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THE "NEW SCIENCE" AND THE HISTORICAL SOCIAL SCIENCES

A Discourse on the Sciences

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The close of the twentieth century is but ten years ahead. We live in an astonishing time. If we look at our feet, we discover shadows from both the past and the future. Shadows of a past we sometimes believe are no longer part of us and sometimes feel we have never left behind. Shadows of a future we sometimes believe we are already in and sometimes feel we shall never enter.

When we look back into the past in an attempt to analyze the present state of the sciences, the first image that comes to mind is that of scientific progress. For the past 30 years the development of science has been so dramatic that all the preceding centuries—from the sixteenth century that gave birth to us all as scientists, to the nineteenth—strike us as ancient history. But a mere blink of an eye will make us realize with wonder that all the great scientists that established and charted our theoretical fields lived and worked between the eighteenth century and the first two decades of the twentieth: Adam Smith, Ricardo, Lavoisier, Humboldt, Darwin, Marx, Durkheim, Max Weber, Pareto, Planck, Poincaré, Einstein. Indeed, we might even say that in scientific terms we are still living in the nineteenth century and that the twentieth has not yet begun, nor will it perhaps begin before it ends. And were we to look ahead into the future, we would likewise be presented with two contradictory images. On the one hand, the potential technological applications inherent in our accumulated knowledge lead us to believe that

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we are on the brink of a society of communication and interaction, free from the needs and insecurities that are still so much part of the lives of many of us. It is as if the twenty-first century is already beginning before it has begun. On the other hand, our concern with the limits of scientific rigor and our awareness of such increasing dangers as ecological disaster or nuclear war make us fear that the twenty-first century might end before it ever begins.

If we think of the synergy theory of Herman Haken, we may say that ours is a most unstable visual system, the least fluctuation of our visual perception causing ruptures in the symmetries of what we see. Looking at one and the same figure, we see first a white Grecian urn upon a black background, then two black Grecian profiles facing each other upon a white background. Which one is the true image? Both and neither. Such is the ambiguity and complexity of our time, a time of transition—at one with so much before and after it, but at odds with itself.

As in other transition periods, which we understand and traverse with difficulty, we must go back to simple things and ask simple questions. Einstein used to say that there are questions that only children can ask, but that, once asked, shed a new light on our perplexities. Today, I have brought along a child who over two centuries ago asked a few simple questions about the sciences and the scientists. He asked them at the beginning of a cycle of scientific production which many of us believe has now come to its close. The child's name is Jean-jacques Rousseau. In his famous *Second Discourse* (1750), Rousseau raised many questions as he replied to the question posed by the Academy of Dijon (1964: 52ff.), itself rather childlike: does the progress of the sciences and the arts contribute to the purity or to the corruption of manners? This is an elementary question, at once profound and easy to understand. In order to answer it—eloquently enough to win first prize and not a few enemies—Rousseau in turn asked the following equally elementary questions: Is there a relationship between science and virtue? Is there any serious reason to replace the common sense knowledge we have of nature and of life, and which we share with the other men and women of our society, with the scientific knowledge produced by a few and unavailable to the majority of the people? Does science contribute to bridging the widening gap in our society between what one is and what one seems to be, between knowing

how to say and knowing how to do, between theory and practice? To these simple questions Rousseau gives an equally simple reply: a resounding no.

It was then the middle of the eighteenth century. Modern science, which had emerged in the sixteenth century out of the scientific revolutions of Copernicus, Galileo, and Newton, was abandoning the esoteric speculations of its founders to become the ferment of an unprecedented social and technological transformation. It was an amazing period of transition, moreover, that perplexed the more alert minds and made them reflect on the very foundations of their society and on the impact wrought upon it by the transformations of the emerging scientific order. Today, 200 years later, all of us are the products of that new order, the protagonists and living witnesses of the changes it brought about. However, in the 1990's things are no longer what they were twenty years ago. For reasons I shall try to sort out, we are once again perplexed, we have once more lost our epistemological confidence. We are overwhelmed by a sense of irremediable loss, all the stranger for our uncertainty about what it is that we are losing. We may even wonder at times if this sense of loss is perhaps just a fear that obscures the latest gains made in our individual and collective lives. And then again, there is always the confusion about what exactly it is that we have gained.

Hence the ambiguity and the complexity of our present time. Hence, also, the idea snared by many, that we live in a period of transition. Hence, finally, the urgent need to give answers to simple, elementary, intelligible questions. An elementary question is a question that reaches, with the clarity of expert techniques, the deepest magma of our individual and collective perplexity. Such were the questions asked by Rousseau; such must ours be. As a matter of fact, two hundred years later, our questions are still the same as Rousseau's: we are once again faced with the need to ask about the relationship between science and virtue.

Indeed, we must once again ask about the value of so-called common sense knowledge, the knowledge that we, as individual or collective subjects, create and use to give meaning to our practices, but which science insists on considering irrelevant, illusory, and false. And, finally, we must ask about the contribution of all this accumulated scientific knowledge to enriching or impoverishing our lives. In other words, we must ask if science has contributed positively or negatively to our happiness. Our difference from Rousseau is that, though our questions are equally simple, our answers will be far less so. A cycle of the hegemony of a certain scientific order has come to an end. The epistemic conditions of our questions are inscribed in the converse of the concepts we use to give them answers. We have to try to remove blinkers, walking a tightrope between being lucid and being unintelligible in our assertions. At the same time, the social and psychological bases of our queries have become different and far more complex. It is one thing to ask whether an automobile can be useful to me and bring me happiness if the question is posed when no one among my neighbors has an automobile, and another when everyone except me has one, or when I alone have one that is more than twenty years old.

Obviously, we have to be far more Rousseauian in our queries than in our responses. Let me begin by briefly characterizing the hegemonic scientific order. I shall then analyze the signs that this hegemony is in crisis, distinguishing between its theoretical and sociological conditions. Finally, I shall speculate on the profile of the new emergent scientific order, again distinguishing between the theoretical and the sociological conditions of its emergence.

My analysis will be based on the following working hypotheses: 1) the distinction between natural and social sciences is beginning to seem meaningless; 2) the social sciences will be the catalyst of the necessary synthesis between them; 3) to achieve this synthesis the social sciences must reject all forms of empirical or logical positivism or of mechanistic idealism or materialism, thus bringing back to the center of knowledge what is conventionally called the humanities; 4) the synthesis I have in mind does not aim at a unified science or even at a general theory, but merely at a set of theoretical aqueducts into which can converge various currents which have hitherto been considered theoretically separate; 5) to the degree that such a synthesis is achieved, the hierarchical distinction between scientific and common sense knowledge will gradually disappear, and praxis will become engaging in the philosophy of praxis.

THE DOMINANT PARADIGM

The prevailing model of rationality of modern science came out of

the scientific revolution of the sixteenth century and was developed primarily in the domain of the natural sciences during the following centuries. Although there were a few preliminary attempts in the eighteenth century, the model would be adopted by the emerging social sciences only in the nineteenth century. From then on, we may speak of a single global model of scientific rationality, with some internal variation to be sure, but one which distinguished itself from and defended itself quite conspicuously and consistently against two non-scientific (and therefore irrational) forms of knowledge that were potentially disturbing: common sense, and the so-called humanities (the latter including, among other things, history, philology, law, literature, philosophy, and theology).

The new scientific rationality, being a global model, was also a totalitarian model, inasmuch as it denied rationality to all forms of knowledge that did not abide by its own epistemological principles and its own methodological rules. This was the main feature of the new paradigm, the feature that best symbolized its break with the preceding scientific paradigms. It was gradually consolidated in Copernicus's heliocentric theory of the movement of the planets, Kepler's laws on the planetary orbits, Galileo's laws on the gravity of bodies, and Newton's great cosmic synthesis, and most of all in the philosophical consciousness conferred upon these findings by Bacon and especially by Descartes. This preoccupation with being the instruments of a fundamental break that allowed for only one form of true knowledge is evident in the protagonists' attitudes. They marvel at their own findings while simultaneously displaying a serene, haughty arrogance vis-a-vis their contemporaries.

In his book on *World Harmony,* published in 1619, Kepler writes, regarding the natural harmonies he had discovered in the celestial motions: "Forgive me, but I am happy; if you are angry, I shall persevere. ... My book may have to wait a long time for its readers. But then, even God had to wait for 6000 years to have his work beheld" (Kepler, 1939: 280). On the other hand, in that marvelous spiritual autobiography, *The Discourse on Method* (to which I shall come back later), Descartes writes, concerning his new method:

> Now I always try to lean towards diffidence rather than presumptions in the judgments I make about myself; and when I cast a philosophical eye upon the various activities and

> undertakings of mankind, there are almost none which I do not consider vain and useless. Nevertheless, I have already reaped such fruit from this method that I cannot but feel extremely satisfied with the progress I think I have already made in the search for truth, and I cannot but entertain such hopes for the future as to venture the opinion that if any purely human occupation has solid worth and importance, it is the one I have chosen. (Descartes, 1988: 21)

To understand this epistemological confidence we have to describe, at least briefly, the main features of the new scientific paradigm. Realizing that what separates them from the still dominant Aristotelian and medieval knowledge was not so much better observation of the facts but rather a new outlook on the world and on life, the protagonists of the new paradigm engaged in a passionate struggle against all forms of dogmatism and authority. The case of Galileo is particularly exemplary, as is Descartes' assertion of intellectual independence: "I was ... unable to choose anyone whose opinions struck me as preferable to those of all others and I found myself as it were forced to become my own guide" (Descartes, 1988: 28). This new way of looking at the world and at life led to two basic distinctions: between scientific knowledge and common sense on the one hand, and between nature and human beings on the other.

Unlike Aristotelian science, modern science systematically distrusted the evidence of our immediate experience. Such evidence which is at the root of common sense knowledge was alleged to be illusory. As Einstein emphasized in his preface to the *Dialogue Concerning the Two Chief World Systems,* Galileo boldly sought to argue that his hypothesis about the rotation of the earth both around the sun and on its axis were not refuted by our inability to observe the mechanical effects of those movements, that is to say, by the fact that the earth seems to be motionless (1970: xvii). On the other hand, in modern science the separation between nature and human beings is total. Nature is mere extension and movement. It is passive, eternal, and reversible. It is a mechanism whose elements can be disassembled and then put back together again in the form of laws. It possesses no quality or dignity which impedes us from unveiling its mysteries. Furthermore, such unveiling is not contem-

plative, but quite active, since it aims at knowing nature in order to dominate and control it. In Bacon's words, science will make of humanity "the master and the owner of nature" (Bacon, 1933).[1]

On the basis of these assumptions, scientific knowledge advances by observing natural phenomena in a free, disinterested, and systematic way, and with as much rigor as possible. Bacon's *Novum Organum* contrasts the uncertainty of unassisted reason to the certainty of ordered experiments (Koyré, 1981: 30). Contrary to what Bacon thought, experiments do not obviate the need for previous theorizing, deductive thinking, or even speculation, but require them not to omit empirical observation as part of the final demonstration. Galileo refuted Aristotle's deductions only to the degree that he found them untenable. And it was Einstein who called our attention to the fact that Galileo's experimental methods were so inadequate that, only by means of daring speculation, could he fill in the gaps in his empirical data (we need only remember that time could not be measured in that era in units smaller than seconds) (Einstein, 1970: xix). As for Descartes, he proceeded unmistakably from ideas to things and not the other way around, and gave priority to metaphysics as the ultimate basis of science.

The ideas that governed observation and experimentation were those simple, clear ideas from which it was thought possible to arrive at a more profound and accurate knowledge of nature—that is to say: mathematical ideas. Mathematics provided modern science not only with its preferred analytical tool, but also with a logic of investigation, as well as a model of representing the structure of matter itself. According to Galileo, the book of nature is inscribed in geometric characters;[2] and Einstein did not think otherwise.[3]

[1] According to Bacon, "the ways that lead man to power and to science are very close, indeed they are almost the same" (1960: 110). Bacon also says that, if the aim of science is to dominate nature, it is equally true that "[n]ature to be commanded must be *obeyed"* (1960: 39; my italics). The latter assertion has, however, not always been stressed as it ought to have been in interpretations of Bacon's theories of science.

[2] Among many other passages of the *Dialogue Concerning the Two Chief World Systems,* see the following speech by Salviati: "Taking man's understanding intensively, in so far as this term denotes understanding some propositions perfectly, I say that die human intellect does understand some of them perfectly, and thus in this it has as much absolute certainty as Nature itself has. Of such are the mathematical sciences alone; that is, geometry and arithmetic, in which the Divine intellect indeed knows infinitely more propositions, since it knows all. But with regard to those few which the

There are two main consequences that derive from the centrality of mathematics in modern science. First, to know means to quantify. Scientific rigor is gauged by the rigor of measurements. The intrinsic qualities of the object, so to speak, do not count, and are replaced by the quantities into which they can be translated. Whatever is not quantifiable is scientifically irrelevant. Secondly, the scientific method is based on the reduction of complexity. The world is complex and the human mind cannot grasp it entirely. To know means to break down and to classify in order to establish systematic relations among these parts. Already in Descartes, one of the rules of the *Method* was precisely to "divide each of the difficulties... into as many parts as possible and as may be required in order to resolve them better" (Descartes, 1988: 29). The primordial distinction is between the "initial conditions" and the "laws of nature." The initial conditions are the realm of complexity and contingency, where it is necessary to select those conditions that are relevant for the facts being observed. The laws of nature are the realm of simplicity and regularity, where it is possible to observe and measure with accuracy. This distinction between initial conditions and the laws of nature was, of course, far from "natural." It was, indeed, totally arbitrary, as Eugene Wigner has noted (1970: 3). Nonetheless, it was the very basis of modern science.

The theoretical nature of scientific knowledge derives from the epistemological presuppositions and from the methodological rules already mentioned. It is a causal knowledge which aims at formulating laws in the light of observed regularities and with a view to foreseeing the future behavior of phenomena. The discovery of the laws of nature, then, rests on the assumption, on the one hand, that the relevant initial conditions can be identified (for example, in the case of falling bodies, the initial position and its velocity), and on the other hand, that the outcome will be independent of the place

human intellect does understand, I believe that its knowledge equals the Divine in objective certainty, for here it succeeds in understanding necessity, beyond which there can be no greater sureness" (Galileo, 1970: 103).

[3] Einstein's admiration for Galileo is well expressed in the "Preface" referred to above (Einstein, 1970). His (instinctively) radical way of "seeing" the mathematical nature of the structure of matter partly explains his long struggle over the interpretation of quantum mechanics (especially against the Copenhagen interpretation). On this point, see Hoffmann (1973: 173ff.).

and time of the initial conditions. In other words, the discovery of the laws of nature is based on the principle that absolute position and absolute time are never relevant initial conditions. This is, according to Wigner (1970: 226), the most important theorem of invariance in classical physics.

The laws, insofar as they are categories of intelligibility, depend on a concept of causality, chosen (but not arbitrarily) among those of Aristotelian physics. Aristotle distinguished four kinds of causes: the material cause, the formal cause, the efficient cause, and the final cause. The laws of modern science are a kind of formal cause that gives priority to *how-it-works* as against *who-is-the-agent* or *what-is-the-purpose* of things. Thus, scientific knowledge breaks with common sense knowledge. Indeed, whereas in common sense (and hence in the practical knowledge it produces) cause and intention coexist comfortably, scientific determination and the formal cause entails ignoring intention. It is this type of formal cause that makes possible the prediction of reality, hence interference with it, and which ultimately allows modern science to answer the question about the foundation of its claims to accuracy and truth by pointing to its successes in manipulating and transforming reality.

Knowledge that is based on the formulation of laws has as its metatheoretical presupposition the idea of order and stability in the world, the idea that the past repeats itself in the future. In Newtonian mechanics, the world of matter is a machine whose operations can be precisely determined by means of physical and mathematical laws—an eternal and static world hovering in an empty space, a world which Cartesian rationalism makes knowable by dividing it into its constituent parts. This idea of a machine-like world was so strong that it became the great universal hypothesis of the modern era. It may be surprising, even paradoxical, that such a way of knowing could become one of the pillars of the idea of progress that has pervaded European thought since the eighteenth century and that was the intellectual sign of the rise of the bourgeoisie.[4] The truth is, however, that order and stability in the world are the precondition for the technological transformation of reality.

Mechanistic determinism provides a clear horizon for a form of

[4] See, among many others, Pollard (1971: 39).18

knowledge that was meant to be utilitarian and functional, acknowledged less for its capacity to understand reality at the deepest level than for its capacity to control and transform it. At the social level, this was also the cognitive horizon most consonant with the interests of the rising bourgeoisie, who considered the society they were beginning to control as the final stage in the evolution of mankind (Comte's positive state, Spencer's industrial society, Durkheim's organic solidarity). Hence, Newton's prestige and the simple laws to which he reduced all the complexities of the cosmic order readily turned modern science into the hegemonic model of rationality that then spilled over from the study of nature into the study of society. As it had been possible to discover the laws of nature, so would it be possible to discover the laws of society.

Bacon, Vico, and Montesquieu were the great precursors. Bacon affirmed the plasticity of human nature, hence its perfectibility-given appropriate political, legal, and social conditions, which can be accurately known. Vico suggested that there are laws that govern the evolution of societies deterministically and that allow for the prediction of the outcome of collective actions. With remarkable premonition, Vico (1968) identified and solved the contradiction between the freedom and unpredictability of individual human action and the determinism and predictability of collective action. Montesquieu (1989) may be considered a precursor of the sociology of law, when he established a relationship between the man-made laws of the legal system and the inescapable laws of nature.

In the eighteenth century these preliminary efforts were expanded and deepened into that intellectual ferment—the Enlightenment—which would create the conditions for the emergence of the social sciences in the nineteenth century. The philosophic understanding of modern science, first formulated in Cartesian rationalism and Baconian empiricism, evolved into nineteenth-century positivism. Since, for positivism, there are only two forms of scientific knowledge—the formal disciplines of logic and mathematics and the empirical sciences following the mechanistic model of the natural sciences—the social sciences could not but be empirical. The way in which the mechanistic model was followed varied, however. It is common to distinguish two main tendencies. The dominant one consisted in applying to the study of society, to the degree possible, all the epistemological and methodological principles that

had dominated the study of nature since the sixteenth century. The other one, long a marginal tendency but with an increasing number of followers, consisted in claiming for the social sciences its own distinct epistemological and methodological status, based upon the specificity of the human being radically different from nature. These two conceptions have usually been taken to be antagonistic, the former being subject to the positivist yoke, the latter free from it, both claiming the monopoly of social-scientific knowledge. I shall offer a different interpretation, once I have briefly characterized them.

The first conception—whose epistemological commitment is clearly symbolized in the name of "social physics" which the scientific study of society was initially called—takes for granted that the natural sciences are the concrete application of a model of knowledge that is universally valid, and indeed the only valid one. Therefore, no matter how large the differences between natural and social phenomena, it is always possible to study the latter as if they were the former. Admittedly, such differences work against social phenomena, or rather, they make the methodological canon harder to accomplish and the knowledge arrived at less accurate. But there are no qualitative differences between scientific procedure in the social sciences and in the natural sciences. In order to study social phenomena as if they were natural phenomena, that is, in order to conceive of social facts as things (as envisioned by Durkheim (1982), the founder of academic sociology), it is necessary to reduce social facts to their external, observable, measurable dimensions. The causes of the rise in the rate of suicide in Europe at the turn of the century are not to be looked for in the motives invoked by those committing suicide in their letters, as had been the custom, but rather by checking the regularities in such conditions as the sex and marital status of those committing suicide, whether or not they had children, their religion, and so on (Durkheim, 1951).

Because such reductionism is not always easy and not always possible without grossly distorting the facts or even reducing them to near irrelevance, the social sciences have a long way to go before they can be made compatible with the criteria of scientificity of the natural sciences. The obstacles are enormous but not insurmountable. *The Structure of Science* by Ernest Nagel is a good example of the efforts made in this field to identify the obstacles and the ways of overcoming them. Some of the principal obstacles he identified are the following: There are no explanatory theories in the social sciences that would allow them to abstract from reality in such a way as to be able to search for adequate proof in that reality in a methodologically controlled way. The social sciences cannot establish universal laws because social phenomena are historically conditioned and culturally determined. The social sciences cannot make reliable predictions because human beings change their behavior according to how much is known about it. Social phenomena are naturally subjective and as such they cannot be understood as objective behavior. The social sciences are not objective because the social scientist cannot free his observations from the values that underlie his general practice, and hence also his practice as a scientist (Nagel, 1961: 447ff).

For each of these obstacles, Nagel tried to demonstrate that the opposition between the social and the natural sciences is not so linear as commonly thought and that, whatever differences there may be, they are either surmountable or negligible. He recognized, however, that overcoming obstacles is not always easy, and that this accounts for the backwardness of the social sciences vis-a-vis the natural sciences. The idea of the backwardness of the social sciences is central to this kind of methodological reasoning, as is the idea that, with time and money, this backwardness may be reduced or even eliminated.

In Thomas Kuhn's theory of scientific revolutions the backwardness of the social sciences was explained by their pre-paradigmatic nature, as opposed to the paradigmatic nature of the natural sciences. The development of knowledge in the natural sciences has allowed for the formulation of a set of principles and theories about the structure of matter which are unquestionably accepted by the entire scientific community. This acceptance is what we mean by a paradigm. But in the social sciences there is no paradigmatic consensus, which is why the debate tends to involve every kind of acquired knowledge. The strain and the waste this involves are both cause and effect of the backwardness of the social sciences.

The second conception claims an independent methodological status for the social sciences. According to this view, the obstacles identified above are insurmountable. Some reject the very notion of a science of society; others argue that it is a different kind of science.

The main argument is that human action is radically subjective. Unlike natural phenomena, human behavior cannot be described, let alone explained, on the basis of its external, objectifiable characteristics, since the same external act may have multiple interpretations. The social sciences will always be a subjective science, not an objective science like the natural sciences. The social sciences must understand social phenomena in terms of the attitudes and the meanings that the agents ascribe to their actions. That requires research methods and epistemological criteria different from those used in the natural sciences, qualitative rather than quantitative methods, in order to arrive at intersubjective, descriptive, empathetic knowledge, as opposed to objective, explanatory, nomothetic knowledge.

The latter conception of the social sciences acknowledges being anti-positivist. Its philosophical tradition is phenomenology in its many varieties, from a more moderate version, as in Max Weber (1968), to a more radical one, as in Peter Winch (1970). However, close inspection reveals that this view, as it has been elaborated, is more dependent on the model of rationality of the natural sciences than it at first seems. It shares the nature/human beings dichotomy, which amounts to a mechanistic view of nature, to which it contrasts, as one might expect, the specificity of human beings. This distinction, which was crucial for the scientific revolution of the sixteenth century, led in turn to others, such as those between nature and culture and between humans and animals, culminating in the eighteenth century in the celebration of the unique character of humanity. The line thus delineated between the study of humanity and the study of nature remained a prisoner of the cognitive priority assigned to the natural sciences, since although, on the one hand, a biological determinism of human behavior was denied, on the other hand, biological arguments were used to establish the specificity of the human being.

The inescapable conclusion then is that both these conceptions of science belong to the paradigm of modern science, even if the second conception points to a crisis in the paradigm and already contains some elements of transition towards a new scientific paradigm.

THE CRISIS IN THE DOMINANT PARADIGM

There are many clear signs today that the model of scientific rationality I have outlined above is going through a profound crisis. In this section I shall argue, first, that the crisis is not only profound but also irreversible; secondly, that we are living in a time of scientific revolution that began with Einstein and quantum physics, and that it is not yet clear when it will end; thirdly, that, although the signs in question allow for nothing more than mere speculation about the paradigm that will emerge out of this revolutionary time, we may already assert with certainty that the basic distinctions underlying the dominant paradigm described above will collapse.

The crisis of the dominant paradigm is the result of a series of interacting conditions. I make a distinction between social and theoretical conditions. I shall pay more attention to theoretical conditions and begin with them. My first remark, which is not as trivial as it sounds, is that the identification of the limits and structural shortcomings of the modern scientific paradigm is the outcome of the great advance in knowledge it made possible. The deepening of knowledge revealed the fragility of the pillars on which it rested.

Einstein was responsible for the first rupture in the paradigm of modern science, indeed a wider rupture than he himself would ever have been able personally to admit. One of Einstein's profoundest insights was the relativity of simultaneity. Einstein distinguished between the simultaneity of events happening in the same place, and the simultaneity of distant events, particularly events separated by astronomical distances. As far as the latter are concerned, the logical problem is the following: how can the observer establish the temporal order of events in space? To be sure, by measuring the velocity of light, assuming, as Einstein's theory does, that in nature there is no velocity that is greater. However, upon measuring velocity going in one direction (from A to B), Einstein was confronted with a vicious circle. In order to determine the simultaneity of distant events the velocity must be known, and in order to measure velocity the simultaneity of events must be known. In a flash of genius, Einstein broke this circle, by demonstrating that the simultaneity of distant events cannot be verified, but merely defined. It is, therefore, arbitrary, and thus, as Reichenbach (1970: 60) pointed

out, when we measure, the results cannot be contradictory insofar as they give us back the simultaneity that we have introduced into the measuring system by definition.

This theory has revolutionized our conceptions of time and space. Since there is no universal simultaneity, Newton's absolute time and space do not exist. Two events that are simultaneous in one system of reference are not simultaneous in another. The laws of physics and geometry are based on local measurements. "The instruments for measuring, be they clocks or yardsticks, have no independent magnitude; rather, they adjust themselves to the metric field of space, the structure of which manifests itself most clearly in the rays of light" (Reichenbach, 1970: 68).

Considering the local character of measurements, and hence of the accuracy of the knowledge thus obtained, led to the second theoretical condition of the crisis of the dominant paradigm, namely quantum physics. If Einstein relativized the accuracy of Newton's law in the field of astrophysics, quantum physics did the same in the field of microphysics. Heisenberg and Bohr demonstrated that it is not possible to observe or measure an object without interfering with it, without actually changing it in such a way that, after being measured, the object is no longer the same as it was before. As Wigner pointed out, "the measurement of the curvature of space caused by a single particle could hardly be carried out without creating new fields which are many billion times greater than the field under investigation" (1970: 7). The idea that we know nothing about the real but what we ourselves bring to it, that is to say, that we know nothing of the real except our intervention in it, is well expressed in Heisenberg's uncertainty principle—we cannot simultaneously reduce the errors of the measurement of velocity and of the position of particles; whatever we do to reduce the error of the one will increase the error of the other (Heisenberg, 1958; 1971). This principle, and therefore the demonstration of the subject's structural interference in the observed object, is of great consequence. On the one hand, since the rigor of our knowledge is structurally limited, we can aspire only to approximate results which makes the laws of physics merely probabilistic. On the other hand, the hypothesis of mechanistic determinism is no longer viable, since the whole of reality is not reducible to the sum of the parts into which we divide it in order to observe and measure it.

Finally, the subject/object distinction is far more complex than it may seem at first. It loses its dichotomous contours to assume the form of a continuum.

The accuracy of measurement that quantum physics put into question would be even more deeply shaken if we question the accuracy of the formal vehicle used to express the measurements, mathematical rigor. This happened with the work of Gödel, which for that reason I consider the third condition of the crisis. The theorem of incompleteness or the theorems about the impossibility, in certain circumstances, of finding within a given formal system the proof of its consistency demonstrate that, even if the rules of mathematical logic are strictly followed, it is possible to formulate undecidable propositions, which can be neither demonstrated nor refuted, one of the propositions being precisely the one that postulates the non-contradictory character of the system.[5] If the laws of nature base their rigor on the rigor of the mathematical formalizations in which they are expressed, then Godel's findings demonstrate that the rigor of mathematics is itself in need of a foundation. After this, it is possible not only to question the accuracy of mathematics but also to redefine it as one form of accuracy that contrasts with alternative forms of rigor. In other words, it is a form of rigor whose conditions of success in modern science can no longer be taken for granted as obvious and natural. The philosophy of mathematics itself has engaged in the creative problematization of these themes, and today it is recognized that mathematical accuracy, like any other form of rigor, is based on a criterion of selectivity, thus having both a constructive and a destructive side.

The fourth theoretical condition of the crisis of the Newtonian paradigm derives from the advances of knowledge in the fields of microphysics, chemistry, and biology over the past twenty years. Let me cite, by way of example, the findings of Ilya Prigogine. His theory of dissipative structures and his principle of "order through fluctuations" established that, in open systems, that is, in systems that function far from equilibrium, evolution is explained by fluctuations of energy which, at certain not entirely predictable moments,

[5] The impact of Gödel's theorems on philosophy of science has been assessed in different ways. See, e.g., Ladrière (1967: 312ff.), Jones (1982: 158), Parain-Vial (1983: 52ff.), Thorn (1985: 36), and Briggs & Peat (1985: 22).

spontaneously generate reactions, which in turn, by means of nonlinear mechanisms, pressure the system beyond its utmost limit of disequilibrium. The situation of bifurcation, that is to say, the critical point at which the slightest fluctuation may lead to a new state, represents the potentiality of the system to be attracted to a new state of lesser entropy. Thus the irreversibility of open systems means that they are the product of their history (Prigogine & Stengers, 1984; Prigogine, 1980; 1981: 73ff.).

The importance of this theory is that it rests on the new conception of matter and of nature, which is hard to reconcile with the one we inherited from classical physics. In place of eternity, we now have history; in place of determinism, unpredictability; in place of mechanicism, interpenetration, spontaneity, irreversibility, and evolution; in place of order, disorder; in place of necessity, creativity and contingency. Prigogine's theory revives even such Aristotelian concepts as potentiality and virtuality, which the sixteenth century scientific revolution appeared to have definitively cast into the dustbin of history.

But the greatest importance of this theory is that it is not an isolated phenomenon. It is rather part of a converging movement, which has gained strength mainly since the 1970's, and which traverses the various natural sciences and even the social sciences. It has indeed a transdisciplinary calling that Jantsch (1980) calls the self-organization paradigm and which is developed, among others, by Prigogine's theory, Haken's synergetics (Haken, 1977; 1985: 205), Eigen's concept of the hypercycle and his theory on the origin of life (Eigen & Schuster, 1979), Maturana and Varela's concept of autopoiesis (Maturana & Varela, 1973; 1975),[6] Thom's catastrophe theory (Thorn, 1985: 85ff.), Jantsch's evolutionary theory (Jantsch, 1981: 83ff.), David Bohm's theory of the "implicate order" (Bohm, 1984), and Geoffrey Chew's S-matrix theory and its underlying "bootstrap" philosophy (Chew, 1970: 762ff.; 1970: 23ff.).[7] This scientific movement, along with the theoretical innovations that I have defined above as so many theoretical conditions of the crisis of the dominant paradigm, have precipitated a profound epistemo-

[6] See Benseler, Heijl &: Koch (1980).

[7] See Capra(1979: 11ff.).

logical reflection on scientific knowledge. This is such a rich and varied reflection that, better than anything else, it exemplifies the intellectual situation of our time.

There are two important sociological facets to this reflection. Firstly, it is predominantly carried out by the scientists themselves, those that have mustered the necessary philosophical competence and concern to problematize their own scientific practice. We can safely state that there have never been so many philosopher-scientists as today, a trend that is not intellectually accidental. After the nineteenth-century scientistic euphoria and the concomitant aversion to philosophical reflection, epitomized by positivism, we have at the end of the twentieth century been seized by the near desperate desire to complement our knowledge of things with our knowledge of our knowledge of things—in other words, with a knowledge of ourselves. The second facet of this reflection is that it deals with questions previously left to sociologists. The analysis of the social conditions, of the cultural contexts, of the organizational models of scientific research, which previously had been the separate realm of the sociology of science, have now come to play a key role in epistemological reflection.

Let me now give a few examples of the main themes of this reflection. First, the concept of laws and the related concept of causality are put into question. The formulation of the laws of nature is based on the idea that the observed phenomena are independent of all but a fairly small number of conditions—the initial conditions—whose interference is observed and measured. This idea, it is now recognized, necessarily creates broad distinctions between phenomena, distinctions which furthermore are always provisional and precarious, since the verification of the non-interference of certain factors is always the result of imperfect knowledge, however more nearly correct they may become. The laws are thus probabilistic, approximate, and provisional, as clearly laid out in Popper's falsifiability principle. But above all, the simplicity of laws constitutes an arbitrary simplification of reality that confines us to a minimal horizon beyond which lie other kinds of knowledge about nature, probably richer and of far greater human interest.

In biology, where interactions among phenomena and forms of self-organization in non-mechanical totalities are more visible, but

also in the other sciences, the notion of law has been partially replaced by the notions of system, structure, pattern, and finally by the notion of process. The decline of the hegemony of laws is parallel to the decline of the hegemony of causality. The questioning of causality in modern times has a long tradition, going back at least to David Hume and logical positivism. Critical reflection has addressed both the ontological problem of causality (what are the characteristics of the causal nexus? does such a nexus exist in reality?) and the methodological problem of causality (what are the criteria of causality? how can a causal nexus be identified or a causal hypothesis tested?). Today, the relativization of the concept of cause stems mainly from the acknowledgment that the central place it has occupied in modern science has its explanation less in ontological or methodological than in pragmatic reasons. The concept of causality is well suited to a science that aims at intervening in reality and that measures its success by the scope of its intervention. After all, a cause is something that can be acted upon. Even advocates of causality, such as Mario Bunge (1979), recognize that it is merely one of the forms of determinism and that it therefore plays a limited, though irreplaceable, role in scientific knowledge.[8] The truth is that, under the aegis of biology and even of microphysics, "causalism" as a category for the intelligibility of the real is now giving way to "finalism."

The second great theme of epistemological reflection deals with the content rather than with the form of scientific knowledge. Since it is a minimal knowledge that closes the door to many other ways of knowing the world, modern scientific knowledge is a sad and disenchanted knowledge that turns nature into an automaton or, as Prigogine says, into an awfully stupid interlocutor (Prigogine & Stengers, 1984). This vilification of nature ends up vilifying the scientist himself inasmuch as it reduces the alleged experimental dialogue to an act of prepotency over nature. Scientific rigor, be-

[8] Bunge writes: "The causal principle is, in short, neither a panacea nor a myth; it is a general hypothesis subsumed under the universal principle of determinacy, and has an approximate validity in its proper domain" (Bunge, 1979: 353). In Portugal, it is only fair to stress Armando de Castro's remarkable theoretical work in this field (Castro, 1975; 1978; 1980; 1982; 1987).

cause it is based on mathematical rigor, quantifies, and because it quantifies, it disqualifies. It is a rigor that, by objectifying phenomena, objectivizes and degrades them; in characterizing the phenomena, it caricatures them. In sum, scientific rigor is a form of rigor which, in asserting the scientist's personality, destroys the personality of nature. In this way, knowledge gains in rigor what it loses in richness. The vaunted successes of technology obscure the limits of our understanding of the world and suppress the question of the human value of a scientific endeavor thus conceived. This question is, however, inscribed in the subject/object relation presiding over modern science, a relationship that internalizes the subject at the cost of externalizing the object, thus making both of them self-enclosed and unable to communicate with each other.

The limits of this kind of knowledge are thus qualitative and cannot be overcome by more research and more precise instruments. Indeed, the qualitative precision of knowledge is itself structurally limited. For example, as far as information theories are concerned, Brillouin's theorem demonstrates that information is not without cost (Brillouin, 1956; Parain-Vial, 1983: 122ff.). Any observation performed on a physical system increases the system's entropy in the laboratory. The gain of a given experiment has therefore to be defined by the relation between the information obtained and the concomitant increase of entropy. But, according to Brillouin, the gain is always less than one and only rarely even close to one. In this view, a rigorous experiment is impossible, for it would require an infinite expenditure of human activity. Finally, precision is limited because, if it is true that knowledge advances only by the progressive subdivision of the object (as is attested by increasing scientific specialization), this also proves the irreducibility of wholes, whether organic or inorganic, to their constituent parts. Thus, the knowledge gained from observing the parts is necessarily distorted. The observed facts are beginning to break out of the solitary confinement to which science has subjected them. The frontiers of objects are less and less clear. The objects themselves are like rings interlocked in such complex chains that they end up being less real than the relations between them.

At the beginning of this section, I said that the crisis of the paradigm of modern science is explained not only by theoretical conditions, which I have just partially indicated, but also by social conditions. The latter cannot be dealt with in detail here.[9] I shall merely suggest that, no matter what the structural limits of scientific rigor, there can be no doubt that what science has gained in rigor over the past 40 or 50 years, it has lost in capacity for self-regulation. The beliefs about the autonomy of science and about the disinterestedness of scientific knowledge, which has long constituted the spontaneous ideology of the scientists, have collapsed due to the global industrialization of science, especially since the 1930's and 1940's. Both in the capitalist societies and in the state socialist societies of eastern Europe, the industrialization of science has made it tainted by the centers of economic, social, and political power, which came to play a decisive role in the definition of scientific priorities.

The industrialization of science occurred both at the level of applied science and at the level of the organization of scientific research. The Hiroshima and Nagasaki bombs were a tragic symbol of applied science. Initially viewed as accidental and fortuitous, they are today, in the face of the ecological disaster and the danger of a nuclear holocaust, increasingly perceived as the manifestation of a mode of scientific production prone to transform accidents into regular events. "Science and technology are showing themselves to be two sides of a historical process in which military and economic interests tend to converge to the point of becoming virtually indistinguishable" (Santos, 1978: 26). As far as the organization of scientific research is concerned, the industrialization of science has brought about two main results. On the one hand, the scientific community has become stratified, the power relations among scientists have become more unequal and authoritarian, and the great majority of scientists have undergone a process of proletarianization within laboratories and research centers. On the other hand, capital-intensive research (dependent on scarce and expensive instruments) made free access to equipment impossible, thus widening the gap, in terms of scientific and technological development, between core and peripheral countries.

Under the social and theoretical conditions just mentioned, the crisis of the paradigm of modern science does not constitute some

On this point, see Santos (1978: llff.).

gloomy quagmire of skepticism or irrationalism. Rather, we find ourselves observing the portrait of an intellectual family that is large and unstable, but also creative and fascinating, at the moment of its rather sad farewell to conceptual points of reference, both theoretical and epistemological, ancestral and intimate, that are no longer persuasive and reassuring, a farewell in search of a better life in the surroundings where optimism is better founded and rationality more plural and where at last knowledge will once again become an enchanted adventure. The characterization of the crisis of the dominant paradigm brings with it the profile of the emergent paradigm. It is that profile I shall now attempt to draw.

THE EMERGENT PARADIGM

We can only speculate about the precise configuration of the dawning paradigm. Such speculation is, of course, based on the signals emitted by the crisis of the present paradigm, though they do not determine the outcome. Indeed, as Rene Poirier has said, and was noted by Hegel and Heidegger before him, "we can know the global coherence of our physical and metaphysical truth only retrospectively" (Poirier, 1983: 10). So, when we speak of the future that we feel we are already living, what we say about it is always the product of a personal synthesis steeped in imagination, in my own case, in the sociological imagination. No wonder then that, though they sometimes converge, the syntheses presented up to now are so different. Ilya Prigogine (1979; 1980; 1981), for example, speaks of the new alliance and the metamorphosis of science. Fritjof Capra (1983; 1984) speaks of the new physics and the Tao of physics; Eugene Wigner (1970: 215ff.), of shifts of the second type; Erich Jantsch (1980; 1981), of the self-organization paradigm; Daniel Bell (1976), of the post-industrial society; Habermas (1984), of the communicative society.

As for myself, I shall speak of the paradigm of prudent knowledge for a decent life. By this phrasing I wish to signify that the scientific revolution we are undergoing today is structurally different from the sixteenth-century revolution. Because it is a scientific revolution occurring in a society that has already undergone a scientific revolution, its emergent paradigm cannot be merely a scientific paradigm (the paradigm of prudent knowledge), but must also be a social paradigm (the paradigm of a decent life). I shall present the emergent paradigm as a set of theses along with the justification of each.

1. All natural-scientific knowledge is social-scientific.

The dichotomy of natural and social sciences no longer has any meaning or utility. This distinction is based on a mechanistic conception of matter and of nature with which it contrasts, it is presumed obviously, the concepts of human beings, culture, and society. The newest findings of physics and biology question the distinction between the organic and the inorganic, between living beings and inert matter, and even between the human and the non-human. The characteristics of self-organization, of metabolism, and of self-reproduction, which were previously thought to be specific to living beings, are nowadays ascribed as well to pre-cellular systems of molecules. Furthermore, they are ascribed traits and behavior that were previously believed to be specific to human beings and to social relations. All the recent scientific theories I have mentioned ascribe to matter the concepts of historicity and progress, freedom and self-determination—and even consciousness, which men and women had previously held to be inalienably their own. I am alluding to Prigogine's dissipative structures, Haken's synergy, David Bohm's "implicate order," Geoffrey Chew's matrix-S and its underlying "bootstrap" theory, as well as Fritjof Capra's synthesis of contemporary physics and Eastern mysticism.

All these theories have a holistic vocation, and some are even intended to resolve the inconsistencies between quantum physics and Einstein's relativity. It is as if men and women had set out in search of the most distant and alien objects, and then, once they had gotten there, had discovered themselves as though they were being reflected in a mirror. At the beginning of the 1960's, extrapolating from quantum mechanics, Eugene Wigner maintained that the "inanimate" is not a different quality but only an extreme case *(caso limite),* that the distinction between body and soul has long ceased to have meaning, and that physics and psychology would eventually merge into one and the same science (Wigner, 1970: 271). Today it is possible to go far beyond quantum mechanics. If quantum mechanics made consciousness part of the act of knowing, we now have to make it part of the object of knowledge itself, and thereby the distinction between subject and object will undergo a radical change.

Not unlike Leibniz's pan-psychism, Bateson's "wider consciousness" refers to a psychic dimension of nature, of which the human mind is but a part, a mind immanent to the global social system and to the planetary ecology that some call God (Bateson, 1985). Geoffrey Chew postulates the existence of consciousness in nature as a necessary element for nature's self-consciousness, which would mean that future theories of matter will have to include the study of human consciousness. At the same time, we witness a renewed interest in Jung's "collective unconscious." Indeed, Capra claims that jung's ideas—primarily the idea of synchronicity to explain the relationship between inner and outer reality—are confirmed in particle physics by the recent concepts of local and non-local interactions.[10] As in Jungian synchrony, non-local interactions are instantaneous and cannot be predicted in accurate mathematical terms. They are, therefore, not the outcome of local causes; we might, at the very most, speak of statistical causality. Capra considers Jung one of the theoretical alternatives to Freud's mechanistic conception, and Bateson asserts that, just as Freud expanded the concept of mind inwardly (allowing us to grasp the subconscious and the unconscious), we now need to expand it outwardly (by recognizing the existence of mental phenomena other than those of individuals and humans).

Similarly, David Bohm's theory of the implicate order, which according to its author may constitute a common base for quantum theory and relativity, considers consciousness and matter as interdependent, though not linked by any causal nexus. They are rather two related projections of a higher reality that is neither matter nor consciousness. According to the emergent paradigm, then, knowledge tends to be non-dualistic. It is a knowledge based on the superseding of familiar and obvious distinctions that were taken for granted until very recently—nature/culture, natural/artificial, animate/inanimate, mind/matter, observer/observed, subjective/objective, and animal/person. This relative collapsing of dichotomous distinctions has its repercussions on the scientific disciplines that derive from them. As a matter of fact, there have been sciences that

[10]SeeBowen(1985:213ff.).

never felt very comfortable with these distinctions, so much so that they had to fracture internally in order to conform to them minimally. I refer to anthropology, geography, and psychology. More than any others they have reflected the contradictions Drought about by the separation between natural and social science. That is why, in this period of paradigmatic transition, it is so important, from an epistemological point of view, to observe what is going on within these sciences.

However, it is not enough to stress the tendency to supersede the distinction between the natural and the social sciences; we must understand the meaning and content of this supersession. Once again, in physical terms, the question is whether the "parameter of order" (Haken) or "attractor" (Prigogine) of this supersession will be the natural or the social sciences. Precisely, because we are living in a state of turbulence, the fluctuations of the new paradigm behave unequally in the various regions of the dominant paradigm, and so the signs of the future are ambiguous. Some interpret them as the emergence of a new naturalism revolving around the biological presuppositions of human behavior. This is the argument of Konrad Lorenz or of sociobiology. For them, the supersession of the dichotomy natural/social sciences is occurring under the aegis of the natural sciences. Against this view, it might be said that its conception of the future is the same conception with which the natural sciences have justified within the dominant paradigm their current scientific, social, and political prestige. It therefore sees in the future only that which will repeat the present. If, on the other hand, we consider more deeply the theoretical content of those sciences that are more advanced in their knowledge of matter, we shall realize that the emergent intelligibility of nature is infused with concepts, theories, metaphors, and analogies from the social sciences. We need only think of Prigogine's "dissipative structures" and Haken's "synergy." Both theories explain the behavior of particles by such concepts as social revolutions, violence, slavery, domination, nuclear democracy—all of which are borrowed from the social sciences (sociology, political science, history, etc.). The same applies to Capra's theories on the relation between physics and psychoanalysis, in which the patterns of matter and the patterns of mind are seen to reflect each other. Even though these theories blur the borderlines between the objects of physics and the objects of biology, the latter has no doubt absorbed the explanatory models of the social sciences more deeply in recent decades. The concepts of teleomorphism, autopoiesis, self-organization, organized potentiality, originality, individuality, and historicity do indeed ascribe human behavior to nature. Thus, in a recent book on the life sciences, Lovelock (1979) states that our bodies are made up of cell cooperatives.

That the explanatory models of the social sciences have been behind the development of the natural sciences for the past decades is further indicated by the fact that, once they have been formulated in their specific domain, the natural-physical sciences are easily applied to the social domain. Thus, for example, Peter Alien (1981), one of Prigogine's closest collaborators, has applied the theory of dissipative structures to economic processes and to the evolution of cities and regions. Haken (1985), in turn, has stressed the potentialities of synergetics to explain revolutionary situations in society. It is as if Durkheim's motto had been reversed. Rather than studying social phenomena as if they were natural phenomena, scientists now study natural phenomena as if they were social phenomena.

The fact that the supersession of the dichotomy between natural and social sciences is being carried out under the aegis of the social sciences, however, is not enough to characterize the model of knowledge in the emergent paradigm. Since, as mentioned above, the social sciences themselves were formed in the nineteenth century according to the models of rationality of the classical natural sciences, to speak of the aegis of the social sciences may turn out to be misleading. I did say, however, that the social sciences were constituted according to two different tendencies: one of them closely linked to the positivist epistemology and methodology of the natural sciences; the other, of an anti-positivist vocation, molded in a complex philosophical tradition of phenomenology, interaction-ism, myth-symbolism, hermeneutics, existentialism, and pragmatism. The latter claim the particularity of the study of society, while at the same time assuming a mechanistic conception of nature. The power of the latter trend in the past decades indicates that it is a model of social sciences which, in a time of scientific revolution, carries within itself the post-modern sign of the emergent paradigm. It is indeed a transitional model, for it defines the specificity of the human in opposition to a conception of nature that the natural sciences today consider superseded; but it is a model less strongly attached to the

past than to the future. In sum, to the degree that the natural sciences are getting closer to the social sciences, the social sciences are getting closer to the humanities. The subject, cast into the diaspora of irrational knowledge by modern science, is returning, charged with the task of rebuilding a new scientific order.

That this is the global trend of our present scientific revolution is also suggested by the ongoing reconceptualization of the epistemological and methodological conditions of social scientific knowledge. I have enumerated above some of the obstacles to the scientificity of the social sciences, which, according to the still dominant paradigm, are supposedly responsible for the backwardness of the social sciences vis-a-vis the natural sciences. But it is also the case, as I have already indicated, that new developments in the knowledge of the natural sciences, and the epistemological reflection that they have brought about, have shown that the obstacles to the scientific knowledge of society and culture are actually conditions of knowledge in general, be it of social or of natural objects. In other words, what used to be considered the explanation of the greater backwardness of the social sciences today is seen as the greater advance of the natural sciences. Hence, Thomas Kuhn's notion of the pre-paradigmatic (i.e., less developed) character of the social sciences (Kuhn, 1962), to which I myself previously subscribed furthermore (Santos, 1978: 29ff.), must be considerably revised, if not abandoned.

The supersession of the natural sciences/social sciences dichotomy tends, therefore, to revalue the humanities. But for this revaluation to take place, the humanities need themselves to be profoundly changed. What there is in them of the future is that they have resisted the separation between subject and object, and that they have preferred to understand the world rather than to manipulate it. Their genuine core was, however, often trapped in mystifying preoccupations (dreamy esotericism and empty erudition). The ghetto into which the humanities chose to retire was in part a strategic defense against the assault of the social sciences that triumphantly wielded the scientistic bias. But it was also the result of the void they felt, once their space had been taken over by the scientistic model. That is what happened in historical studies with quantitative history, in legal studies with the pure theory of law and legal dogmatics, and in philological, literary, and linguistic studies with structuralism. The genuine core of the humanities must be recovered and put to the service of a global reflection about the world. The text, which has always been the concern of philology, is one of the basic analogies upon which the knowledge about nature and society will be built in the emergent paradigm.

The humanistic conception of the social sciences, as the catalyst of the gradual melting together of natural and social sciences, places the person, as author and subject of the world, at the very center of knowledge, but, unlike what happened in the traditional humanities, it places what we today call nature at the center of the person. There is no human nature because all nature is human. It is therefore necessary to look for global categories of intelligibility, hot concepts capable of melting down the frontiers into which modern science has divided and enclosed reality. Post-modern science is an admittedly analogical science that knows what it knows less well through what it knows better. I have already invoked the textual analogy. Other important basic categories of the emergent paradigms are, to my mind, the analogies of play, of drama, and even of biography. Today the world is natural or social, tomorrow it will be both, and will be looked at as if it were a text or a play, theater or an autobiography. Clifford Geertz spoke of these humanistic analogies (1983: 19ff.) but he restricted their use to the social sciences; I conceive of them as universal categories of intelligibility.

It will not be long before particle physics shall speak of particles playing, or biology of the molecular theater, or astrophysics of the heavenly text, or chemistry of the biography of chemical reactions. Each of these analogies unveils a corner of the world. Total nakedness, which will always be the nakedness of those who see themselves in what they see, will arise out of the configurations of analogies we may be capable of imagining. After all, the play presupposes a stage, the stage requires a text, the text is its author's autobiography. Play, theater, text, or biography, the world is communication, and that is why the existential logic of post-modern science is to promote the "communicative situation" as conceived by Habermas. Streams of meanings and their constellations are converging into rivers, whose sources are in our local practices, which drag along with them the sands of our molecular, individual, communal, social, and planetary trajectories. This is not a jumble of meanings (which would be noise, not meaning), but rather interactions and

intertextualities organized around local projects of undivided knowledge. From this arises the second characteristic of post-modern scientific knowledge.

2. All knowledge is local and total.

In modern science knowledge advances by specialization. Knowledge is ever more rigorous as its object is restricted. Indeed, herein lies what is today recognized as the basic dilemma of modern science: its rigor increases in direct proportion to the arbitrariness with which it straitjackets reality. As a disciplinary knowledge, it is prone to be a disciplined knowledge—that is to say, it organizes knowledge by policing the borders and repressing all trespassers. It is recognized today that the extreme fragmentation and disciplinarity of scientific knowledge turns the scientist into a specialized ignorant person—a negative development whose effects are visible primarily in the applied sciences. Technology today is concerned about its destructive impact on the ecosystems. Medicine is realizing that the hyperspecialization of medical knowledge has transformed the patient into a meaningless checkerboard of parts, when in fact we are only ever ill as a whole person. Pharmacy is discovering the destructive side of drugs, all the more destructive to the degree that they are more specific, and looks for a new logic of chemical combination heedful of organic equilibrium. Law, having reduced the complexity of legal life to the dryness of dogmatics, is rediscovering the philosophical and sociological world in its search for a lost prudence. Economics, after having legitimated quantitative and technocratic reductionism claiming thereby success in economic predictions, is being forced to recognize, given the poverty of the results, that the human and sociological quality of the economic agents and processes is now sneaking in through the window after having been forced out the door. In order to garner the recognition of its users (who, whether public or private, institutional or individual, have always been in a position of power vis-a-vis those being analyzed), applied psychology has favored efficient and manageable tools, such as tests, which have reduced personality's richness to the functional demands of unidimensional institutions.

The evils of this fragmentation of knowledge and the arbitrary reductionism it carried with it are now being recognized, but the measures offered to correct them usually end up doing nothing more than reproducing them in another guise. New disciplines are created to solve the problems brought about by the old, and thus the same model of scientificity is reproduced. To give one example, the general practitioner, resurrected in the hope of compensating for medical hyperspecialization, is running the risk of being transformed into simply one more specialist. This perverse effect suggests that there is no solution for this problem within the dominant paradigm, for the latter is precisely the problem, from which all the others arise.

In the emergent paradigm, knowledge is total. Its horizon is Wigner's universal totality or Bohm's undivided totality. But it is as local as it is total. It is gathered around themes adopted by concrete social groups at a given time as projects of local life, be it to recover the history of a place, to preserve a green space, to build a computer adequate to the local needs, to make the infant mortality rate decrease, to invent a new musical instrument, to wipe out an illness, etc., etc. Post-modern fragmentation is thematic rather than disciplinary. Its themes are like galleries along which the various kinds of knowledge move, meeting each other. Unlike what happens in the present paradigm, knowledge advances as its object grows larger. Like a tree, it grows by differentiation and the spreading of its roots, in search of new and more varied interfaces.

But though it is local, post-modern knowledge is also total, because it reconstitutes the local cognitive projects, stressing their exemplarity and thus turning them into enlightened local thinking. While claiming to be analogic, as I said earlier, the science of the emergent paradigm also claims to be a translator. That is to say, it encourages the emigration of concepts and theories developed locally to other cognitive spheres and their utilization outside their original context. Such a procedure, which was suppressed in the form of knowledge that conceived via operationalism and generalized via quantification and uniformity, is quite normal in the form of knowledge that conceives via the imagination and generalizes via quality and exemplarity.

Though total, post-modern knowledge is not deterministic; though local, it is not descriptive. It is knowledge about the conditions of possibility. It is knowledge about the conditions of possibility of human action projected into the world from local time-spaces.

Such knowledge is relatively unmethodical, since it springs from methodological plurality. Each method is a language, and reality replies in the language of the question. Only a constellation of methods can capture the silence between each language asking questions. In the phase of scientific revolution we are traversing, this plurality of methods is possible only through methodological transgression.[11] If it is true that each method clarifies only that which is convenient for it, and when it does clarify anything, does not allow for any major surprises, scientific innovation consists in inventing persuasive contexts that allow the application of methods outside their natural habitat. Since the narrowing of the gap between the natural and the social sciences will bring the former nearer to the latter, we might wonder whether it is possible, for example, to do a philological analysis of an urban project, to interview a bird, or to perform participant observation among computers.

Methodological transgression affects the literary styles and genres that govern scientific discourse. Post-modern science does not adopt a unidimensional, easily identifiable style; it uses a configuration of styles constructed according to the scientist's criteria and personal imagination. Discursive tolerance is the other side of methodological plurality. In this transition phase there are already clear signs of this process of stylistic fusion, of interpenetration of writing canons. Clifford Geertz (1983: 20) studied this phenomenon in the social sciences and presented a few examples: philosophical investigation that sounds like literary criticism in Sartre's work on Flaubert; baroque fantasies under the guise of empirical observations in jorge Luis Borges; parables presented as if they were ethnographic research in Carlos Castañeda; epistemological studies in the form of political texts, as in Paul Feyerabend's *Against Method.* And like Geertz, we might ask if Foucault is a historian, a philosopher, a sociologist, or a political scientist. The individualized, transdisciplinary composites indicated by these examples suggest a movement towards a greater personalization of scientific knowledge. And here we arrive at the third characteristic of scientific knowledge in the emergent paradigm.

[11] On the concept of methodological transgression, see Santos (1981: 275ff.).

3. All knowledge is self-knowledge.

Modern science consecrated man as epistemic subject but expelled him, as it had expelled God, as empirical subject. Rigorous, factual, objective knowledge could not permit the interference of human or religious values. This is the ground for the dichotomous distinction between subject and object. However, this distinction was never as acceptable in the social sciences as in the natural sciences, and as already stated, this was the supposed cause of the former's backwardness. After all, the objects of study were men and women, like those studying them. The epistemological distinction between subject and object had to be methodologically articulated with the empirical distance between subject and object. This is quite obvious if we compare the methodological strategies of cultural and social anthropology on the one hand, and of sociology on the other. In anthropology the empirical distance between subject and object was enormous. The subject was the "civilized" anthropologist; the object was the "primitive" (or "savage") people. In this case, it was acceptable, even necessary, that an object be narrowed down by means of methodologies calling for a greater intimacy with the object, namely ethnographic field work and participant observation. In sociology, on the other hand, the empirical distance between subject and object was small or even non-existent. European scientists did research on their fellow-citizens. In this case, the epistemological distinction required a widening of the distance by means of methodologies of detachment: for example, the sociological questionnaire, content analysis, and the structured interview.

Anthropology, between postwar decolonization and the Vietnam war, and sociology, since the late 1960's, have come to question this methodological status quo, as well as the underlying notions of social detachment. All of a sudden, the savages were seen to be within us, within our societies, and sociology proceeded more often to utilize methods (like participant observation) which earlier had been almost the monopoly of anthropology. At the same time, in anthropology the objects had become peers, full-fledged members of the United Nations, and had to be studied according to sociological methods. The effect of these shifts in distinction between subject and object in the social sciences finally exploded in the poststructuralist period.

In the field of the natural sciences, the return of the subject had already been announced by quantum mechanics when it demonstrated that the act of knowledge and the product of knowledge were inseparable. The developments in microphysics, astrophysics, and biology during the last decades have restored to nature the properties of which they had been deprived by modern science. The deepening of knowledge conducted according to a materialist matrix finally emerged as an idealistic knowledge. The new dignity of nature was further strengthened by the realization that disordered technological development had separated us from, rather than united us with, nature, and that the exploitation of nature entailed the exploitation of man. The uneasiness that the distinction between subject and object had always provoked in the social sciences thus spread to the natural sciences. The subject was coming back donning the object's garb. Furthermore, Bateson's concepts of the "immanent mind," the "wider mind," and the "collective mind," as well as many others, represented dispersed indications that that other fugitive of modern science, God, might be about to return. He will return transfigured, with nothing divine about him except our desire for harmony and communion with all that surrounds us and which is, we now see, our innermost self. A new gnosis is in the process of gestation.

We can assert today, to paraphrase Clausewitz, that the object is the continuation of the subject by other means. Therefore, all scientific knowledge is self-knowledge. Science does not discover; rather it creates. And the creative acts performed by each scientist and by the scientific community as a whole must be understood intimately before we can use this knowledge to know reality. Metaphysical presuppositions, systems of belief, value judgments do not come before or after the scientific explanation of nature or society; they are part and parcel of it. Modern science is not the only possible explanation of reality; and there is no scientific reason whatsoever that it should even be considered better than the alternative explanations of metaphysics, astrology, religion, art, or poetry. The reason why we give priority today to a form of knowledge based on the prediction and control of phenomena has nothing to do with science. It is a value judgment. The scientific explanation of phenomena is the self-justification of science as the central phenomenon of our contemporaneity. Thus, science is autobiographical.

The consecration of modern science in the course of the past 400 years has naturalized the explanation of reality, to the extent that we cannot conceive of the real except in ways that science offers us. Without such categories as space, time, matter, and number—the cardinal metaphors of modern physics according to Roger Jones (1982)—we are incapable of thinking, even if we are now capable of considering them conventional, arbitrary, metaphorical categories. The process of naturalization was slow. The protagonists of the scientific revolution had a clear sense that the innermost proof of their personal convictions preceded and gave coherence to the external proofs they developed. Descartes revealed better than anyone else die autobiographical character of science. He wrote in his *Discourse on Method:* "I shall be glad ... to reveal in this discourse what paths I have followed, and to present my life in it as in a picture, so that everyone may judge it for himself; and thus, learning from public response the opinions held of it, I shall add a new means of self-instruction to those I am accustomed to using" (Descartes, 1988: 21). Today we know, or suspect, that our personal trajectories and that of the collective scientific community, as well as the values, the beliefs, and prejudices they bring with them, are the innermost proof of our knowledge, without which our laboratory or archival research, our calculations or our field work would be no more than a tangle of meaningless efforts, from beginning to end. Nonetheless, such knowledge of our life trajectories and values, of which we may or may not be aware, flows in subterranean, clandestine ways, in the unspoken presumptions of our current scientific discourse.

In the emergent paradigm, the autobiographical and self-referential character of science is fully acknowledged. Modern science has bequeathed us a functional knowledge of the world which has enlarged to an extraordinary degree our prospects of survival. Today, the question is not how to survive, but how to live. This requires another form of knowledge, holistic, intimate knowledge, that does not separate us from, but rather connects us personally with, whatever we study. The uncertainty of knowledge, which modern science has always viewed as a technical limitation to be gradually overcome, is transformed into the key to understanding of a world that must be contemplated rather than controlled. This has nothing to do with the medieval wonderment before a hostile

reality haunted by the divine spirit. It is rather a sense of prudence before a world which, even though it be tamed, reveals to us each day the precarious meaning of our life, however stable it may be at the level of survival. The science of the emergent paradigm is contemplative rather than active. The quality of knowledge is assessed not only by what it controls or operates in the external world but by the personal satisfaction it brings to whoever enjoys and partakes of it.

The esthetic dimension of science has been acknowledged by scientists and philosophers of science from Poincaré to Kuhn, from Polanyi to Popper. Roger Jones (1982: 41) thought that Newton's system was a work of art as much as a work of science. Scientific creation in the emergent paradigm is becoming ever nearer to literary or artistic creation. They share the belief that the active dimension of the transformation of reality (the sculptor chiseling the block of stone) should be subordinated to the contemplation of the result (the work of art). Scientific discourse, in its turn, is getting increasingly close to the discourse of literary criticism. In a way, literary criticism presages the subversion of the subject/object relation which the emergent paradigm seeks to effect. In literary criticism, the object of study, as we would call it in scientific language, has always been, in effect, a supersubject (a poet, a novelist, a dramatist) in relation to whom the critic was no more than a secondary subject or secondary author. It is true that, in recent times, the critic has been tempted to outdo the writer under scrutiny, to the point that we might even speak of a struggle for supremacy. But precisely because it is a struggle, it involves two subjects rather than a subject and an object. Each is the other's translation; both are creators of texts. Their texts are written in different languages, but both languages are necessary to learn how to appreciate the words and the world.

Thus resubjectified, scientific knowledge teaches us how to live and becomes everyday know-how. Hence the fourth and last characteristic of post-modern science.

4. All scientific knowledge aims at becoming common sense.

I have argued that the foundation of the privileged status of scientific rationality is not in itself scientific. We know today that modern science teaches us very little about our way of being in the world, and that the little that it teaches us will always be scanty, no matter how much we increase it, since its scantiness is inscribed in the very form of knowledge it constitutes. Modern science produces both knowledge and ignorance. If it turns the scientist into someone with specialized ignorance, it turns the ordinary citizen into someone with generalized ignorance.

On the other hand, post-modern science knows that no single form of knowledge is in itself rational; only their collective configuration can be rational. Therefore it tries to enter into a dialogue with other forms of knowledge and permits itself to be influenced by them. The most important other form is common sense knowledge, the ordinary, practical knowledge that guides our everyday behavior and gives meaning to our life. Modern science built itself against common sense, which it deemed superficial, illusory, and false. Post-modern science tries to rehabilitate common sense, for it recognizes in this form of knowledge some capacity to enrich our relationship with the world. Common sense knowledge, it is true, tends to be a mystified and mystifying knowledge, but in spite of that, and in spite of its conservative quality, it does have a Utopian and liberating dimension that may be enhanced by its dialogue with scientific knowledge. This Utopian, liberating quality may be seen to flourish in many different characteristics of our common sense knowledge.

Common sense collapses cause and intention. It rests on a worldview based on action and on the principle of individual creativity and responsibility. Common sense is practical and pragmatic. It reproduces knowledge drawn from the life trajectories and experiences of a given social group, and asserts that this link to group experience renders it reliable and reassuring. Common sense is self-evident and transparent. It mistrusts the opacity of technological objectives and the esoteric nature of knowledge, arguing the principle of equal access to discourse, to cognitive and linguistic competence. Common sense is superficial, because it disdains structures that cannot be consciously apprehended, but for the same reason it is expert at capturing the horizontal complexity of conscious relations both among people and between people and things. Common sense knowledge is non-disciplinary and non-methodical. It is ! not the product of a practice expressly devised to create it; it reproduces itself spontaneously in the daily happenings of life. Common sense accepts what exists as is. It favors actions that do not provoke significant ruptures in reality. Finally, common sense is rhetorical and metaphorical; it does not teach, it persuades.

In the light of what was said about the emerging paradigm, these characteristics of common sense have the merit of anticipating it. Left to itself, common sense is conservative and may well legitimate claims to superior knowledge. However, once articulated with scientific knowledge, it may be the source of a new rationality —a rationality comprised of multiple rationalities. For this configuration of knowledge to occur, it is necessary to invert the epistemological break. In modern science the epistemological break symbolizes the qualitative leap from common sense knowledge to scientific knowledge; in post-modern science the most important leap is that from scientific knowledge to common sense knowledge. Post-modern scientific knowledge fulfills itself only insofar as it becomes translated into common sense. Only thus will it be a clear science that fulfills Wittgenstein's dictum: "Everything that can be said, can be said clearly" (Wittgenstein, 1981: 4.116). Only thus will it be a transparent science that does justice to Nietzsche's desire that "all commerce among men aims at letting each one read upon the other's soul, common language being the sound expression of that common soul" (Nietzsche, 1971: 139).

By becoming common sense, post-modern science does not shun the knowledge that produces technology, but does believe that, as knowledge must translate into self-knowledge, so technological development must translate into life wisdom. The latter points out the markers of prudence for our scientific adventure, prudence being the acknowledgment and control of insecurity. Just as Descartes, at the threshold of modern science, knew doubt rather than suffered it, we too, at the threshold of post-modern science, should know insecurity rather than suffer it.

In this phase of scientific transition and revolution, such insecurity derives from the fact that our epistemological reflection is far more advanced and sophisticated than our scientific practice. None of us could at this moment visualize concrete research projects that might fully correspond to the emergent paradigm I have sketched here. That is precisely because we are in a period of transition. We have sufficient doubts about the past to imagine the future, but we live too much in the present to accomplish the future in it. We are divided and fragmented. We know we are on the path, but not how far along in the journey we are. The epistemological condition of science is visible in the existential condition of the scientists. In the end, if all knowledge is self-knowledge, then all ignorance is self-ignorance.

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