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"NEW" UNEXPECTED ONTOLOGICAL AND EPISTEMOLOGICAL DEVELOPMENTS THAT MOVE THE FOUNDATIONS OF MODERN SCIENCE[1]

"NUEVOS" E INESPERADOS DESARROLLO QUE MUEVEN LOS CIMIENTOS DE LA CIENCIA MODERNA

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> It takes a lot of courage to release the familiar and seemingly secure, to embrace the new.
> But there is no real security
> in what is no longer meaningful.
> (Alan Cohen)

Abstract: *Context.* In this article, we present a theoretical corpus built with developments from different disciplines, in which we bring together concepts, theories and "new" scientific perspectives developed during the 20th century. It is a work of deep theoretical reflection in the field of research methodology. *Problem.* The purpose of this work is to contribute to the overcoming of the disciplinary reductionism and assuming the complexity that today requires the construction of a science of the whole.
Method This article has been developed through a deep interdisciplinary literature review.
Result. These ontological and epistemological developments mark a profound change of course on modern science, questioning the fundamental principles that

1 This article was written in English with the collaboration of the doctoral grant holder Melisa Mandolessi.

previously gave its sustention. Also, we consider that these developments are founding principles of life, so we seek to put them in relation to the reader's everyday life, in intimate connection with everything that affects him and at the same time it is affected by him.
Implication. The paper concludes with the challenge of the human quest of unraveling essential finds for the evolution of life that would help us to preserve and empower our existence.
Key words*:* Research methodology, ontology, epistemology, modern science, complex research perspective

Resumen: *Contexto*. En este artículo presentamos un corpus teórico construido con desarrollos de diferentes disciplinas, en el que reunimos conceptos, teorías y "nuevas" perspectivas científicas desarrolladas durante el siglo XX. Se trata de un trabajo de profunda reflexión teórica en el campo de la metodología de la investigación.
Problemática. El propósito de este trabajo es contribuir a la superación del reduccionismo disciplinario y a la asunción de la complejidad que hoy en día requiere la construcción de una ciencia de la totalidad.
Método. Este artículo ha sido desarrollado a través de una profunda revisión bibliográfica interdisciplinaria.
Resultado. Estos desarrollos ontológicos y epistemológicos marcan un profundo cambio de rumbo en la ciencia moderna, cuestionando los principios fundamentales que antes le daban sustento. Además, consideramos que estos desarrollos son principios fundamentales de la vida, por lo que buscamos ponerlos en relación con la vida cotidiana del lector, en íntima conexión con todo lo que le afecta y al mismo tiempo es afectado por él.
Implicación. El documento concluye con el desafío de la búsqueda humana de desentrañar los hallazgos esenciales para la evolución de la vida que nos ayudarían a preservar y potenciar nuestra existencia.
Palabras clave: Metodología de investigación, ontología, epistemología, ciencia moderna, perspectiva de investigación compleja.

Introduction

From the mechanical world’s matrix to the waving properties of matter

The ontological and epistemological developments here refer are not that new or that old as to what the development of the history of science concerned. We refer to findings, assumptions, theories and empirical data; some of which have already celebrated their centenary. Human thought, for his maturity and development takes time and while it happens, as Krell (2011) points out, *the unexpected science flowers in the rotten field of official science*.

This article presents different concepts and unexpected theoretical developments from various disciplines, contributed by scientists called by Briggs and Peat (1998), *the mirror scientists*.

The purpose of this paper is to contribute to overcoming disciplinary reductionism and to assume the complexity that is required nowadays for the construction of a science of the whole.

It is important to clarify in advance that the theoretical developments to which we refer here, are not intricate scientific lucubrations, but founding principles of life, in intimate connection with everything that affects us, and we affect. In the midst of all these developments we find the challenge of the human quest, to unravel key findings for the evolution of life that preserve and enhance our existence.

The first topic we tackle lead us to ask ourselves again: What is reality? Do we have any kind of involvement in it? Positivism led us to conceive a world with solid entities, substance, defined, established, circumscribed, as if it had an existence outside of our minds and our bodies. And there we perceive ourselves, sitting as critical spectators, waiting for somebody, perhaps some political, religious or current government leader, to change it. Is it possible to construct our reality?

Participation, multidimensionality, simultaneity, unpredictability, uncertainty, instability, entropy, irreversibility, chaos, creativity, randomness, nonlinearity, complementarity, becoming, weft, network, flow, holomovement, asymmetry, autoecoorganization, autopoiesis, recursion, feedback, synchronicity, coevolution, holography, complexity and UNIcity!!! are some of the features of reality, warned to us by the new developments of science in the twentieth century.

How to deal with this complete and complex reality?

To address this reality, the disciplinary fields, imitating the ancient Greece style, raised their barriers. The physicist turned philosopher, the philosopher studied neuroscience, the biologist embarked on the act of knowing and the chemist confessed his love for arts. Since that moment, neither hard nor soft, quantum physics, thermodynamics, social constructionism, cybernetics, biology knowledge, systems theory, complexity theory, the holographic perspective, fractal mathematics, neuroscience, and many other interdisciplinary fields now work in all sciences.

We pretend to separate us from the mechanical view of nature, today we begin to recognize that we are partakers, craftsmen, authors and leaders of a holographic, inclusive and intertwined reality.

Significant concepts in the development of the mirror's science

Earthquakes in the foundations of classical mechanics

The physics of the twentieth century found an exponential development through its leading thinkers: Planck, Broglie, Einstein, Bohr, Heisenberg, Schrödinger, Dirac, Von Neuman, who questioned the essential principles of classical physics. Matter is not fundamental. As expressed by Capra (2009) modern physics had to abandon the idea of elementary particles as primary units, because the number of elementary particles grew from three to six in 1935, to eighteen in 1955 and today are known over two hundred! And as if that were not enough ... subatomic particles can exist in two or more states at once!

The observer determines the observed

The theoretical developments to which we refer consider that "the fluid and turbulent universe is a mirror" (Briggs & Peat 1998), which is the same as saying in terms of Morin (1995) the observer is the observed.

Quantum theory has raised uncomfortable questions such as: What is the relationship between the observer and the observed? What happens when the observer makes a measurement? How does the observer determine what he observes?

When we look, we focus and determine a possibility, when we are not looking there are many. In classical physics the outside world takes precedence over the internal world. Now we are facing physics which dared to explore in depth the internal world and found that there are plenty of possibilities, all and none (emptiness) waiting for observers to focus. Thus, the universe consists of interrelated and interdependent events that interact dynamically and simultaneously.

Consistently, Thomas Kuhn (1967), physicist-turned-historian and philosopher of science, through his brief and provocative piece "Structure of Scientific Revolutions", made it clear that knowledge depends largely on the point of view of the observer. There, the author expresses that knowledge is subject to the epistemological matrix from which it is conceived. Later, the concept of matrix was replaced by Kuhn himself by the concept of paradigm. Congruently, Einstein pointed to young Heisenberg "there was no point trying to build theories from observable, because, after all, it was theory itself which indicated physicists what could be seen and not in the nature" (Briggs & Peat 1998: 47).

The wave-particle duality. One thing, the other or both at once?

It was Louis de Broglie, scientific and nobility, who described the dual behavior of particles. It was on his ideas that Schrödinger based his theory about superposition of the states of matter on the equation for wave function.

The latter, through the application of the wave functions, evidences that this is a characteristic of the nature of the matter. The mere act of observing, changes the system state. Bohr believed that the wave function of the particles could be in superposition states, ie, subatomic particles can exist in two or more states at a time. These are probabilities of manifestation until they are observed. Only after the act of observation, we find the particle in a specific coordinate of space and time. Einstein disagreed strongly with Bohr on these concepts; he was not resigned to cleave the local from the real. And in return for his famous phrase: *God does not play dice.* Bohr used to answer: *Einstein, stop telling God what to do with his dice!*

> This means that the universe can never be described with a clear and single figure but must be apprehendede by overlapping visions, complementary and sometimes paradoxical (Briggs and Peat 1998: 57).

In this sense, an electron would not have defined properties but “tendencies to exist”. The notion of superposition of possible states is fundamental in quantum theory, to specify the state of the system from this context, means taking into account the superposition of all possible states.

The discovery of light and electrons, as both, wave and particle simultaneously, led to Heisenberg, Bohr’s famous apprentice, to the uncertainty principle. Heisenberg had proven in his laboratory that certain pairs of physical variables cannot be determined simultaneously and accurately, such as, for example, the position and movement amount of a given object. And it is impossible to, simultaneously and accurately, determine the position and velocity of the electron.

> Had not science built its reputation within human subjects, precisely because of its ability to perform quantitative predictions? (Mindlin 2008).

Agreements and disagreements among the mirror’ scientist

The “non-locality” of space and time is another concept that leads us to systems’ complexity.

Einstein showed in 1935 that quantum theory leads to the idea of nonlocality. Two particles that have been in contact will continue to be correlated even in remote and the measurement of properties of one of them, it will instantly influence on the properties measured in the other. Since there is no physical information traveling from one particle to another, Einstein called this, ‘spooky’ action and he took it as proof that quantum theory could not be considered complete. He thought that some explanation was missing, a theory still not discovered without this “nonlocality” should underlie quantum mechanics.

Much later, measurements in several laboratories (1982) finally showed that Einstein was wrong and that the atomic world is essentially nonlocal. Bohr and Heisenberg in Copenhagen agreed that all property is the product of a particular measurement. There are no separate and independent of the observer objects, at the quantum level there is an indivisible whole.

The universe is fluid and comprehensive. The matter is equivalent to energy, gravity to acceleration, space to time. Everything is a unified field.

All these concepts have a transcendent impact in the understanding of social phenomena, which seen from the mirror science conception find no great distance from the phenomena of nature; since “social” and “natural” are not parts of, but the same single whole that constitutes “*physis*”, the essential nature of all things.

Parts do not exist

For Bohm (1998) “Nature itself is a web of living energy, every object is a mirror made of a yarn of all that is”. He develops a theory of implicit order of the universe. This, as a whole, is a mobile causal network, so nature cannot be analyzed into parts. He uses the analogy of the hologram to illustrate the existence of a holistic universe, where “everything reflects everything else,” organized by “implicit or implicate order”.

Parts and fragments exist as “relative autonomies “. So things and ourselves also, constitute “relatively autonomous sub-totalities” of the whole fluid motion, which is the universe.

The holomovement, the whole flowing

The movement is not synonymous path from one point to another, but an experience varying degrees of deployment, all present simultaneously. The holomovement is timeless, different temporal orders are many aspects of it. Time and space are projections of higher dimensional reality. A practical, everyday experience of this concept is the particular perception of time passing, each particular perception is different psychological temporary orders. What is shown as dashed and hazardous to our eyes really are different orders of folding and unfolding of phenomena. Chance contains a complex and different level of order, so that chance would not be such, but varying degrees of order.

Mind and matter in a multidimensional reality

Reality it is conceived as multidimensional, where consciousness is a whole. While the mind is a subtle form of matter, matter is a cruder form of mind (Briggs & Peat 1998). For Bohm, in inanimate matter lies implicit life, just as consciousness is implied in the matter; matter and mind are closely intertwined, everything is alive, the inanimate world is a living world.

The "relatively stable forms" are the product of cognition that our mind produces. Humans also learn through language, maps that allow us to encode sensory information, in relatively stable forms in close relation to culture.

The fallacy of a stable world

Our western culture has a strong imprint of explicit conscience; we are trained to abstract subtotals (Bohm 1988) which very often have little of relativity and a lot of stability. Just as the process of individuation through the construction of identity, leads to a strict and rigid constituency of self, leaving little room to warn the underlying implicit order that has individual existence and its holographic nature that gives him back the reflection of the whole.

The significant presence of explicit order has enabled the man many advances in the exploration of subtotals, while it had inhibited him in the comprehension of the unnoticed implicit order; where the not yet deployed gives endless possibilities to change and transform reality in which he lives, from the options that multidimensional reality offers.

Civilization implies high degrees of explicitness. Thus, cultures that don´t have any contact with writing, that move in a more engaged, less unfolded order, are closer to understanding, i.e., they have a greater awareness that things flow into each other.

Bohm believes that behind the concept of individual conscience lurks a great fallacy. In the implicate order, consciousness as a whole, total awareness of the human species, has a primary reality. Even more, fortunately, all consciousness is involved in the matter and matter is the unfolding of consciousness. Thus, the individual consciousness, as an individual electron, is an abstraction, useful sometimes, but sometimes destructive and misleading (Briggs & Peat 1998: 140).

For Bohm, mind and matter are mutually implied, they are projections of a multidimensional higher reality. The observer and the observed arise from the same indivisible process, flowing toward each other, both are caused by the underlying total movement.

Far from equilibrium systems, earthquakes to modern science

As Bohm has emphasized in a universe unfolding, Prigogine makes its main contribution, emphasizing an irreversible world, where chaos is nothing but a new order that responds to far from equilibrium systems, characterized by entropy. Both scientists agreed on "being as becoming."

Expanding classical thermodynamics, Prigogine studied the systems irreversible processes, understanding they can only be understood in relation to its environment. He conceived a theory of dissipative structures, which he considered a new state of matter. He held that the universe "is not made from the bottom up but a web of levels and divergent laws" (Briggs & Peat 1998: 186), where everything relates to everything.

Prigogine characterized explosive processes with sudden changes, shocks, turbulence through the concept of entropy. These are irreversible processes that unfold through increasing disorder. Further, notes that these processes are more common than reversible processes where a system is affected by a change and it can reach equilibrium states. The entropy moves us in time, turning back is impossible. The word entropy comes from the greek (ἐντροπία) and means evolution or transformation, and it is from this concept that Prigogine describes thermodynamic systems.

Still chaos... entropy increases and the symmetry is broken!.

What Prigogine makes clear is that entropy increases and structures break down. Systems, in order to maintain its shape have to dissipate entropy. The same Prigogine points out that physicists and mathematicians of the time, felt that the second law of thermodynamics was a useful concept for engineers and physicochemical, but they did not warn in it a fundamental epistemological contribution.

Another important concept is "symmetry breaking", the equations can be symmetric but the real processes not, the famous *arrow of time* is irreversible due to the symmetry breaking. The universe is asymmetric, that is the result of the instability inherent to matter. The arrow of time indicates the evolution of dynamical systems into states of higher probability. Time is dynamic, asymmetric and irreversible as it is an immovable past, which comes before the uncertain and random future. From the dissipative paradigm, the process replaces things and, at the same time, it prioritizes time over space.

Definitely everything is woven together

Through the *Complexus*, the conjuncted weave, Morin (2001) allies in a common mission with Blaise Pascal, who had expressed, three centuries ago, that everything is cause and caused, everything is connected by a natural bond, so it is impossible to know the parts without knowing the whole and it is also impossible to know the whole without knowing the parts. It is therefore, a moving knowledge, flowing from one point to another, going from the part to the whole and from the whole to the parts. A trussed knowledge, without hierarchies of the parties, analogous to the web of life.

> The web of life consists of networks within networks. In each scale, under closer scrutiny, the nodes of a network are revealed as smaller networks. We tend to arrange these systems, all nesting within larger systems in a hierarchical scheme by placing the bigger ones above the smaller as an inverted pyramid, but this is merely a human projection. In nature there is neither up nor down, hierarchies do not exist, there are only networks within networks (Capra 1996).

For the construction of this binding thinking, Morin (2001) proposes seven principles: *auto-eco-organization, dialogic, reintroduction*, *systemic, holographic, feedback and recursion*. The last four, interest us more, because they all have large overlap in the transdisciplinary developments we have been discussing. The *systemic principle*, opposing to the reductionist view of reality as "isolated parts", provides a fertile body of knowledge to understand the universe as a field of interlaced and co-determined relationships. Living organisms are conceived as integrated units, so any behavior responds to patterns of behavior within the system. In 1947, Denis Gabor discovered the mathematical *principle of holography*, three-dimensional image produced by the no lens photography perfected later with the development of the laser. This image is a powerful metaphor to explain the nature of the universe. Within the holistic approach (from the Greek holos = whole) grows at the hands of several experts, the *holographic* perspective. Pribram from neurology, Bohm from physics, Wilber from philosophy, Morin from sociology, they all converge in affirming that every part is the whole.

In the systems theory, the concept of *feedback* is vital. This concept developed by Wiener, explains that the ability of a system with a self-regulating behavior depends on information exchange processes, including feedback and negative feedback. This conception of feedback or loopback contributes to crack the principle of linear causality of classical science. This loop is also *recursive*, this means that events, effects or behaviors of a system are, at the same time, produced and producers.

The ability to produce, autopoiesis

Maturana and Varela (1984) propose that the decisive characteristic of living beings is their ability to create themselves. The living being and the environment form a unit, only discernible to an observer. Cognition explained as a biological phenomenon seeks to end the belief that there is an objective knowledge. Converging with the concepts we developed indicate that there are no absolute truths.

This view holds that what is central to human understanding is the operational autonomy of the individual vivo. This research made it possible to understand the dimension of knowledge which arises and there is self-awareness. Living beings are autonomous units. This autonomy involves the ability to specify your own legality, i.e. what is proper to him.

Its unique product in themselves, where there is no separation between product and producer. The work of these biologists constitutes a unitary ontological explanatory system of life and human experience.

Fortunately, we are not alone: the coevolution

Erich Jantsch, Austrian astrophysicist, tried to joint Prigogine's perspective with that of Maturana and Varela's. Thus, he defined autopoiesis, demarcated by the latter two as "*the state of a dissipative structure once it passed through the turbulence of youth and adolescence and it <established> its identity in the environment, far from equilibrium*" (Briggs & Peat 1998: 195). He called "self-organizing structures" to the dissipative structures of autopoietic nature. The balance in this sense is "the relative stability of a dissipative structure once it has been formed" (Briggs & Peat 1998: 208). To Jantsch, increased autonomy is closely related to increasing openness and instability. The ability to self-determine ourselves (autopoiesis) gives us a broader relationship with the whole and its infinite possibilities and, consequently, makes us more unstable. We do not exist separately, we are "a fluid aspect of the energy exchange of larger structures: your company, city, family, culture and religion" (Briggs & Peat 1998: 203). Jantsch, inspired by the concept of self-organization, introduces a valuable concept: coevolution. This concept "does not deny adaptation, or the struggle of individuals for survival, but does not consider them as the main driving force for the development of new forms of life" (Briggs & Peat 1998: 209). The driving form would be the evolutionary bilateral cooperation. Not only the species evolve, so does the atmosphere.

Paradoxically, the greater the autonomy of a self-organizing structure, the more "distributed" or "shared" it is. Resulting in coevolution. The change in systems could be thought as the holistic appearance of a dissipative structure, resulting from the interaction of micro and macro processes.

Craftsmen of an invented reality

From everything above developed, we understand that reality is constructed, we are artisans of it. Knowledge is in the mind of people, and the *cognizant subject* has no choice but to build what he or she knows on the basis of their own experience. Knowledge is then constructed from the experiences of those involved in the web. The mirror science seems to become the best perspective for understanding this reflected and complex universe. Since we invented reality when we observe it, we could say that theories, paradigms and perspectives of reality are our own beliefs.

Modern science had left neatly separated from science, issues related to faiths. From a science of the whole we can no longer cleave wave and particle, emotion and reason, part and whole, nor can we continue to separate mind and matter.

Dizziness at the edge of the vortex

It is possible that this trip by uncertainty and the holomovement of recursive loops of complexity, finds us at this point of reading the article, a little queasy. These are the vagaries of the science of totality, where control is held not by the thread but by the network that interweaves us.

The interest in delving into these findings is to take them as inputs, to contribute to the construction of a complex approach of being in this world and investigating it. As we have been pointing out, these ontological and epistemological reflections are commonly not the subject of discussion among scientists that "know" and use these theories.

> While the actual physicists skillfully dodge the paradoxes of their theories with great aplomb and a seemingly endless success, other scientists are running down the maps into another reality barely noticed (Briggs & Peat 1998: 98).

In a bold synthesis of this way of looking at reality as a whole, the scientific developments of the twentieth century, before our astonished eyes, provide us the following contributions:

- ✓ The world does not exist independently of our experience.
- ✓ Nothing exists without our involvement.
- ✓ All realities exist simultaneously, our gaze determines a reality.
- ✓ "There is nothing out there" as repeatedly stated.
- ✓ The matter is not fundamental.
- ✓ We affect the reality we see, is the consciousness that you choose.
- ✓ The consciousness that determines the construction of reality is fundamental.
- ✓ At the fundamental level of consciousness we are one.
- ✓ Life is a frame in which we, as all living beings are interconnected strands.
- ✓ There are no hierarchies in this network, just different layers of complexity, networks nesting within networks.

- ✓ The continuity and discontinuity are part of the act of deploying matter,
- ✓ Each cause, cause everything else.
- ✓ The randomness and chaos are another type of order.
- ✓ There is a simultaneous determination and indeterminacy of the universe.
- ✓ The part is a relative abstraction of the whole.
- ✓ No parts but sub-totalities.
- ✓ The mutability, acausality and synchronicity are principles of nature.

Implications of these developments in the construction of scientific knowledge

We need to stop viewing experience exclusively inside the laboratories, start being spontaneous partakers of the universe, experiencing the theories about the world that we sketched. The clearest example that we are a whole with the universe, parts of the same weave, and that it is a cause what causes everything else, we are suffering it in the flesh nowadays, through serious ecological problems which we live today. To damage is to affect something, it's to affect ourselves (Briggs & Peat 1998: 160).

And after all, Kuhn pointed out the paradox: a theory must be accepted before substantial evidence that prove it arises. It has to be accepted because it is a new way of looking and scientists have to stall the glasses to see something (Briggs & Peat 1998: 250).

Upon completion of this paper, we consider that how to "do science" has not been transformed to the extent that scientific findings would suggest, or to the extent that the world has been transformed in recent times.

> Science has remained strong on this and it has been little what has allowed itself transforming. Despite positions within the social sciences about the need to "open them up" (Wallerstein 1996), the reaction has been to state the need for references to a policontextual world but from a monocontextual scientific practice (Gómez Vargas 2003: 4)

This monocontextual scientific practice, locates the interdisciplinarity in an ontological and epistemological level of speech, more than in a practice of knowledge production. In the best case, interdisciplinary dialogue has been given within large areas of knowledge, with serious problems to jump disciplinary fences. Disciplinary indifference, probably marked by the fierce concern of the positivist paradigm of clearly define the object of particular study in science; clouded our gaze to the Greek tradition had begun while observing the universe and human thought.

These "new" ontological and epistemological developments that move the floor of modern science are to turn in tributaries of a complex interdisciplinary approach.

Final assessments

Writing this article has not been simple and straightforward for two reasons. The first reason is that the ideas and concepts that are expressed here were born in the context of a larger study our research team is conducting, so the task of making a synthesis of them but looking not to lose the depth of the concepts has not been easy. The second reason in direct correspondence with the first, repositions us in the methodological discomfort of how to account through the language the part-whole relationship. How to account for the major contributions of the science of the whole, knowing that the whole as such is elusive? How to do it without falling into the Cartesian mistake of speaking about parts? By disciplines, and which ones? We can no longer distinguish them clearly! Why theoretical developments, again, which ones? By authors, which authors and why? There are many, many of them that will "stay out". Outside what? Is not the whole in the part?

The part perspective and the fear of error return us the suffering. David Bohm said that human suffering, embodied in the most pressing social problems, founds its reasons in the fragmented worldview. Our perception records "parts" where there are "sub-totalities". Thus we act without becoming aware that what affects "a part" affects the whole. We seek to contribute to the construction of a complex approach to the task of investigating, where it is no longer possible to do reality splits and multiple cuts, where we only need courage and co-reason for choosing to do science with a conscience, with responsibility and commitment to the immeasurable totality.

References

Bohm D. (2002) *Wholeness and the implicate order (Vol. 10).* Psychology Press.

Briggs J. & Peat F. D. (1989) *Turbulent mirror: An illustrated guide to chaos theory and the science of wholeness*. HarperCollins Publishers. New York.

Capra F. (1996) *The web of life: A new synthesis of mind and matter*. HarperCollins Publishers. New York.

Capra F. (2010) *The Tao of physics: An exploration of the parallels between modern physics and eastern mysticism.* Shambhala Publications. Boulder, Colorado.

Gibbons M., Limoges C., Nowotny H., Schwartzman S., Scott P. & Trow M. (1994) *The new production of knowledge: The dynamics of science and research in contemporary societies*. SAGE Publications. London.

Gómez Vargas H. (2003) Sujeto del mundo, sujeto del conocimiento. O de las perspectivas para construir conocimiento en un mundo social complejo. En *Revista Texto Abierto*. Nro. 3-4 Universidad Iberoamericana León, Departamento de Ciencias del Hombre, León, Guanajuato, México.

Jantsch E. (1980) *The self- Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*. Pergamon Press. Oxford.

Krell H. (2011) Ciencia Normal, ciencia revolucionaria. Retrieved from: http://www.ilvem.com/shop/detallenot.asp?notid=820 on 05 March 2012.

Kuhn T. (1962). 'The Structure of Scientific Revolutions'. The University of Chicago Press. Chicago.

Maturana H, Varela F. (1984) *El árbol de conocimiento. Las bases biológicas del entendimiento humano*. Lumen. Buenos Aires.

Morin E. (1995) *Introducción al pensamiento complejo*. Gedisa. Barcelona.

Morin E. (2001) *La cabeza bien puesta. Repensar la reforma. Reformar el pensamiento*. Nueva Visión. Buenos Aires.

Prigogine I & Stengers I. (1979) *La nouvelle alliance: métamorphose de la science*. Gallimard. Paris.

Prigogine I. (1991) *El nacimiento del tiempo*. Tusquets. Barcelona.

Prigogine I. (2002) *Nuevos Paradigmas, cultura y subjetividad*. Paidós. Buenos Aires.