Ilya Prigogine -- towards a unity of science and culture

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Three years after receiving the Nobel Prize in chemistry, Ilya Prigogine spends part of his time helping to put into practice what he tried to show through his theoretical work -- the unity of science and culture.

"I am very much against the priesthood of science, against isolating scientist, putting them in ivory towers. Why shouldn't science be a part of the cultural process, when today the future of the world depends very much on sience , technology, and new inventions?" Dr. Prigogine asks.

Prigogine, who splits his time between the University of Texas at Austin and the Free University of Brussels, has been asked to prepare a report for the European Community on possible new incentives for European research. He will propose a "Perception Center," out of which a "kind of national science center for Europe could be formed for improving the integration of science into European society."

Science is more "fragmented and withdrawn" in Europe than in the United States, Prigogine says. He envisions the center as a place where issues "on the borderline" between science and society could be discussed, and which could also instigate research in areas where European society feels it is needed. "You have something like this in the United States in the National Academy of Sciences," he says, "but I would like to see people outside of science represented, to make the interaction between scientists and other people as free as possible. I think if such a center had existed the discussions on nuclear energy would not have taken the form they have."

Like European unity, Prigogine says, this plan is an ambitious but not impossible idea. "The European Community budget now is largely devoted to agriculture. It seems not impossible to diversity into scientific research and development." He had been in contact with most of the governments of the nine Community members and says, "I consider it [the plan] like the product of two quantities -- the chances of realizing it are very small and the object is very large, so the product is finite."

Prigogine's views are the "flip" side of the cliche that science has become too important to be left to the scientists. Once asked why he and other scientists were becoming more interested in social problems, Prigogine responded , "because they are too important to be left to social scientists."

But it has been his refusal to accept reality as a divided world, whether it be the "two cultures" of C.P. Snow or contradictory laws governing physical and biological systems, that underlies Prigogine's theoritical intuition and philosophical viewpoint.

Today Prigogine assesses the significance of his work in thermodynamics first in terms of its contributions to changing how scientists think. "The importance of far-from-equilibrium conditions has now permeated our thinking. The number of papers dealing with the way in which new structures may originate is enormous ," he says. He also sees his work as a contribution to a new way of perceiving the world around us, in which instability, nonlinearity, and fluctuations are the key words, rather than stability, predictability, and universality.

"Take, for example, the problem of climate," Prigogine says."The classical idea was that we have to live in a climate that was made by God, by some initial [set] conditions. Now we know that change can occur, not because the sun doesn't send us a constant amount of energy, but as the result of some nonlinear interaction between the energy that comes from the outside world and the surface of the earth. The climate is not stable or eternal; many conditions are possible. So now we believe in neither a promise of paradise nor that we are doomed to decline and destruction in a world that is running down. We see that more depends on us, on how we handle these problems."

In classical physics, Prigogine explains, time was a parameter with no past and no future, yet all physical and psychological life is one-directional. "We don't play the piano the same tomorrow as we did today." Because of this conflict, he believes, "science was an unstable insertion into society" that pushed philosophers to develop a "second way of thinking" in opposition to scientific knowledge, and this conflict came to dominate Western thought.

"Now this dilemma is no more so much with us, and we can at least consider a noncontradictory unity of knowledge. We must go beyond the temptation to define the eternal as truth and the temporal as illusion."

Prigogine has described his own and other work that has contributed to this "metamorphosis of science" in his new book, written with Isabelle Stengers and published in France by Gallimard. It is entitled "La Nouvelle Alliance" ("The New Alliance") and is scheduled for publication in English this year.

Prigogine's work in nonequilibrium thermodynamics and his description of the conditions under which so-called dissipative structures may be created, for which he received the Nobel Prize, forms the background for his sweeping observations.

Dissipative structures are "giant fluctuations stabilized by exchanges of matter and energy," he explains. The creation of such structures depends both on the system's distance from equilibrium and the presence of nonlinear relationships (e.g., feedback) within the system. The distance from equilibrium is determined by the amount and rate of exchanges with the environment; with a great deal of exchange, a system is far from equilibrium, and with very little, it is at or near equilibrium.

Fluctuations (variations from average behavior) are always present, but will not grow if nonlinearities do not exist in the system. In addition, Prigogine says, "Only fluctuations exceeding a critical size escape being damped by interaction with the rest of the system and can resist the system's power of integration." When diffusion is very rapid the system becomes homogenized before the fluctuation can grow large enough to destabilize it. In earlier work Prigogine had shown that spontaneous fluctuations in systems near equilibrium regress in time and disappear, just as they do at equilibrium.

This theoretical work describes how new order or structure in physical systems can develop out of apparent disorder, and it forms a bridge between laws governing physical systems, which were thought to progress toward disorder, and biological systems that develop new forms and greater complexity.

Freeing ourselves of the constraints of Newtonian science does not mean that Newton was wrong, Prigogine stresses, only that the views of classical physics are idealizations that are not always applicable. "The traditional driving force of physics was the belief in the simplicity of the microscopic, and that belief is difficult to maintain today.

"I think what is important to underline is that at equilibrium or near equilibrium, the laws of physics are universal, and being universal you would expect a great uniformity in nature. Phenomena should always behave in the same way." But if that were so, he asks, "why do we live in such a rich universe, with a large number of unique beings and singular behaviors? The classical universe would be like a desert, a kind of lunar landscape, but that is not our landscape."

Far from equilibrium conditions modify this picture, Dr. Prigogine says. "We know that, far from equilibrium, the laws no longer are universal. They depend on specific types of bifurcations [branchings] that lead to various behaviors. Therefore you have a kind of paradox -- that the same mechanisms near equilibrium are mechanisms of doom or destruction, while further from equilibrium they may become processes of construction and coherence. All this coexists, which makes for events that produce the richness of the physical world around us.

"What we once thought -- that if we knew the initial conditions then we can predict -- is an idealization. Now we see a multiplicity of possible solutions, and nobody can predict.

"We no longer have to set science and ethics, or science and responsibility, into opposition. There is the same undetermination in scientific matters as in others. We no longer have the excuse to live on two levels, to say we believe in freedom and at the same time that we believe in perfect causal determination."

Prigogine is continuing his work on behavior of far-from-equilibrium systems, focusing now on bifurcations. "We are asking how such decisions start and are affected. How can we express this quantitatively? Does memory enter into matter, not just living systems? We want to understand better the selection mechanisms that result in structure or order."

For example, "Everybody know that gravitation affects the pressure distribution in a gas. But gravitation is a small effect and we have to go up a few hundred feet before the pressure changes appreciably. Still, when we take a plant and turn it around it returns to its initial shape. What is the physical basis for such an extraordinary sensitivity? This would be a clue to a basic property of matter -- adaptability.

"This is still largely an unexplored field, but some theoretical possibilities exist already that are very interesting, because it makes the gap between life and nonlife smaller, while preserving the originality of each."

In an editorial in Science, Lewis Thomas, dean of medicine at Yale, described science as "the most powerful and productive thing human beings have learned to do together for centuries -- more effective than farming, or hunting and fishing , or building cathedrals, or making money." Prigogine's efforts are directed toward infusing the thinking of members of this most "social, communal, and interdependent activity" into society as a whole.