

ILYA PRIGOGINE:
AN INTERVIEW WITH A HUMANIST,
NOBEL LAUREATE FOR SCIENCE

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PRESENTATION¹

... trying to give a new meaning or a more general meaning to the world of rationality. After all we have to find what I like to call a “narrow passage” (...) between this deterministic world and a completely undeterministic world, and perhaps one of the attempts which I have tried to make is essentially to formalize this world in between.

These are the closing words in the following interview, words that summarize the aim, a tremendously humane aim, of the so-called hard sciences for one of our fin-de-siècle most prominent scholars and scientists, Ilya Prigogine (Moscow 1917). Professor Prigogine proposes a view of reality that includes chaos, instability, uncertainty and non-equilibrium in a new scientific rationality appropriate to a present universe plagued with questions about itself, about science proper, about ethics, society and so forth. Science, he poses, can be neither deterministic nor reductive any more, because relations in both living and non-living systems are in constant evolution, not simply because they grow up but because they change and, in changing, new unpredicted variables appear. Arbitrarily small differences in the initial conditions are amplified with the result that new dynamic states of matter may originate, states that reflect the interaction of a given system with its surroundings. Cause-effect relations disappear. Contradicting Hawking’s statement that we are approaching the end of science, Prigogine says that we are in the beginnings of a coherent view of the universe.

Nobel Laureate for Chemistry in 1977, Emeritus Professor at Brussels *Université Libre*, Director of the Solvay International Institute for Chemistry and Physics and of the Center for Statistical Mechanics at the University of Austin, Texas. In this Laboratory, also known as Centre ‘Ilya Prigogine’ he coordinates 80 researchers working on the mathematical formulation of his findings on the irreversibility of time and on what he paradoxically calls ‘deterministic chaos’. Before being awarded the Nobel Prize for his findings in Thermodynamics he devoted himself to the study of material systems progressively far from thermodynamic equilibrium, giving way to physical explanations concerning the emergence of the structures in which living matter randomly organizes itself; he called them ‘Dissipative Structures’. Prigogine thus appears as the father of the Theory of Dissipative Structures, also known as Bifurcation Theory, that has been applied to several disciplines such as Sociology (Laszlo, 1989), Anthropology (Ballandier, 1989), Linguistics (Wildgen, 1994), Theory of Culture or Literary Theory (Hayles, 1990 & Hayles, ed. 1991) among others.

Moreover, his own reflections on culture, art and science have opened up a broad passage toward the unification of what were previously confronted and almost irreconcilable

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disciplines. Those 'two cultures' we have heard of since long -the humanistic and the scientific, the latter based on the idea that the human being, the 'subject', was incapable of knowing the objective science- conclude their separation with the introduction of possibilities and uncertainties in science. Prigogine speaks of *la nouvelle alliance*, the problem of the two cultures; and his own scientific discoveries do not keep natural science and human science separate any more. This common field helps, in his view, to a more complete integration of the human being.

In the Conference *From Energy to Information: Representation in Science, Art and Literature*, held at The University of Texas at Austin (April 3-5, 1997), Ilya Prigogine started his Keynote Address *Nature as Construction*, making well noticeable that during the last sixteen years he has been saying the same things and that he still will do that as long as they live as his best known way of seeing our reality and of constructing a future for other persons.¹

A few historical remarks were presented. The influence of classical science associated with Newton and extended through quantum mechanics and relativity were discussed. Classical science emphasized stability, permanence, and equilibrium. At the end of this century, Prigogine insists, we see fluctuations, instability, and evolution on all levels, from cosmology to biology and human sciences. The classical ideal of science was associated to a geometrical, atemporal vision. Now we perceive the importance of the narrative element in nature. Thanks to recent advances in theoretical physics and mathematics, this narrative element can now be incorporated into the basic laws of physics. These laws now express not certitudes but possibilities, as is appropriate for the evolving universe in which we are embedded.

Katherine Hayles, one of the American most important voices in science, literature and cultural theory in the 20th century and that appears in this interview was also present at the referred Conference presenting part of her oncoming book *How we became posthuman: virtual bodies in Cybernetics, Literature and Informatics*, a study of the impact of information technologies on contemporary literature and literary theory, set in the context of the evolving history of cybernetics.

As is clearly seen in the interview, Ilya Prigogine's scientific ideas also lead to a new approach to the social and humanistic sciences, an approach that is progressively finding a firm ground inside our own paradigm. No other scientist is probably cited more often in the fields farthest away from the hard sciences.

A *Doctor Honoris Causa* by 25 Universities the world over and a member of half a hundred Academies and Research Societies, Dr. Prigogine holds, among other distinctions and decorations, the Swante Arrhenius Gold Medal of the Royal Swedish Academy (1966); he is a Centennial Fellow of the American Chemistry Society (1976); he holds the Rumford Gold Medal of the Royal London Academy (1977); the Nobel Prize for Chemistry (1977). He was awarded the title of Knight of the Japanese Order of the Rising Sun with its Gold and Silver Medals (1990). He also holds a Viscounty granted by the King and Queen of Belgium on 1989, the *Grand Croix de l'Ordre de Léopold II* and is a Commander of the French *Légion d'Honneur*.

This previously unpublished conversation is a transcription of the original recording. It was done in Madrid in November 1992; in spite of its age, it keeps its interest as the recent

¹ The questions he posed were the same questions underlying this interview: Is the universe ruled by deterministic laws? Is the future given, or is nature a construction that is going on forever? Is time an "illusion," as stated by Einstein? ... These questions have been discussed since the dawn of Western rationality.

developments in the paradigm of Chaos in so many disciplines clearly demonstrate. I have only introduced a few minor changes and preferred to keep the colloquial and personal, humane, tones of the conversation.

GUERRA: Professor, you have repeated again and again the present possibilities of a very subtle alliance between what you call 'the two cultures' (natural sciences and human sciences). As you have mentioned, this alliance is possible now due to the new developments in the scientific trend usually referred to as 'Chaos Theory'.

Could you explain briefly why previous forms of science have broken this relationship, and then why it's precisely the sciences of chaos that allow it?

PRIGOGINE: Certainly. The classical view was that the world is ruled by laws of nature, the basic laws of nature. An example of a basic law of nature is Newton's Law. Newton's Law relates acceleration to force, and one of the main characteristics of Newton's Law is that it is deterministic: Once you know the initial conditions you can predict what will happen. And at the same time it is reversible; in other words, there is no difference between past and future (but this is no fundamental law). Therefore, the differences between past and future are not related to the fundamental laws, because the main characteristic of Newton's Law is again found back in Schrödinger and Einstein, but they are due to the phenomenology, they are due to the fact that when we speak about biology we speak about very complex things that we cannot reach through the fundamental laws.

Therefore the world is split in a sense in two descriptions: the fundamental and the phenomenological. The fundamental description does not contain time, the direction of time is not part of the fundamental laws; but the direction of time is part of the phenomenological. That is something which I find very difficult to understand because in this view we ourselves are part of the phenomenology. So in a sense we are part of the phenomenology and still we are the people who enunciate and discover the fundamental laws. It seems to me that it's a kind of contradiction.

As you know this subdivision has some philosophical background, and some, I would say, ideological or technical background. Ideological, as I've tried to explain in my books, is the idea that for God there would be no difference between past and future, and therefore that, for well-informed scientists, there wouldn't be any difference between past and future either. Therefore the elimination of time appeared as a kind of progress, yet there is also a technical aspect because Newton's and Schrödinger's findings have led to many verifications, experimental verifications: If I consider, for example, the pendulum or planetary motion I can verify Newton's Law; the past in essence is the pendulum or planetary motion, a good symbol of the Universe, and for a long time there was no way out of this question. That is why the discovery of Chaos has changed the situation. And I would not say the 'discovery of Chaos', I would even say that it happened earlier, with the discovery of Poincaré that not everything was in the differential equations, that there are integrable systems and non-integrable systems; integrable systems are indeed like the pendulum or planetary motion, but non-integrable systems can behave very differently, in spite of the fact that the differential equations are about the same. The discovery of Poincaré dates from 1889, but you need to wait till 1950 before it was assimilated. That is in short what the meaning of non-integrability was. Non-integrability may lead to stochasticity, to unpredictability, and that is really what you can call 'Chaos'. In other words, that even if you have the differential equation, the universe cannot be reduced to the Newtonian description: Once you have stochasticity you are very close to temporality. Therefore then,

you know the system has all possibilities of acquiring a direction of time. And therefore, time through instability appears now on the fundamental level.

That completely changes the relation between fundamental science and on the other hand human science. Human sciences, human culture, are narrative: they tell stories. To tell stories is not really scientific, and therefore the question is how to have a dialogue between, on the one hand, a fundamental science, which has truths, and, on the other, the human sciences, which are narrative, which tell you stories, which are anecdotic. And so, I think that is one of the reasons why if you have at once on one side the fundamental truths and on the other the anecdotic truths, descriptions which have more than anecdotal value help to establish a dialogue between such different things. Then now, as time is entering the fundamental description, uncertainty is entering the fundamental description, you come to a closer relation, you see that, after all, history is a set of unstable stories; everybody knows that Cleopatra would not be so pretty now, that now Napoleon would not have been ill at the battle of Waterloo. But now we find the same situation in science, we find bifurcations, small causes which lead to large effects; therefore, I would say, this is a basic structure of Nature, and that's what I meant.

GUERRA: In your particular opinion, what are the Sciences of Chaos? To what extent the things you do are included in this framework known as 'Sciences of Chaos'? I mean, Fractal Objects and Catastrophe Theory are usually also considered as part of them.

PRIGOGINE: Catastrophe Theory is a deterministic theory. It belongs to a completely different field in spite of the fact that there has been much confusion. Catastrophe theory, I would say, is much closer to the ideas of my friend David Bohm; it is very close to the idea of Bohm of 'encoding' and 'decoding', in other words, according to Bohm's view, Nature in essence has encoded some truths, some possibilities. What you have to do is to decode things. His example was often to take a machine and put something that you can turn on its axis, you put in let's say a liquid which is very viscous and then you add some ink, and then you turn it around and it becomes grey, then you turn it back and you see God. Therefore the problem is to decode things, which are in essence already there.

Catastrophe Theory is not a theory of genesis, is not a theory of becoming, it is a theory of non-linear systems, which have various regions of function; you can go from one region to another region but everything is already there. René Thom, whose mathematical work I admire, is a very conservative mind from my point of view, and I also think that the point of view of David Bohm was a conservative point of view. It is the idea that everything is already there; on the contrary, what I try to show is that the idea of dynamical chaos leads to a view of the laws of nature which is radically different. I would say that there are three types of laws, or formulations of laws of Nature. The classical laws, the classical formulations are in terms of individual trajectories. Then you have a single formulation, a statistical formulation, given by Einstein, but which was reducible to individual behaviour, and what Chaos shows you is that there is a statistical formulation which is irreducible to individual behaviour. In other words, the behaviour of the world cannot be reduced to the behaviour of individual particles or individual trajectories. It is, in a sense, as if you tried to write the history of mankind by speaking about individuals; it is impossible. You have to take into account the collectivity, because this description is richer, more complex but richer than the classical description.

And that is the kind of formulation of laws of Nature which I'm advocating; in other words, laws of Nature which do not give certitude but possibility, which show this evolution of the situation which at every moment gives various possibilities, but not certitude. In essence I could say, to give you an example, I could ask, is this glass or this quantity of water aged? The molecules individually speaking are not aged, the relations of the

molecules are aged: the molecules collide, create correlations, these correlations propagate. That is the meaning of time. Like our conversation: we are speaking now, we are discussing some fundamental questions that establish the relation between us; then you will perhaps write something, other people will read it, and the information of our discussion is diffused and everyone of us is the sender of some diffused words and is the receiver of other diffused words. Therefore it is a kind of collective history. It is not the history which can be reduced to single events, and that I think is the basic difference between what I try to do and the Catastrophe Theory.

Now, you said something about fractals; fractals have not much to do with me, fractals is simply a geometrical classification which emphasizes a kind of geometrical complexity, a particular prototype of geometrical representation. Sometime ago I was very impressed by some artifacts in Costa Rica; in Costa Rica, in Pre-Columbian times, they produced spheres, they didn't put any symbol in the sphere, they didn't draw anything, no figurative representation: just the perfection of the sphere, and they produced spheres two metres high. There were, I don't know, forty tombs, and it must have been an enormous effort to produce these perfect spheres. Why did they produce these perfect spheres? Because they found that the sphere is something cosmical, something which represents, perhaps, the perfection of the world. So, all through Neolithic time, Paleolithic time, you see the idea of spheres, the idea of spirals, the idea of triangles. And I think that what is interesting in fact is that we now see another type of cosmology; we see clouds which are nicer clouds, nicer volumes, we see lines which are nicer lines, nicer surfaces on any complex natural system. So I can see that fractals enrich our vision of the complexity of natural force, but fractals are not a dynamic but simply a static description.

GUERRA: To what do you attribute the fact that in your work you deal with literature and art while René Thom focusses more on linguistics?

PRIGOGINE: Well, I always hope, of course, that one day there will be a closer relation between linguistics and all these new types of mathematical developments, because after all linguistics is also a problem where there are structures, evolutions of structures. As you know, about the same time as Darwin, a German linguist had posed evolution laws for language, I don't remember his name now; he spoke about the evolution of language in about the same type of terminology, in other words, fluctuations, some fluctuations are amplified, and so on. Well, I have always been impressed by the fact that the twentieth-century starts these many creations in an independent way; one of the questions tackles what you see in music. Music tries to establish a new tonal system. Art with Cézanne, with Kandinsky, tries to renew the meaning of the basic structure of matter, and in science it is done by relativity and quantum mechanics. There is some parallelism and I would think it is this parallelism that gives what you can call a unity to our culture at the end of the century. Of course I'm not saying that there is a kind of causal relation, in my view the beginning of the century appears as a preparation for a big transition, and we are in this transition. It is of course very difficult to appreciate where it will go. Today we feel that we are living in a much more difficult world and we can certainly not be too optimistic as we were even a few years ago. But still I remain a little optimistic because I always like to remember that at the beginning of the century everything was under the sign of inequality, I mean, inequality between nations, between people who considered themselves civilized and that the others were non-civilized, inequality between social classes, inequality in the family and so on. Today, some progresses have been achieved and I would say that new types of communication have been established; horrible things still happen but perhaps not on the same scale that when they were happening during the first part of the century.

GUERRA: In your books, you discuss and comment on works of literature and art in general. These ideas were born from your own contact with reality as both a scientist and a

man who loves art - I've heard that you play the piano, have a good ear for poetry, etc., or having read specific philosophers and literary critics you discovered special relations with your scientific concepts?

PRIGOGINE: I would say that my interest in art, to some extent, is also a kind of justification of my own attitude. In a sense, my attitude emphasizing the role of time, the role of irreversibility, was always received in science with great hostility. I like to remember an anecdote: When I organized the first Conference, which I have organized ever since, in 1946, there were many famous thermodynamists and physicists, and they were already speaking about 'reversibility'; I remember the most famous thermodynamist of this time standing up at the end of my lecture and saying: "I'm really astonished why this young man is interested in irreversibility. Irreversibility is only transient, why be interested in irreversibility?" I was so astonished that I had not the presence of mind to say "my dear professor so and so, we are also transient, and therefore it's very natural that we are interested in our human condition."

But anyway, I would say, it is the idea of being interested in the concept of time in science that appears as anathema, because the tradition of the *Weltanschauung* was to choose between timeless science, which at that time was thought to lead to the fundamental, and the anti-scientific time-oriented metaphysics, and that is Heidegger, and that is Bergson, and so on. And my tentative to some extent was to go beyond this dichotomy and to find a science which accepts time as one of the main fundamental aspects; and in a sense, this is a very ambitious programme, and I have tried to achieve it in different steps: my work on dissipative structure was showing that time plays a very important constructive role, that you can push it behind no more and I wanted to go further and to show that time had to be put into the fundamental laws; in a sense, my justification was that it appears in art, in history and so on. You see, time is important, time is constitutive. This was not so trivial, because as you know there have been very great people disturbed, people that I admire. They were speaking about the malediction of time, of history, about the beauty of crystals, of time as entropy, as dissolution, of disorder. I had to convince myself that the direction which I was taking was meaningful.

GUERRA: What's your opinion of the books that apply your theory to art, literature and culture, such as those by Katherine Hayles in the U.S.A. or the semiotic works by Omar Calabresse in Italy?

PRIGOGINE: Well, I think everybody has to take his or her own responsibility. There are some remarks of Katherine Hayles that I find very interesting, but others show up the difficulties of understanding. Katherine Hayles considered my work, my books, my book *La nouvelle alliance* or *Order Out of Chaos*, still a programme, and there is something true about it. To some extent this was true, because my point in these books was: I had discovered the dissipative structures and I had a very strong point, that is, that irreversibility has to play a fundamental role. At that time, I was already showing the direction we should go in, but I did not yet have the mathematics for this, because the mathematics for this is a very new mathematics, one which involves a change in structure or functional spaces, the transition from Euclidean space to non-Euclidean space and so on. Therefore I cannot criticize her completely when she said that it was still a programme, but I'm very happy to say that this programme has now been completed.

GUERRA: Music seems to be the art that reveals more possibilities of reflecting these chaotic assumptions. If this is true, could you tell me why and to what extent?

PRIGOGINE: I have no copy here but there is an interview with me published in *New Perspectives* (a Californian review). But, I would say, I shall not try to give a theory or to indicate in which direction music should go. I believe music is a very complex problem

involving both intellectual representation and physiology. In my opinion attempts like Cage's or attempts like Boulez's perhaps go too far in intellectual representation; but on the other hand I'm not at all advocating a kind of return to nineteenth-century romanticism. I think the main point about music is that Chaos is, from this point of view, a part of the study of time series, and the structure of time series is really a new subject, and I think this will have an influence on the time series of music in the long term.

GUERRA: In the new scientific epistemology, where do science and philosophy end and where does mysticism begin?

PRIGOGINE: I don't know exactly what the meaning of your question is. For me science is a dialogue with Nature, it is essentially one of the forms of the dialogue which goes on since Paleolithic times, I mean, certainly since Neolithic times, --observatories, Stonehenge, the discovery of agriculture, the discovery of the observation of animals, and so on--. Men, for some reasons I cannot comment briefly, have always been involved in the exploration of their environment and in the question related to their position in relation to the environment. This dialogue with Nature is, in some sense, a dialogue which transcends because Nature is not men, it is outside men to some extent; to some extent man is the result of Nature, originated from Nature. To some extent, this dialogue which is transcendent has taken various forms: it has taken the form of music, the form of religion, it is at the basis of a lot of paintings ... Therefore, I don't know what you call mysticism. I mean, perhaps science is a way of asking about mysterious natural phenomena in the 20th century using a kind of specific vocabulary.

I would say that what is specific to science is that these questions have to be asked using the mathematical tradition, the tradition of Newton, the tradition of Einstein, which we cannot ignore. This is, I would say, why I cannot agree with attempts, like the attempt of Whitehead or others who want to reconsider the whole, the whole part, I mean, the whole situation, who want to annihilate all the parts to reconstruct everything. I think that it is too difficult. You see, to give you the perspective in which I've tried to work is in a sense ... I'll tell you an anecdote. Heisenberg used to say, to ask, what is the difference between an abstract painter and a scientist, and his answer was that the abstract painter tries to be as original as possible, while a good theoretical physicist tries to be as little original as possible. In some sense, I've always tried to be as little original as possible, because, when you ask questions about, for instance, the paradox of time, or the paradox of quantum mechanics, think about the solutions which have been proposed.

Many are the theories, for instance, of brain interaction, the whole of consciousness and so on. They are all non-dynamic theories, but I've tried to answer these questions in the tradition of dynamics. I've always said that concepts like time, like irreversibility, like evolution, will find their expression in the basic laws of physics, not by destroying them, but by amplifying them, by making them more complete. And that is the direction in which I work. Therefore I think I have followed the European tradition a little, the Western tradition of rationality, but trying to give a new meaning or a more general meaning to the world of rationality.

After all we have to find what I like to call "a narrow passage". A world of determinism is an alienating world. What is our place in a world of automata? Here we cannot conceive that the meeting we have had today has been pre-determined as a big bang, that is very difficult to imagine. A world of accidents, a world in which we would play dice is also not a world in which we can live. My aim has been to find a narrow passage between this deterministic world and a completely undeterministic world, and perhaps one of the attempts which I've tried to make is essentially to formalize this world in between, not the world of determinism and not the world of the future.

GUERRA: Thank you very much Professor Prigogine.

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