confirmation of mechanisms coherent with the basis of many biological phenomena, and has encouraged the development of a new point of view regarding condensed matter founded on coherent quantum electrodynamics, that goes far beyond the atomistic revolution. The elementary systems, atoms and molecules, lose their individuality in the atomistic vision in order to generate new collective systems.

In fact, as brought to light by Ilya Prigogine and also Giuliano Preparata (1942–2000) who, prior to his untimely death, attempted to build a bridge between the physicists and new medical-biologists, it seems difficult to hypothesize a biological world that originates by chance, without the presence of self-organizational mechanisms operating at various levels.

Today everyone recognizes the important role of quantum physics at the atomic and subatomic level of matter. Even the studies of Carlo Rubbia – Nobel Prize winner for physics in 1984 – who made a decisive contribution to the discovery of the W and Z particles known as Bosons, and of electromagnetic forces, have indirectly confirmed that any solid body, despite appearing inert at a macroscopic level, at a microscopic level consists of one part of matter, the neutron, and by billions of elementary particles in perpetual movement; in other words, by an enormously greater quantity of energy. In this way the importance of knowledge of the quantistic and electromagnetic aspects has also been evidenced in the medical field (Figure 1).

The repercussions of these new scientific conquests on the chemical, biological, and therefore clinical-therapeutic aspects, have not yet been sufficiently investigated or taken into due consideration.

Nuclear magnetic resonance (NMR) and positron emission tomography (PET scanning) are both unique and significant conquests in this field, well known to everyone. On the basis of the principle of resonance applied to hydrogen atoms, NMR is able to record any variations in the electromagnetic field of these atoms in the human body, or other objects under examination, in the form of images. PET scanning instead highlights the physiological functions of the cells, and via the emission of positrons from an injected radio-drug, studies the consumption of several energetic substrata (glucose) or the presence of several biochemical compounds in relation to the various organs examined. As a result, thanks to these photographic images it is now possible to investigate the most hidden recesses of the human organism in order to formulate brilliant diagnoses and undertake optimal therapeutic itineraries.

It is precisely in the quest to get to know and understand the 'still unknown', that technological progress has been made for detecting the development of the fetus's encephalon in an even more efficacious way than with ultrasonography, right from the 20th week of gestation. This allows the provision of reliable diagnostic indications about the fetus's normal, or abnormal evolution in order to reveal more effectively any suffering in progress during the perinatal period that could call for adequate therapeutic intervention.

The human organism, as with all matter, is an assembly of electrical charges, protons, electrons, and quarks that are in continual, perfect, and harmonic oscillation as the expression of a physiological

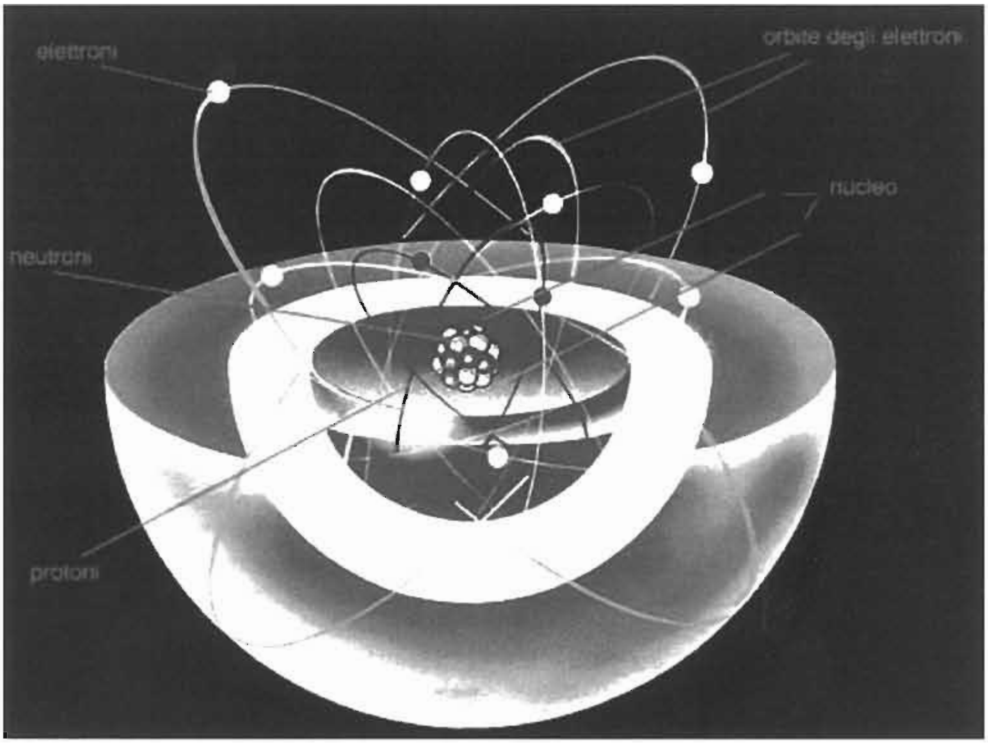


Figure 1. Electrons, neutrons, protons, electron orbits, nucleus.

condition (Figure 1). These electrical charges represent the constituent part of an unimaginable number of atoms, which in turn form billions of molecules from which the cells of our organism originate. Consequently there are well-grounded reasons for believing that the pathological conditions that we consider as an anomaly of a chemical and histological nature are also closely linked to more or less extensive disorders in these 'electrical charges' and in the electromagnetic network, thus representing the '*primum movens*' of a pathological condition. The challenges of the biological and medical technique and science could therefore lie in detecting the electromagnetic disorders of the various pathological conditions and understanding how to re-establish a physiological status of electromagnetic balance.

Limited research on the quantum aspects in the medical field can also be blamed on the fact that quantum mechanics are intuitively difficult to comprehend and call for a certain commitment in order to be assimilated, or for fully understanding the language and recognizing the characteristics of the microscopic components of the entire creation with their continual fluctuation–oscillation.

These aspects bring the words of Claude Bernard (1813–1878) to mind: 'what we know is the main obstacle of what we don't know', whereas with Socratic wisdom the fact of 'knowing we don't know' should create the conditions for us to attempt to know and understand what is not yet known.

## The theory of information

As far as the theory of information is concerned, all living species adapt their behavior to their environmental conditions by means of the interchanging of information which is perceived and produced on the basis of genetic attitudes and experience acquired, thus encouraging an associative and collaborative will: the will to communicate.

Each society constitutes and governs itself via the information processes, representing not just a simple aggregation of men, but rather, a series of ideas, feelings, and experiences all shared thanks to cognitive processes that are determined by the circulation of information.

In 1928 Ralph Vinton Hartley (1888–1970) came up with an initial definition of information in mathematical terms; however the true theory of information based on binary logics was elaborated in 1948 by American electronic engineer, Claude E. Shannon (1916–2001), father of the digital system. This theory is the fulcrum around which all current information-communication has progressed and evolved and which, on the basis of mathematical laws, regulates all forms of processing, transmitting, and memorizing of the information-communication.

Within the fields of technology, science, history, traditions, religious faiths, political ideologies, economy, social projects, and international agreements, etc., information can be spread and sent in real- or recorded time to the furthest most remote corners of the world by transmitted voice, image, sound, and music thanks to magnetic recording of data, telephone, radio, digital technologies, and sophisticated telematics.

In this way a constant flow of unending opinions has been created, and if the communication instruments used are capable of reaching a so-called mass public, every social sector is involved either directly or indirectly, thus constituting the heritage of ideas and culture of entire groups of people.

The enormous political relevance of the social consequences of information determine an ongoing and underground international conflict, always in act, for gaining control of the means of spreading information. These form a true strategic weapon both internally and externally for any government, in times of war and in times of peace, because the overwhelming development of satellite and online technology, as well as the inevitable flow of information, overcomes any barrier and is a determining factor in the spreading of democracy.

Kant stated that "wisdom is indispensable in order to select from among the various problems faced, those with solutions that are important for humanity". Well-grounded reasons therefore exist for believing that the historical evolution of the last century also took place thanks to the prodigies of the information system which, with their exchange of information-communication and experiences, have given rise to the cultural growth, social and economic development, and spreading of scientific and medical knowledge with results in the diagnostic-therapeutic fields that up until a decade ago would have been inconceivable. Moreover, just as news and news images 'fly' from one point to another all over the world, thanks also to the internet, new acquisitions, diagnostic-therapeutic progress, and images of patients and technological investigations fly from one nation to another and from one continent to another in the medical field, making the most recent knowledge and skills available in real-time in order to solve severe pathological conditions.

## The science of complexity

Last but not least, the science of complexity. This science studies the ways in which the interactions between many simple components of complex systems produce surprising results. The birth of the science of complexity can be attributed to the studies conducted on world meteorological models at the beginning of the sixties by meteorologist Edward Lorenz, the mathematician to whom we owe the theory of chaos. The reason for this scientific delay lies in the fact that to effectively process enormous amounts of information, the data must be processed electronically, something that has only been made possible with the development of our most modern computers.

As a result, it is now possible to study complex systems and by investigating the interactions between the myriad of simple entities making up these systems, this science is capable of understanding the complexity of various phenomena and their causes, producing quite amazing results.

According to one school of thought, the theory of complexity involves three relevant new aspects: a new allegiance between philosophy and science, a new method of 'making' science, and a new concept of natural evolution. By using valid methodologies, situations, concepts, models, and methods for all the disciplines, it can be applied in practically every scientific field, like physics, chemistry, biology, medicine, and also economics, sociology, and psychology, etc.

The study of these models led to the discovery by Lorenz of the so-called tangible dependence on the initial conditions, the so-called 'butterfly effect', meaning that a tiny alteration or variation in the initial parameters can give rise to large-scale phenomena. A prime example of this is how an air perturbation provoked by a butterfly in any given square in the world (e.g., in Beijing) can be the cause of a hurricane, several weeks later, in another place a long way away (Gulf of Mexico for example).

In other words, the tendency of a non-linear phenomenon was discovered, that is, a phenomenon in which slight differences in the initial conditions produce unpredictable variations that cannot be explained by the Aristotelian logic of cause and effect. This phenomenon had already been glimpsed in the dynamics field by the great French scientist Henri Poincaré (1854–1912) at the beginning of the twentieth century, but at that time it was impossible to develop it any further also due to the lack of sufficient calculation skills, only recently available.

The discovery of this and other unexpected reactions, combined with already-existing and unresolved problems, has catalyzed the development of this science. Two Nobel Prize winners, Ilya Prigogine, famous for his studies on irreversible thermodynamics, and Murray Gell-Mann (Nobel Prize winner for physics in 1969), who discovered quarks, have encouraged the development of this science in Europe and the USA respectively.

The progressive evolution of the science of complexity has thus given rise to artificial intelligence, a term first coined by John McCarthy in 1956. This represents the series of actions–reactions resembling those in humans, though deriving from electronic processors. It is inspired by a complex philosophical system centered not so much around a deductive Aristotelian logic, but rather, around a new logic and new mathematics, that of the non-linear complex systems. Whenever multi-factorial influences coexist, it is indispensable for us to reorganize our ideas concerning the concepts of cause and effect and to resort to these systems.

Artificial adaptive systems and artificial neural networks have evolved within this context. Artificial adaptive systems are theories whose mathematical algorithms and generative algebras create artificial models of natural phenomena. They are mainly used for understanding and explaining various types of pathologies, from Alzheimer's to gastroenteric diseases, and also for studying ecosystems, etc.

Artificial neural networks are mathematical equation systems making up one aspect of cybernetics. Interconnected according to a principle resembling the interactive processes of the human brain, they are capable of recognizing schemas, using data, and learning by means of example, just as we do in our daily activities.

They process data with mechanisms that do not follow any specific rules, and their main distinguishing feature with respect to other systems lies precisely in the fact that they learn from data received in order to discover the rules that link them, and to resolve complex systems. They exploit maths capable of non-linear decoding dynamics, and are therefore able to discover by themselves the rules present, but not easily evidenced, in the database, as well as to eliminate superfluous or even fuzzy data in the aim of solving complex systems that would otherwise remain unsolved. They are also particularly good at analyzing, though with a different approach, complex systems in the medical field, as well as solving non-linear problems, obtaining approximate rules that determine their solution in an excellent manner.

Neural networks have consequently been resorted to in the biological and medical world for studying the nucleotidic sequence of the human genome or the amino acids of proteins, and for determining long-term results for tumoral pathologies, etc. As they allow the drawing of conclusions in the single individual, they have been proposed for predicting the response to specific therapies and assessing the usefulness of specific diagnostic instruments. It has been demonstrated how these are capable of predicting the intrauterine growth restriction (IUGR) condition with an extremely high degree of probability, based on several biohumoral variables connected with the insulin-like growth factor–insulin-like growth factor binding proteins (IGF–IGFBP) system and interleukin-6 (IL-6). In the future this could lead to the hypothesizing and programming of specific therapeutic intervention, possibly also via the use of new anti-cytokine drugs or other anti-inflammatory drugs during fetal life up until the perinatal period. Within the context of the 'programming', this would all be aimed at preventing the onset and/or attenuating the gravity of various types of pathogens, first and foremost metabolic diseases in the adult. We could even hope to be able to elaborate models for optimizing the decision to interrupt mechanical ventilation in premature neonates, for predicting the risk of intraventricular hemorrhage or mortality in preterm infants, and for predicting survival in the case of infantile cranial traumas, etc.

In the wake of these results, artificial neural networks, evolved algorithms, and various other systems of 'artificial intelligence' are being introduced into the medical field, not only as a potent means of optimizing the prognosis in particular, and diagnosis and therapy in general, but also as an efficient quality control instrument. The fact of being able to exploit all the information that exists or that can be collected, will allow us to understand the rules underlying a wide variety of clinical problems that are still waiting for an answer.

Hand in hand with the scientific and technological evolution, we have witnessed the passing over in the maternal–infantile and perinatal field from a generativity seen as a biological-moral obligation, to parenting seen as a responsible choice for a personal psychological, affective, and/or dynastic need. This can only be realized when the parents are considered as capable of offering their child more than just the adequate material and psychological instruments believed indispensable for its physical, economic, and cultural requirements. Unfortunately this often occurs at too late an age and consequently the only-child syndrome prevails with its well-known shortcomings. Moreover, after thousands of years of obstetrical-neonatal tragedies, the result of the naturality of events, birth today is far safer than it was even only several decades ago, and now when a child is born, we know everything about him. Thanks to the innumerable aspects of prenatal monitoring, the child's sex, size, facial profile, intrauterine motility, sleeping–waking rhythms, etc., are all tabulated, meaning that the parents are already well-acquainted with their child right from the fetal period. This possibility of identifying and caring, even before birth, gives rise to wonderful expectations in the adults, and in many cases represents the most intense expression of affective bonds between the couple.

Whereas it is now imperative for the child to be healthy, with zero risks and an absolute guarantee of survival, once upon a time infants born with a birth weight of little less than two kilograms were considered as without any chance of survival and were therefore placed on the windowsill so that their soul could rise up to heaven more easily.

Years ago a mother acquired the rights, respect, and attention in a relational and behavioral context from the patriarchal family that would have been unthinkable up until several months previously. This was thanks to the event that she had generated, and she took on her role as nurturer and sole person responsible for the care of her child as soon as she recovered after the birth. Nowadays, despite the importance of precocious breastfeeding on galactogenesis, on the care, the sensorial perceptions and the role of the stimulation and handling in the development of CNS meaning that all the nurturing and care of the neonate is delegated to the new mother, the frequent lack of a family nucleus to back her up and offer assistance often transforms an ardently desired joy into a heavy burden, causing unimaginable stress with psycho-behavioral consequences and results that are at times quite severe, even at a distance of many years.

Moreover, everyone is aware of the reduction in perinatal and neonatal mortality and the effective control of infective pathologies that are no longer the main cause of death, and consequently, the prolonging of the average lifespan. Nevertheless, the negative side of the positive medal is represented by the fact that other pathologies have emerged, including psycho-behavioral disorders, often originating precisely during the perinatal period, and chronic-degenerative pathologies which, on the basis of the 'programming' theory, would appear to have their origins in those special 'sensitive windows', and namely, fetal, perinatal, and neonatal life.

In such a complex scientific scenario with such a rapid evolution, enhanced by the progress made during the recently-ended century, the essential elements are represented by the spreading of new knowledge, the making of cultural comparisons closely linked to research, and the updating of all those assisting the patient, because, as Goethe declared, there's nothing more dangerous than active ignorance.

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