

CHAPTER 12/Science As Power TOWARD A NEW SOCIAL THEORY OF SCIENCE

It remains for me to show how science is social relations. For even if Marcuse has already argued for the ineluctability of the relation between science, technology, and social domination, he has not provided a systematic, detailed explanation of the way in which, by virtue of its own concepts and methods, scientific practices promotes a universe in which domination of nature is linked to the domination of humans, or the way in which science is a form of power. The fundamental argument advanced by Horkheimer and Adorno concerning the presumptions of science and technology refers to the Enlightenment's transformation of nature into an object, the simultaneous estrangement of nature by taking it as an antagonist rather than a partner of human culture and the organization of production and the state by bureaucratic management. Thus, "rationality" itself becomes inextricably linked to domination. The division of labor is now conceived as the segmentation of tasks and their performance by qualified persons who have found their place in the order of nature and society by purely individual talents, while, conforming to the pre-given organizational chart that defines the boundaries of their authority and has the status of a natural fact.

The imputation to nature of characteristics that are nothing more than the objectivization of the table of organization of the social world has imparted to both the appearance of natural facts as well. On the one hand, nature is taken as external to human consciousness, a hallmark of the scientific attitude since the sixteenth century. On the other hand, as we have seen, humans have attempted to make their world "scientific," to organize economic, political, and social life according to a system of rationality that is understood as consistent with natural law. The point made by Critical Theory is that society has reified nature and its own relations. Although external to consciousness, we have imposed our own class-dominated, bureaucratically organized division of labor on the external world, which, in contemplation, appears at once lawlike in its structure, chaotic. For the floods, torrential rains, snows, earthquakes, as much as disease, in short, the unexpected "revolts" of nature have become phenomena to be controlled; these events define the task of science, the horizon in the quest for dominion. Just as nature is understood as subject to subsumption under human powers, so humans themselves are increasingly regarded as controllable. The "sciences of man" have been mobilized in the drive for social and psychological domination; the instincts, according to B. F. Skinner, the latest of the behavior managers, must be directed, lest the famous "war of all against all," that is, the freedom of the marketplace, result in the destruction of the human species itself.¹ Of course, Skinner is just the most "humanistic" of the scientific managers of human behavior. At a more global level, governments have now recruited social science in a wide-ranging effort to manage international relations and biology to "manage" human reproduction.

For in late industrial societies, east and west, the fear of nature has been projected onto the fear of humans, a fear of their psychic structure as much as their command over the material means of destruction. And, of course, the object of economic science

throughout most of the twentieth century has become the uncontrolled vicissitudes of civil society that lead to inexplicable crises or wars. Economics is now nothing but a technology masked as social theory for assisting the state, in both East and West, in managing the economy, or, to be more precise, in displacing contradictions from the relations of material production to other institutions and countries.

We have already seen that the choice of scientific inquiry is now subject to corporate and state determination, not necessarily by coercion or even material incentives of a crude type, but in virtue of the capital requirements of the apparatus of scientific work. For the costs of scientific research (at both “natural and social levels”) have made it virtually impossible for the aristocratic scientists to pursue their labors in the privacy of their estates. Nor can scientific work proceed on the basis of patronage by aristocrats and prosperous business persons. The days are over when Frederick Engels, for example, a Manchester textile employer, could slip an occasional twenty pounds to his friend Karl Marx so that the progress of the development of a science of society would not be disrupted by Marx’s need to write a few pieces for the New York Tribune to keep family and body together. Now the patron has become a corporate foundation established as a tax dodge and to provide a bureaucracy for the conduct of research that appears independent of corporate sponsorship. The state, too, insofar as its veneer of ideological and economic neutrality has become a major support for research, is a crucial patron. And corporations, confined for the most part by their emphasis on “applied” research (a euphemism for technological development), help define the parameters of the financing of all sciences.

The state and the large corporate foundations claim that their grants are free of political influence and that they have created a mechanism for bringing members of the scientific community into decision making, to legitimate their claims to neutrality. Many scientists believe that such measures safeguard the integrity of “pure” scientific research. However, it must be noted that leading scientists and technologists are increasingly integrated into the management of the state. When Harold Brown, president of the California Institute for Technology, a major scientific and technical research and educational center, became Jimmy Carter’s Secretary of Defense, it was a sign that the scientific establishment had achieved considerable status in the commanding heights of political power in America. For it is one thing to place scientists high in the councils of the National Science Foundation, a government agency that funds research, and quite another to acknowledge that science is no longer a “servant of power” (in Loren Baritz’s terms).² Science and power are now in the process of merging, a frightening verification of the theoretical appraisal that the division between the state and civil society³ is undergoing a collapse, if it has not already been accomplished. From the political and ideological perspective, the control of scientific research by the guardians of “normal” science ensures, in the first place, that the choice of the field for scientific inquiry will remain subject to the determination of those who are considered mainstream scientists. By bringing them into the apparatus of government and the corporation foundations, as well as the large corporations (which perform about one-third of all scientific research),

the social system legitimates its own claim to neutrality from the conflicts of civil society and makes sure that science reproduces a certain direction of inquiry. It is true that the Department of Defense finances “pure” research, that the Department of Health and Welfare is interested in biological sciences, not only those fields subject to immediate application, but also more long-range and theoretical areas. The vast sums of money appropriated by the state and private foundations each year are subject to the priorities of Congress, the executive branch of government, and economic considerations. It is not that the government and corporate foundation bureaucracies consciously believe in the subordination of science; on the contrary, many if not most are persuaded that the autonomy of research ought to be maintained “in the national interest.” But the management of science by leading scientists and scientific bureaucrats (those who were scientists, but have become managers of research projects and institutions such as universities that manage research) has an ideological content, insofar as science is itself a “normative” activity. (1) Theory and method, (2) the form of result, (3) field of inquiry, and (4) the constitution of the scientific object are categories within which norms are established and normative activity defined. To the extent that the norms within these categories are part of the taken-for-granted assumptions of science, coercive control by the state and corporate apparatuses becomes more or less unnecessary; scientific culture (the matrix of conventions of inquiry, social and political networks among scientists, the language and institutions of science) is usually the sufficient condition for bringing science within the apparatus politically and for reproducing ideologies in which the domination of nature, already a normatively constructed practice, is linked to the domination of humans.

Beyond the social determination of the field of inquiry, the constitution of the scientific object of knowledge of inquiry is linked to the prevailing social and technical division of labor. At the level of the so-called social division of labor, science itself is constituted by various distinct fields or practices whose demarcation has purely historical roots. Or, the rationality that informs the division of conventional scientific fields may be shown to conform to systems of classification that have historical origins. There is a social logic of the classification of the sciences, rather than a logic that is “given” by nature.

It is by now commonplace to remark that the relation of magic, science, and philosophy is an internal, rather than external, conjunctural phenomenon. Historians of science have pointed out that science breaks from magic and religion and becomes a secular philosophy only during the Athenian city-state, and breaks with philosophy during the Renaissance period, during the development of capitalism. These breaks are accompanied by mutations in the logic of natural and social inquiry whose relationship to changes in the concept of rationality is intimate. Yet, the logic of science is continuous as well. This continuity may be traced, in part, to Aristotle’s invention of a binary structure for classifying levels of material things. Aristotle presented the system of classification according to which physics, astronomy, biology, and other sciences were arranged as an outcome of the logic of identity and exclusion. This logic proceeds from a system of binaries (the either/or) in which the exclusion of oppositions within the thing (an explicit

repudiation of Heraclitus and the other pre-Socratic philosophers) is taken as the foundation. The principle of classification also contains the concepts of levels, according to which reality is arranged hierarchically in a series of mutually excluding layers of object-classes.

Aristotle deals in both a theory of “natural causes” and a theory of the “prime mover” -- God. There is both a scientific and a religious element in his theory, and the religious side gets bracketed by modern science; but the logic of noncontradiction and hierarchy remains central to both stages of the history of sciences. Thus, even if we may sidestep for now the question of whether ancient and medieval sciences were dedicated to empirical observation as the ground for their theoretical formulations (as Feyerabend claims),⁴ the foundation of modern science accepted much of Aristotle’s classification system, because the logic of scientific inquiry remained largely intact until the nineteenth century. We may speak of an Aristotelian revolution as the genuine epistemological break between what is called science and prior forms of natural inquiry, because it is he who divides the natural as well as the social world and thus defines the scientific object as one level of that world.⁵

The concept of levels of material existence was at first integrated into “natural philosophy” only implicitly. But, by the sixteenth century, it was clear that a hierarchy of sciences had already taken shape. Mathematics, of course, was the “queen” of the sciences, because its object had the greatest degree of generality and was not confined to any one science. Physics was privileged among the so-called empirical sciences because it attempted to find the most fundamental unit of matter to which all other levels could be reduced and to discover the laws of material motion and transformation. Astronomy was similarly important but, as we have already seen, lived in the intersection of practical concerns such as navigation and the ideal of knowledge for its own sake. In a sense, it was not a separate field of science because it was subsumed, from the beginning of the modern era, by physics. Chemistry, biology, and psychology are sciences whose separation from philosophical speculation came only with the period of industrialization. The development of psychology as an independent discipline really came out of the mind/body split introduced by Cartesian metaphysics and the British empiricists. As a branch of biology, the field had been dominated by the reduction of mental phenomena to properties that could be traced to physical and chemical causes. As late as the time of Freud, the conflict between the concept of the mind as a legitimate object of knowledge and its reduction to the instincts, which were supposed to possess a bioenergetic character, made the object of knowledge ambiguous.

The division among the sciences into fields of inquiry was generated by the adaptation of the rules of formal logic to systems of classification, the concept of levels in nature, which is grounded in (1) the logical principle of boundaries or exclusion, where a thing is only what it is and excludes another, and (2) the principle of contradiction, which asserts the separability of a thing from anything else, or a determinate other. A and B exclude each other by definition but may be arranged in a grid as binary oppositions or vertically as an ordered discourse. The concept of hierarchy, in which these defined

sciences are arranged in vertical order, is presented in Aristotle, and in the modern era, legitimated by the social organization of sciences as if these are a property of nature.

The concept of levels in vertical ascending or descending order presupposes the formal rationality of Aristotelian philosophy and cannot be taken as an observation from nature. In turn, this type of rationality, challenged in the modern period by Vico and Hegel,⁶ has remained hegemonic in the constitution of the fields of scientific inquiry, determining the relative weight, both within the scientific community and in society at large, of the various disciplines. I call these divisions social because they correspond to various branches of industry under capitalism, which are similarly historically formed -- as industry is formed. In place of steel, automobiles, electronics, retail, public sector, etc., science is organized into various fields that are considered as separate discourses corresponding to separate levels of reality.

But science is also organized according to a technical division of labor in two ways: first, the distinctions between pure and applied sciences, and second, between these and “technology,” appear to be objectively rooted in the nature of the objects. Scientific workers in these three fields acquire a common education only at the beginning of their training; occupational nomenclature as well as prescribed curriculum vary depending on which of the fields is pursued. The applied scientist may develop new types of cosmetics, synthetic fibers, or artificial fertilizers, but not concern himself/herself with the physical chemistry of matter except insofar as it relates to the development of a product. The character of the scientific object here is socially determined, more specifically, has to do with the difference between the pure researcher, who is engaged in making discoveries about the “nature” of the material world, apparently with no ulterior purpose beyond the discovery itself, and the applied researcher, who is part of the system of rational-purposive action: knowledge is gained about the material world, indeed, the object of knowledge is clearly defined in terms of its commercial, industrial, or social uses. Society has placed an ideological premium on the acquisition of knowledge for its own sake and an economic premium on the practical, i.e., technical outcomes of knowledge. In this respect, the technical division of labor masks the fact that both types of knowledge depend on historical and social context -- particularly the way in which the relation of the state, the economy, and the ideological forms divides scientific labor. The parameters of the object of knowledge are socially prescribed depending upon this context, and are given significance by their respective institutional frameworks. Thus, discoveries made in each sphere that do not conform to the teleological presuppositions of that sphere may be suppressed. Even though the pure scientist may discover a practical use for his/her theory, such applications would tend to be “forgotten,” laid aside, regarded as either inappropriate or trivial because intervention may not bring prestige with the community of pure science. Conversely, the industrial laboratory is not considered a place for “pure science.” The applied scientists’ work must yield a marketable product, that is, a product which can yield at least the average rate of profit.

The technical division of labor appears to be normal, a division of branches of scientific labor, just as any other two branches of the same industry seem naturally divided according to types of tasks. But this logic masks the hierarchical character of the

divisions; the ideological outcome is to preserve the notion of a pure science unsullied by the marketplace. At the same time, the difference between “pure” and “applied” science retains the concept of the neutrality of at least one branch of scientific research.

The organization of scientific research takes place on the same basis as the organization of industrial labor. At the pinnacle of a research project or institution there is a manager; in the university, the site of much of what is called pure science, this person is a professor and is considered a working scientist and teacher. But, as a manager, this individual has a specific set of responsibilities that correspond to those of any other superintendent: raising funds for the research, hiring and firing professional and technical staff, and equally important, maintaining relations with the administration of the university, the funding source, and the scientific community at large. He is an administrator/politician whose skills range from those of persuasion to repression. Often, he becomes a manager as a result of his stature in the field of inquiry, usually gained years before his academic ascendancy. Thus, he becomes the logical person for the managerial function because he belongs to the social network called the scientific community and the academic community. His ability to maneuver within bureaucracies is made possible by years of sitting on committees, including review panels for the National Science Foundation and other agencies where he has gained contacts. When he writes a research proposal, scientific bureaucrats and university administrators are inclined to accept it because they know him to be a normal scientist who is also an effective negotiator and operator.⁷

I have already remarked that scientific research is no longer the province of individuals; it is now a vast social, economic, and political enterprise. In the first place, it is located in mainstream institutions of society: the universities, corporations, and “independent” institutes, often connected to both schools and business. The nature of the research process in both the pure and applied branches is connected to the use of high technology equipment amounting to several million dollars for even modest projects. Often the equipment is nontransferable, that is, cannot be used for other projects because it is designed for specific experiments, by scientists working on the project. It is not unusual for many projects to be funded as joint ventures among several institutions who are similarly connected to government agencies and the scientific establishment.

Each project is organized as a job hierarchy below the principal investigator, or manager of the project. Research scientists fall into two distinct groups within universities: the academic faculty, whose major responsibility is to work on the project and whose ancillary task is teaching, and a growing number of researchers hired for the individual project, possessing no academic standing. These are usually postdoctoral fellows or migrant employees who are hired on contract and who perform their duties at the direction of the faculty members or directly under the principal investigator. Often their activities do not differ from those of other researchers on the university faculty, but even if they are included as authors when the results of the project are published, this may not be significant for their careers.⁸

The homology between migrant construction or farm workers and many scientific researchers does not refer to the type of work they perform, but to their social position

within the scientific project. Even if highly paid, they are never integrated into the “scientific community”; their relationship to the institutions of primary research is always tenuous because they are only part of the “team” for the life of the contract. Thus, their influence is usually confined to the single project. They are often assigned specific tasks within a much larger investigation, which, however complex and based on their sophistication about the major issues in the field, is largely controlled by those with stable ties to the scientific establishment, including those institutions charged with the bulk of research.

Graduate students in physics, chemistry, and biology occupy an ambiguous position with respect to research. Typically, their work is linked to their doctoral dissertation. In turn, the choice of both field of inquiry and object is defined by their thesis director, who may be either an academic member of a research team or a manager. The function of the doctoral study in the sciences, as in the social sciences and humanities, remains primarily to constitute a rite of passage into the field. But the natural sciences, and increasingly the social sciences, possess more power than other disciplines to ensure that the candidate has internalized their ideological precepts. Since the process of knowledge acquisition is far more collective, the research project is the scene for the reproduction of the scientific laborer as much as the production of knowledge. The graduate student is obliged to accept a thesis director who not only advises on intellectual issues connected to the research topic, but selects the topic, supervises the methodology of inquiry, and manages the process itself. The graduate student is often completely under the domination of faculty, which not only approves the results, but intervenes at every step of the research to ensure that the intellectual canons of the scientific community are observed.⁹

Thus, the process of paradigm maintenance is built into the training of the graduate student in the sciences, since the student is already a regular member of the research team and the dissertation consists in little more than a report of results of one segment of the project, reconceptualized in academic terms so as to meet the requirements of the university. This merging of the academic process in the sciences with the research functions of the university serves to undermine any critical function of the academy at its foundations, because the social organization of scientific labor at the micro level conflates learning with performance. The concept of critical distance associated with the acquisition of theoretical knowledge is foreshortened by the increasing tendency of social and natural scientific graduate study to be integrated with research projects that are commissioned by the government and by private foundations or are indirectly (or directly) associated with product development for private industry. In many sciences where the experimental activity depends on the availability of fairly expensive equipment, the learning process for students takes place within the framework of research projects even if the research takes place on the university site. Access to up-to-date equipment is limited to those who participate as members of the research team.

This rule is equally true for the social sciences which increasingly employ computers for calculation and data gathering. As quantitative methods become more “normal” in the social sciences in comparison to older qualitative research methodologies

such as ethnography, the whole enterprise of social scientific research, in both universities and private or government research institutions, is bound up with norms of natural science. Although it is still possible for students to enter the social sciences without being committed to its positivist objectives, it is increasingly difficult to complete graduate degrees in most major universities without participating in funded research projects. It is not only that the student is obliged to learn certain methods that imply scientific ideologies or paradigms. The basis upon which degrees are granted is increasingly bound up with such research as is currently funded by the government or private foundations. In sociology, economics, and political science, most funded research contains explicit or implicit policy outcomes. The mobilization of the social sciences for purposes of helping to shape and evaluate social policy has become characteristic of research since World War II. The research is linked with instrumental ends that become disturbing for the social sciences, and much of the research is fragmented, narrow, and, in the last analysis, remains part of system maintenance. It is not uncommon for large grants to be made for social research on drug abuse, alcoholism, child abuse, and criminal behavior. These areas are selected by funding agencies on a relatively arbitrary basis: the topic has become politically significant; the “public is clamoring” for solutions. Federal, state, and local governments are under pressure to “do something.” The task of research is either to legitimate a series of preselected responses by providing a “scientific” veneer for policies, or to help guide political and social agencies in the selection of options.

Very little of this applied research has the time, the money, or the inclination to challenge the presuppositions of these topics, although individual researchers sometimes become critics of the categories and institutions associated with these practices. For example, can the causes of crime be discovered on the basis of data that focus on individuals, or even local environments such as neighborhoods? Or, to be more far-reaching, does crime have a cause? Or, do we have an adequate definition of what we mean by crime, that is, is it a discontinuous set of behaviors and attitudes that can be separated out from the complex of activities that make up daily life within society?

Social research devoted to discovering the causes for criminal behavior often selects the wrong object (the individual), makes the assumption that crime can be abstracted from a larger series, and that the medical model (treatment) may be applied to its cure. Thus, much of the debate in what is called in sociology “deviance” centers on options that are circumscribed by these viewpoints. Students who select “deviance” as their area of sociological study are provided with funds to complete their dissertation through their participation in projects supported by government agencies. In many cases, their adviser is principal investigator for the project and, as in physics and biology, sets the parameter for the student’s research; the student is then assigned to a particular segment of the project. Without this opportunity to work on the project, the student would be obliged to teach in undergraduate programs in order to earn sufficient money to write. Since many departments of sociology are oriented nearly completely to policy research, this student might not find an adviser, a necessary requisite for the dissertation. And, even if such a person could be found from among senior faculty, the burdens of being a teaching assistant or an adjunct for several courses might prove too difficult to

allow the student to do much writing and research. The induction of social scientists into paradigm maintenance, while not yet as overwhelming as in the natural sciences, is becoming increasingly common.

The managers, of course, are responsible for another, equally central function of research. They define or supervise the definition of the object of knowledge. Their position in the specialized field of inquiry is such as to enable them to determine what is an appropriate object of investigation as well as a fundable field of inquiry. This object is often technically divided, not only by the broad divisions such as between chemistry and physics, but even more narrowly. Within each scientific discipline, which defines the level of the scientific object, there are subdisciplines that define the field within the level. Examples of such subdisciplines are quantum theory, high energy physics, and cosmology, and even these have further divisions. Some scientists are trying to determine the properties of causality in relation to these fields, others to determine the properties of specific metals, particles, or waves, to predict their behavior and control their action in a field.

From the cognitive perspective of scientists, these fields appear to be a logical set that is generated by the progressive march of science. One “problem” is solved and another arises as a side effect of the solution. As we gain more knowledge, so many scientists believe, we are able to pose new questions that are now capable of solution by virtue of our prior knowledge. But even if this tells one part of the story, it remains an incomplete account. The division of scientific labor into sets of problems to be solved already implies that such categories of “prediction and control” form the presupposition of science. Its purity is mediated by the rational-purposive character of the scientific labor process. Problem-solving approaches to science are forms of fragmentation of the object. The subject, the scientist, has inserted herself/himself into the field of observation from the outset. Thus, science is a form of purposive action that proceeds from a rationality that is conventional, but that appears to have the force of natural fact. The progressive subdivisions within each level, or scientific discipline, already embodies the history of scientific interventions into nature. Nature has now been defined and subdivided in accordance with the social will of the scientific community as well as the corporations and the elite sciences, is organized within the boundaries of the social and technical division of labor analogous to any industrial enterprise. The organization of scientific labor is not a socially neutral process. And the determination of the object of knowledge presupposes this division of labor, the technical parameters of which correspond to those of any other branch of the labor process. Just as the assembly line is organized according to definite rules, preeminently that work is divided into a series of discrete, repetitive operations, and the function of management appears merely that of coordination of these fragmented tasks, so scientific labor is organized in terms of an object of knowledge that remains discrete and fragmented and is given significance only by its managers.

If Althusser is correct that theories, experimental method, and technique constitute the mechanism of scientific knowledge -- its internal apparatus, which becomes

the criterion, in the last instance, of the truth of its discoveries -- then one of the crucial tasks for an argument that wishes to oppose the separation of science, ideology, and social relations is to show the ideological character of the experimental method. The Copernican revolution has been supposed by most writers to consist in the first place in taking account of the observation of nature in the development of scientific theory. Its sufficient contribution to the history of science has been traditionally understood as the insistence that a scientific proposition can be verified (falsified) only by means of experiment. However, the experiment is an ambiguous activity.

The presupposition of all science, according to Karl Popper,¹⁰ is that no proposition may be said to be scientific unless it can be falsified by observation or experiment. Thus, no statements about the material or social world may be taken seriously if it cannot be reduced to a form that may permit the methods of experimental science to operate. This a priori is part of the apparatus of modern science, is closely linked to what contemporary sciences mean by theory: a theory is a proposition that can be verified (falsified) by experiment/observation.

Now, "observation" is not the same as "experiment" in the commonsense use of these terms. Observation usually implies the reception by the senses of external phenomena. But, for science, the term "observation" is linked to experiment; the scientist observes effects of experiments, or to be more typical, records results of experiments in numerical form. A theory is merely a hypothesis that can be quantified by means of observing effects recorded in numerical form. In these terms, the scientific observation of human behavior, no less than the observation of subatomic particles, is concerned with effects that are presumed to be accurate reflections of the intrinsic properties of the object.

The ambiguity of the experimental method becomes apparent when we remember that its preconditions include decisions about how the object of knowledge is to be constituted, not only by its classification according to levels and fields, but also in the setting up by the scientist of the boundaries of the experimental field. It is commonplace among scientists to reduce the number of variables to be observed to the least number possible because the ability to make sense of the observations is understood to be a function of this reduction. Thus, the second condition, after its definition, is to delimit the observational field by decontextualizing the object so as to facilitate the project of predicting and controlling behavior. I do not wish to dispute this procedure for the moment, merely to point out that such decontextualization implies that the category of interpretability has already changed the concept of observation to conform to the requirement of prediction and control. What is observed is the effects of an experiment on an object under certain conditions determined by the scientist and his/her apparatus. Of course, the investigator knows that decontextualization limits the claims resulting from the experiment. He/she often tries to model the environment within which the organism or object interacts within the framework of experiment. But the requirement for at least statistical probability for prediction and control restricts the degree to which the experimental method may be taken as an "objective" mechanism of knowledge.

Experiment is a type of human activity that is an intervention by the investigative team into “objective” processes. The forms of intervention entail the establishment of the context within which the object is observed; the machinery employed to produce the effects from which inferences are made according to theoretical presuppositions and from the rational-purposive basis of all modern knowledge. Werner Heisenberg’s indeterminacy principle attempted to preserve the objectivity of scientific theory by inserting the observer into the observation field and arguing for a science that recognized the problematic character of the results and included these in its calculations, procedures, and results. The instrument of observation must be taken into account in the measurement of the object as well as in the determination of its position, according to Heisenberg.

The philosophical implications of this argument have disturbed scientists and philosophers because claims of science to precise calculation of the movement of particles, and the integrity of the experimental method itself have been challenged by the revelation that the object of knowledge may be our relation with the object, not the thing itself. As I have shown in chapter 9, most physicists as well as philosophers have now been obliged to acknowledge that nature offers more than one option, depending on the theoretical framework in which the experiment is conducted. There is said to be a “degree of truth” in these determinate options, now called interference of possibilities. The framework adopted by the scientist to understand the results of experiments will make the result itself.

Largely because of the development of quantum theory, modern theoretical physics, at least, has been forced to work with uncertainties. The experiment is one valid means of knowing the external world, provided we understand that knowledge depends on its theoretical presuppositions, which are taken as no more than possible explanations for the characteristics of matter.¹¹

The crisis in science has occurred because of the challenge posed by Heisenberg and others to its positivist assumptions, particularly the notion that the relation of the observer to the observed is unproblematic. When Heisenberg reduced to mathematical language the simple notion that what is observed depends on the apparatus of observation, that is, depends on experiment, the scientificity of science was thrown into question. In the 1930s and 1940s, some, like James Jeans and Arthur Eddington, took these discoveries to mean that nature was, at the bottom, a mental construct, or at least was unknowable. Others understood Heisenberg’s principle as an invocation to further limit the variables, to further narrow their field of observation, or to calculate the impact of the mechanism of experiment and make their results more probabilistic.

Since we can only calculate effects and infer causes, control and predict behavior by constituting the object of knowledge theoretically and changing it in the process of our intervention, I argue that the so-called laws of nature are better described as laws of science. Scientific theory describes the relation of humans to the object of knowledge, not the objects themselves, taken at a distance. Further, our knowledge of effects is always mediated by the logic of scientific discovery, e.g., by its concepts of causality as a part of the apparatus of discovery.

Linear causality assumes that the relation of cause and effect can be expressed as a function of temporal succession. Owing to recent developments in quantum mechanics, we can postulate that it is possible to know the effects of absent causes; that is, speaking metaphorically, effects may anticipate causes so that our perception of them may precede the physical occurrence of a “cause.” The hypothesis that challenges our conventional conception of linear time and causality and that asserts the possibility of time’s reversal also raises the question of the degree to which the concept of “time’s arrow” is inherent in all scientific theory. If these experiments are successful, the conclusions about the way time as “clock-time” has been constituted historically will be open to question. We will have “proved” by means of experiment what has long been suspected by philosophers, literary and social critics: that time is, in part, a conventional construction, its segmentation into hours and minutes a product of the need for industrial discipline, for rational organization of social labor in the early bourgeois epoch. To be sure, we may discover that time’s arrow is inverted and that the evolutionary assumption of the progressive nature of time possesses only a “degree of truth” insofar as it is one possible option in answer to the question about the complexity of temporality. But so was the older theory of time and causation “experimentally” verified.

Since our knowledge of the external world is gained principally by theoretical construction and experiment, and since the purpose of experiment is not the verification of hypotheses in an abstract sense but the prediction and control of external phenomena, the masked basis of experiment is domination of nature and of humans. Prediction and control are presupposed in the language of science-mathematics and statistics. Mathematics is understood by scientists to be necessary to remove the ambiguities of ordinary language, to gain a degree of precision in the description of results and the inferences about the internal construction of the objects of knowledge. There is an “intrinsic uncertainty in the meaning of words,” in Heisenberg’s view,¹² a conclusion that already prompted Aristotle’s solution to this problem by investigating the formal structure of language and “conclusions and deductions” independent of the content. Aristotle thought that formal logic would lay the “solid basis for scientific thinking.”¹³ That “solid basis” could be obtained only when form was abstracted from content and when the relations of these forms were expressed symbolically. The separation of quantity from quality is intrinsic to the constitution of the physical and chemical object in the reduction of all observations to their mathematical, that is, symbolic, form. I have argued that the logic of these relations has historically obeyed rules that are not ideologically innocent: they are linked to the attempt to achieve dominion over nature in order to satisfy human ends. In turn, these ends are mediated by social relations, by the further mediation provided by the scientific community, which operates according to rules of evidence and canons of truth that are part of the legacy of Western logical thought.

The implications of modern developments in theoretical physics have called into question the logical tradition because new ideas such as “coexistent states” and “uncertainty of possibilities”¹⁴ seem incongruous with the loss of contradiction and mutual exclusion. Heisenberg has discovered that the logical principles that underly

mathematical symbolization are no longer in a relation of simple correspondence to nature. The concepts derive from the theoretical ambiguity of physics, its noncorrespondence with nature, which Heisenberg has called the “limits of the correlation” between the older languages of classical physics and the new concepts soluble only if

one confines the language to the description of facts, i.e., experimental results. However, if one wishes to speak of the atomic particles themselves, one must either use the mathematical scheme as the only supplement to natural language or one must combine it with a language that made use of a modified logic or of no well defined logic at all.¹⁵

When science digs into the areas of “potentialities or possibilities,” it has left the world of experimentally adduced facts or things, and the old logic must be abandoned.

If natural language is filled with meanings that defy precision and thus make control and prediction difficult, the language of control, mathematics, contains within it a limit on science. The questions within scientific theory that imply a logic that defies the formal categories of space and time and that have renounced, however implicitly, the rational-purposive, i.e., experimental, basis of investigation, lead to the discovery that ordinary language, precisely because of its undecidability, is more suited to these issues. Experimental methods, the results of which are formulated in purely quantitative terms, may not be abandoned but must be placed in a subordinate position to speculative science frankly concerned with a reconceptualization of all the fundamental presuppositions of the old science.

Despite his intentions to preserve the heuristic value of experimental, mathematical science, Heisenberg opened a Pandora’s box: he began the process by which physical science must become reflexive, that is, must recognize its own presuppositions as interested, that is, as ideological. A scientific practice that forces research to subordinate itself to a normative a priori of prediction and control is prevented from reformulating the object of knowledge in ways that may be suggested by the anomalies arising from its own methodology. The presence of measurement in the observational field, that is, the objectivity of mediation, the challenge to time’s forward direction, which questions conventional theories of cause and effect as a temporal series, the self-limiting character of quantitative a prioris to research -- these may not result in the formulation of a new paradigm as long as science remains entwined with the requirements of domination. Such questions will remain on the margins of normal science, relegated to the purgatory of projects that are poorly funded, or worse, regarded as secondary priorities in the organization of scientific research, subordinate to defense requirements, or the construction of bigger and more efficient machinery to “treat” conditions such as heart disease and cancer that have become a concomitant of industrialization. Of course, the establishment of priorities for scientific research is common to all nation-states that manage science and technology. These priorities embody the economic and political programs of these states, are formulated in terms of technical problems that require solution for the benefit of the entire society. But, as certain branches of science stumble

on anomalies that cannot be fitted into the existing ideological presuppositions of science, not merely the particular paradigm, the question of the internal processes by which new paradigms are formulated is thrown into doubt.

Take the question of medical science. In the United States, millions of dollars every year are appropriated by government and private corporations to find “treatments” for diseases whose “causes” are related to the entire matrix of social existence within our society. The object of knowledge is defined as the human body, not principally the quality of social life. Research institutions employ a virtual army of scientists, engineers, and technicians to discover chemical treatments for these diseases. The experimental method dictates that medical treatments be tested on animals under laboratory conditions. Researchers also test hypotheses about the causes of the diseases under the same conditions. Causal factors stemming from the “external” environment, such as the relationship of cigarettes and industrial pollution to cancer and the relationship of stress produced by insecurity and tension arising from working conditions to heart disease, are acknowledged but studiously avoided as the object of knowledge. The scientific object is the effects of these conditions on the human body, which, in the last instance, constitutes the limit on scientific inquiry related to medicine. For medical science is confined to the study of the human body, even if practitioners may take external factors into account. Thus, the question of defining the causes and cures of infirmities finds its parameters within the characteristics of the body itself. As a result, medical science, more or less willfully, defines its tasks in terms of ameliorating the effects of a social system that produces disease. In effect, within a system where rationality is determined, in part, by the criterion of capital accumulation, the rationality of scientific research on disease cannot be in conflict with the larger rationality without risk.

Even late capitalist and state socialist science has been required to study the degree to which the rationality of capital accumulation affects the physical environment. But, because of the social divisions within the sciences, these questions are not the province of medical research. If studies of the impact on the biosphere of the use of some types of spray cans show that these devices should be banned, government regulation may prevent the entire species from becoming extinct. Yet, medical science may not adequately study the degree to which repetitive labor performed at a killing pace should be stopped to prevent heart disease, or whether certain materials that pollute the work environment with carcinogens, such as some types of plastics, should be declared illegal. Funds for medical research dealing with the prevention of disease by social means are far less available than funds for research treating the individual as the object of knowledge. Medical research in the United States is confined almost wholly to discovering treatments for diseases already presumed inevitable. Occupational health-related research comes regularly under severe political attack by large corporations that may be forced to change labor processes and equipment, both with respect to what is produced and with respect to how production is conducted. Managers of medical research projects internalize the attacks by avoiding such subjects as may be considered unlikely by funding sources, by media, and finally by their own professional communities.

Nevertheless, some preventive medical research goes on, and its results are published and sometimes disseminated beyond the networks of professional science. But environmentally related research of all types occupies the margins of medical science. It is not considered “sexy,” except when its results show that specialization and segmentation have gone too far, that it is sometimes in capital’s interest to pull back, either because popular movements have exerted political pressure or because the legitimacy of the state and the corporations has been undermined, as was the case with the food scandals of the early twentieth century.

The case of medical science illustrates the ideological content of science, the degree to which science is constituted by social relations. First, the object of knowledge perpetuates the division between the body, the mind, and the external environment. Second, the technical division of labor within medicine segments parts of the body so that research is often directed to discrete characteristics of each part that may be susceptible to disease, without considering the relationship between these and the body taken as a whole. There are exceptions to the extreme rationalization of the body into fragments for the purposes of study; but, for the most part, medical science accepts the invocation to reduce the number of variables within its experimental methodology to a minimum. This reduction of variability, of course, becomes ideological insofar as it induces an epistemological perspective which does not conform to the way in which the human being acts in the world, but which sets internalist boundaries that conform to the precepts of normal scientific inquiry. Thus, the chemistry of the body is a legitimate object; the work environment is not.

Third, medical science, by dealing with effects of absent causes, produces treatments that are often detrimental to the rest of the body. The “side effects” of medication are understood by specialists as unintended consequences of certain remedies. Since the object has been so narrowly construed, chemical treatments often produce more problems than they resolve. And, since the mind/body split has, for the most part, been preserved in medical research, or, to be more precise, the problems of the mind are increasingly reduced to the body, mental illness is treated as a problem of chemical imbalances, skewed metabolism, nutritional aberrations, or some other type of physical mutation. For a brief period after World War II, when ego psychology became fashionable among middle strata groups, the reverse tendency was observed. For numerous physicians as well as social workers, teachers, and nonprofessionals, many diseases could be traced to “psychosomatic” causes. The psyche was believed to produce everything from the common cold to heart disease. But this psychological reductionism was just the other side of physical reductionism.

Of course, there is a great deal of validity in both perspectives. The division of labor within science has blinded each to the dialectical relation of the body to the mind, their indissolubility. Most medical research cannot conceptualize the notion of a body-subject, that is, a body that acts in the world and has both conscious/unconscious sides which constitute physical as well as mental functions. Even if such “unscientific” conceptions could be formulated, research that began from this relationship would

encounter difficulties gaining support, because of the difficulty in reducing such conceptions to discrete experiments and in quantifying the results.¹⁶

Yet, the consequence of our understanding of pathology resulting from the mind/body split, the methods of normal contemporary science, and the reductionist ideologies has been to perpetuate the “mysteries of the organism.” Despite the fact that billions of dollars are allocated for research that seeks to develop elaborate chemical treatments, which may disturb the internal relations within the body, or to construct machines to deal with symptoms, medical science is imprisoned by its own ideology. It still operates on the basis of linear causality and has been unable to find “cures” for diseases that have no simple origin. Yet, there is no prospect for immediate change: large-scale research will continue to search within the fragmented body for the secrets of disease, for the one vaccine or chemical cure for our maladies, in the hopes of avoiding social or preventive medicines.¹⁷

Of course, as critics have shown,¹⁸ the expansion of a misdirected medical research establishment is predicated upon the political pressure of large drug and machinery corporations, in alliance with hospital associations, research institutes, and the dominant forces in the medical profession who control these medical institutions. Yet, it would be a mistake to attribute all the problems of scientific research to the power of these institutions. Political and economic power must be linked to the reproduction of an ideology of science, in this case ideological presuppositions for the discovery of causes and treatments of diseases. For, even if “profit” was taken out of medicine, it does not follow that science would immediately turn to a more integrated, dialectical view of its object. As the experience of those countries in which the private ownership of capital has been abolished shows, the transformation of science and technology entails the transformation of the epistemological as well as the material foundations of science.

It is time to summarize the discussion of the relation of science and ideology. I shall follow it with a discussion of the problem of the truth in relation to ideology. My central thesis that science may not be considered a separate discourse from ideology depends on the following propositions:

1. The concept of the science/ideology antinomy is itself ideological because it fails to comprehend that all knowledge is a form of social relations and is discursively constituted. Within late capitalism and state socialism, these relations are organized according to a division of labor (principally the division between intellectual and manual labor). The rational-purposeful basis of social production under both capitalism and state socialism means that science is a labor process as well as an ideology whose truth claims are entwined with the interest of domination. This ideological function is revealed in at least five ways:

- a. The choice of the object of knowledge or inquiry is determined by the complex of economic and political alliances made between scientific institutions, corporations, and the state. These have a virtual monopoly of the means of scientific production and dictate, more or less completely, those projects that may be supported. This monopoly does not preclude funding occasional projects that depart, in one way or another (although never in toto), from the canon of normal science. But these are always relegated

to exceptions, whose function is to legitimate normal, incremental science. Contrary to Kuhn's ascription of paradigmatic change to internal developments within science, particularly the relation of experimental results to accepted scientific laws, since science as well as technology are entwined with the relations of power, these changes will always be constrained and configured by social and political influences.

b. But although the end of the alliance of science with corporate and state institutions and technology is a necessary condition for an emancipatory scientific theory and practice, it is not a sufficient condition. As Marcuse has reminded us, after centuries of reproduction of society according to division of classes and the division of labor, we have internalized, even introjected, domination.¹⁹ Specifically, this means that the object of knowledge has been constituted according to the social division of scientific labor (physics, chemistry, biology, psychology, and human sciences), and these categories are considered separate objective levels of natural and social reality, rather than necessary but partial abstractions from the totality of social existence.

Second, the object is constituted by a technical division of labor, where specialization of tasks within a field determines the perception of the investigator, such that a fragment is defined as the object, taken out of its natural context for the purposes of study. The result of this fragmentation is to impute characteristics to an object, discovered under certain circumstances but taken as intrinsic to the object.

c. Ways of knowing in contemporary science are discursively produced. The experimental method is not an "observation of nature" free of presuppositions. It assumes (i) that the abstraction of the object from its natural context is unproblematic, (ii) the intervention of the observer into the observed both by measurements that produce certain "effects" from which inferences are made, and by producing "causes" of the effects, such as by applying electrical currents of certain frequencies and magnitudes in physics, by inoculating animals to produce symptoms from which causes are inferred, and so on. The assumption of intervention is only part of the reflexivity of science to the extent that it tries to "correct" for its ingression. But the experimental method must be recognized as informed by its presupposition of intention, that is, the control of nature and humans so that their action may be predicted. Its claim to value neutrality is vitiated by the degree to which behavioral hypotheses or symptomatic readings are endemic to scientific inquiry.

d. The form of the results of science is historically located in the formal logic of Aristotle, which tried to understand forms of nature irrespective of their particular content. Galileo's doctrine that the "book of nature" was written in the language of mathematics was the logical culmination of this attempt to reduce nature to a form that permitted its predictability and control. But mathematics as the hegemonic form of scientific discourse constitutes a boundary to science. To the extent that knowledge is inextricably linked to language discourse, it generates a set, an internal unity that excludes those questions that require natural language and do not rationalize anomalies in terms that reduce signification to their technological dimensions. The separation of quantity from quality is linked to the divorce between means and ends. For example, a society wishing to "use" the results of science to serve class-determined or class-mediated human

ends requires science to take a form in which it may be infinitely fungible. Even if the ostensible purposes of research are not instrumental in the immediate uses of results, the quantification of results lends technical significance to the research. Under present conditions, such technical uses are almost always connected to social and natural domination or profit.

e. The development of conventions that are legitimated and reproduced within the scientific community determine what is called truth, and what is acceptable as science. These conventions are not separate from the paradigms of scientific knowledge, which may be seen as both the presuppositions and the outcome of the systemic requirement that certain traditions of inquiry, methods, and forms of results be followed. The observance of the conventions is just the other side of the rituals and credentials that are preconditions for entrance into the scientific community. Thus, no less than any other specialization in the division of labor, the scientific community regulates entrance requirements, conditions for membership maintenance, and power relations within the community. Since the entire machine of scientific investigation presupposes the social relations of the prevailing mode of production, the project of transforming science must be consonant with the project of transforming social relations.

2. The struggle for the transformation of ideology into critical science is a project in our period which is made possible by recent philosophical work. It proceeds on the foundation that the critique of all presuppositions of science and ideology must be the only absolute principle of science. Thus, a reflexive science is radically opposed to “normal” science that takes its ethical, epistemological, and methodological foundations for granted. Althusser’s Freudian metaphors have validity insofar as change can take place only when what occurs behind our backs is brought to our conscious view, that is, when science takes itself as its object.

Since the turn of the century, when it became apparent that capitalism had undergone a fundamental transformation in its structure and material/ideological practices, those who wished to preserve Marxism as a living socialist philosophy and critique of capitalist society have tried to comprehend the character of the changes and to discover their implications for Marxism itself. The Frankfurt School, which tried to integrate Freud and Weber with a Marxist framework, made a serious effort to challenge the theoretical presuppositions of Marxism in the light of historical changes.²⁰ More recently, others have claimed that the historical conditions that produced Marxism have been surpassed by the integration of the working class into late capitalist society. As I have shown above in my critique of Habermas, such positions do not constitute a critique of Marxism from within but abolish its foundations by constituting a new scientific object. At the same time, whether in its French manifestations (the new philosophers) or its German expression, post-Marxism, since it cannot identify the motive force of history because it has abandoned the category altogether, is left with a new positivism. For those who have abandoned agency as a vital historical category, there are no conditions for the transformation of society. All critical theory may do is refine the categories of the eternal, reified present and wait for the “will” of humans to take care of the rest. But Gouldner is right to point to the historicity of Marxism, especially its nineteenth-century insistence

on the autonomy of science. For a critical theory cannot be critical of itself if its highest aspiration remains to achieve scientificity in the traditional sense. It is this aspect of Marxism that has generated the post-Marxist antinomies as much as the changed social conditions within late capitalism and the deformations of state socialist societies.

Historical agents are not necessarily personified in particular social categories, for example, industrial workers, scientists, or women. To approach the question in this way ignores the critique made by contemporary philosophy and social theory of Marxism, or, to be more exact, merely replaces workers with women, the Third World, or whatever. What is at issue here is the discovery that agency is produced discursively and that people attach themselves to certain discourse because these offer a vision of an alternative to the system of production and reproduction of social life. I hope to show in a future work that the emergent agency today defines itself against the prevailing rationality, not within it, and this characteristic precludes the substitution of one group of personified agents for another, or the reform of the management system governing the production of either knowledge or things. For what is at stake in the struggle over historicity is the challenge to the dual system of domination over nature and humans, of which the prevailing division of labor is a crucial element, but also the entire system of social production and appropriation.

In short, the discourse we need to elaborate is already present in the various critiques of Marxism, liberalism, and conventional science.

3. Science and ideology have the same object -- the material world and social relations that have been produced by social labor considered historically. All relations with this world are mediated by material and social structures and the concept of unmediated relations that may produce knowledges that are independent of the social processes by which they were acquired is the ideology of science that draws its inspiration from the bourgeois protest against feudalism. Since the relations of science, magic, and religion are internal to each other because they all purport to offer adequate explanations for natural and social phenomena, it is rank ethnocentrism to claim that one may be privileged over the others without specifying the social-historical setting which under capitalism tends to subsume all discourse under its system of rational-purposeful action. Within this framework, modern science becomes a partner of industrialization, whose social consequences have both liberated us from the brute struggle with nature, but only partially, and imprisoned us in a logic of domination and degradation.

4. If science is ideological, what is truth? My argument leads to the conclusion that truth is the critical exposition of the relations of humans to nature within a developing, historically mediated, context. Within this critical project, the form of appearance of social relations is a unidimensional rationality that implies particular conceptions of space and time, causality, and construes the object of knowledge both discursively and socially. Thus, the laws of science are the laws of nature, providing one specifies the system of rationality within which they are discovered. Their reified "natural" appearance remains opaque without the weapons of criticism: we can discover the external world as a product of the collective labor of centuries, not by observation, but by the construction of a series of concepts that are contradictory to the certainty of the

senses that only report the surfaces. I am not claiming that critical science exists. Normal science, particularly the study of microphenomena, has also contained a critical dimension but is not, itself, critical, especially of its own presuppositions, for example, the discovery of the atom, which was theorized long before it was “observed,” and the hypothesis of the psychic structure, whose existence could only be inferred from a “reading” of symptoms. In the study of society, Marx’s theory of surplus value is, above all, a logical discovery; examples given to illustrate it are mostly “made up.” This does not imply that Marx failed to do detailed historical and empirical economic research. My point is that Marx’s theoretical framework was constituted by the relation of history to its conceptual foundations in dialectical philosophy.

But normal science is enslaved by its positivist presuppositions. Its structure of inquiry as much as its picture of the world makes it positive and descriptive rather than critical. For science and technology within its current framework to challenge its foundations would be tantamount to its self-immolation because it would be required to separate itself from the economic, social, and political conditions for its work as much as its epistemology.

5. What we call science and what we call ideology are distinguished in practice by the degree to which the acceptance of the ideology of science exempts it from being called ideology. “Ideology” is the general form of all human thought because social relations coded as discourse not only mediate but constitute thought itself -- the forms of discourse refer to the material world in ways that are demarcated from each other yet all appear as truth. The various moments of discourse appear as common sense. Ideology, in general, takes the form of discursive hegemony. The most general sense in which hegemony is exercised is the internalization of an entire conception of the material and social world by the population of a given social formation. The most powerful form of hegemony is inscribed in science, which is constituted both by its paradigms at the theoretical level and by the complex of institutions and material practices that are reproduced as self-focused and self-evident facts. Scientific ideology refers to a totality of forms of conceptualization that not only are reproduced as knowledge of the material world but take on the appearance of the material world, such that the opacity of things has the force of nature. The laws of science are perceived as properties of nature, bereft of their material and historical determinations and mediations.

Some Theses on Science and Technology

1. There are three key aspects of capitalism as a social formation: the universalization of the commodity form over all production; that is, production for exchange and for profit becomes the dominant rationale for investment of labor and money capital; the Industrial Revolution, in which machines become the central productive force, together with the technologies of the organization of labor; and urbanization, which is usually distinguished from medieval or ancient cities which were centers for regional and world trade in food. The modern city, now a site of industrial production, becomes the space of accumulation of capital whose main form is fixed capital, or machines and buildings.

Although scientific and technological knowledge play a crucial role in the development of capitalism, it is not until the mid-nineteenth century that intellectual labor (whose sole possession is knowledge) becomes a major productive force, partly displacing both craft and unskilled types of manual labor. In his *Grundrisse*, Marx already takes notice of this shift, which is still nascent even in England. The first half of the twentieth century is marked by the ascendancy of knowledge (if not of a new intellectual class) as the premier productive force. This transformation is manifest not only in the rise of the engineer as a key player in production, but by the advent of scientific management which seeks to both subordinate the manual labor force to its direction, and to impose systematic methods of control and organization over the state and the corporations. Management is an ideology to the degree that it seeks power on the basis of a new rationality that claims the mantle of science in affairs outside the laboratory and other traditional sites of scientific work; it is also a potentially competing community that challenges the hegemony of capital and the state, or, to be more exact, wants to impose its unique discourse on these hitherto autonomous sites.

By the first half of the twentieth century, neither science and technology nor management, the two most important forms of intellectual labor, had as yet captured more than the workplace, more than the sphere of production of things. Still to be conquered are the military and other state institutions, the crucial economic institutions of capital, principally financial agents and, more globally, cultural life.

2. The past thirty years have been characterized by the emergence of technology as the discursive formation that constitutes the dominant space of dispersion in industrial society. This entails massive impositions in (nearly) all social relations or discursive formations. Here, I define “discursive formation,” following Foucault, as a group of statements that form a unity. These statements include the formation of the knowledge object, the rules for investigation as well as the specific claims about the objects. To say that the discourse of technology is dispersed everywhere does not signify a kind of technological determinism in the older meaning of the term; what is commonly understood as “technology,” namely, machines or tools, do not constitute the determining element of social life. I am not arguing that means constitute ends in the modern world, or that the forces of production determine social relations. Instead, I understand technology as a constituted totality that drives production; more broadly, it is a type of rationality that (in Heidegger’s felicitous phrase) “enframes” scientific thought and also constitutes a sensorium, a field of perception. Further, technology is not merely an extension of human powers, “mediating” our relation to the external world, or nature, but has penetrated human character structure. That is, one may not sharply distinguish “emotions,” “feelings,” and other terms of interiority from the technological sensorium, just as science has become virtually identical with technology. This statement implies that we are wired, that the mass communication media, perhaps the most powerful technological achievement of this century, are neither extensions of collective human powers, nor an awesome otherness standing against us, but occupy the space of social life such that no relations -- those within the psychic structure, or between individuals, or among and between collectivities -- can escape the enframing of technology.

3. Technology is not an epistemic agent alone, although it is surely entwined with all forms of knowledge, including language and art; it is the discourse that modifies, when it does not entirely shape, objects as well as the rules of knowledge formation.

4. Thus, to speak of technology is to speak of culture; for the objects of the social world are not only constituted socially, in the sense that “natural” objects have been so severely mediated that to speak of physics, biology, etc., as direct causal agents in the social matrix appears naive. More to the point, technology as discourse defines social construction.

5. In turn, natural objects are also socially constructed. It is not a question of whether these natural objects, or, to be more precise, the objects of natural scientific knowledge, exist independently of the act of knowing. This question is answered by the assumption of “real” time as opposed to the presupposition, common among neo-Kantians, that time always has a referent, that temporality is therefore a relative, not an unconditioned, category. Surely, the earth evolved long before life on earth. The question is whether objects of natural scientific knowledge are constituted outside the social field. If this is possible, we can assume that science or art may develop procedures that effectively neutralize the effects emanating from the means by which we produce knowledge/art. Performance art may be such an attempt. The artist foregoes the use of tools -- brushes, chisels, cameras, as well as the raw materials (paper, stone, film) upon which are inscribed shapes, colors, lines. Performance art, like more conventional theater, attempts to restore to the body its autonomous space. Communication is no longer mediated by things. This might satisfy the antitechnological impulse were it not for the body itself, which is already incorporated into the technological sensorium. Movement is never natural; it is enframed in technology.

6. Science invented the algorithm of reproducible, testable experiments to screen out the social world, including the prejudices of the investigator, relations of domination and subordination in the laboratory, the pressures of the scientific community to conform to established paradigms, and so on. In short, the progress of science is presumed guaranteed by the requirement that any statement about the object be falsifiable by standard experimentation (Popper). However, if it can be shown that the experimental method presupposes a technological telos, the effort to achieve value neutrality in the sciences is unachievable unless this telos is, itself, considered value neutral.

7. The fact is, science and technology have been constituted as discursive formations, which, by definition, exclude the social and cultural world as relevant influences in knowledge production. Gaston Bachelard and Louis Althusser go so far as to claim that science is constituted by its separation from common sense (even though Stephen Toulmin defines science as “organized common sense.”) If organization may be related to technology as one of its modes of existence, science becomes a kind of technology. Popper’s definition, cited earlier, is to specify the criticism through organization as the metarule for achieving scientific truth, if by that term we mean knowledge uncontaminated by ideology. This is nearly identical to Bachelard’s program for verification, although Bachelard adds the requirement that criticism extend to the axiomatic foundations of science, not merely to theories operating within a given

paradigm. But, unlike Bachelard, Popper in his later work abandons the traditional epistemological assumption that knowledge is constituted through the interaction of objects to be known and the knower. For Popper, while this process may be entirely accurate as a description of how knowledge is gained, the “third world” of theories and propositions, which he calls epistemologies, stands independent of both the objects and the subjects who know them. Knowledge takes on an ontological existence and thereby itself becomes objective. This is, for Popper, the most reliable of the three worlds because its existence no longer depends on the fallible processes of acquisition. The theories have been tested, and the results have become autonomous. Clearly, Popper hopes to avoid the messiness of epistemological questions. By separating the processes of the production of scientific knowledge from their structure, Popper wants to remove behaviorist or psychological aspects from judgments about the contents of scientific knowledge. But, as David Bloor has pointed out in his critique of Frege, psychology is not really at issue when addressing the production of knowledge. More to the point is the question of social determinants, mediations, etc., of scientific knowledge. What we want to know is whether the products of the knowledge process, the representations called theories, propositions, and statements, can be shown to be independent of discourses of the social, cultural, ideological. We want to ask whether the products of science, notwithstanding the social processes that combine to construct them, are true. That is, can the thesis of realism be maintained with respect to scientific knowledge? The issue is not whether theories refer to an object. The question is whether that object is free of social construction, which, even if admitted, leaves no traces.

Bloor focuses his argument on mathematics, which Frege, following Kant, regards as not an abstraction from objects but as derived from pure intuition. Popper, following Brouwer’s suggestion, disputes this by asserting that mathematics uses discursive, particularly logical, thought.²¹ He has not escaped Kant’s invocation of the mental sources of mathematical knowledge. Bloor’s argument is that while Frege is right to reject the contention that the products of mathematics are derived by abstraction from material objects (such as pebbles), he also rejects the idea that arithmetic has no source outside mind. Bloor substitutes social for psychological and “material” determination of mathematical knowledge. He adduces several examples culled from the literature on the philosophy of mathematics to show that many ideas correspond not to scientific necessity but to cultural influences. In this, he follows Spengler’s and Wittgenstein’s concept that different cultures will produce different mathematical concepts. We can show that evolving concepts in the theory of numbers as well as other branches of mathematics vary according to influences already present in a culture. Taking the evidence of Evans-Prichard’s famous study of the Azande, Bloor disputes the idea that there can be only one logic. He argues that the refusal of the Azande to acknowledge the contradiction in their culture between the assumption that all are witches and the fact that this is not the case is not due to “a lack of theoretical interest” in the subject of logical contradictions. Rather, according to Bloor, the “logic” of the Azande in deflecting the contradiction is no different from “Western” logic that regularly denies that bomber pilots are murderers even though a murderer is defined as someone who deliberately kills

someone else. From the point of view of the society within which pilots function, they are seen as persons who perform their duty out of loyalty to the government. From the point of view of the victim, however, they are murderers since the victim experiences only the danger of death without the referent of duty to government. Bloor invokes this example to demonstrate that social interest mediates logic, and that the assumption that there is a “pure” logic separate from culture is false.

We don't have to stop with Bloor's perspectivist refutation of the notion of objective knowledge. Scientific experiment may be shown to derive from a specific conception of “value,” that of intervention into nature as the road to reliable knowledge. Or we might cite the problematic object of scientific knowledge, that the construction of the object has both cultural and political presuppositions. The point is that neither logic nor mathematics escapes the “contamination” of the social. What remains to be discovered is the nature of that contamination, its relation to the truth value of scientific propositions, and, most particularly, the role of science and technology in the social world.

8. Whatever our solution to the problems posed in Thesis 7, we are faced with the fact that science and technology remain subjects for intense discussion and disputation. These debates must be explained, for, since the nineteenth century, the advances in scientific knowledge have been supposed to eliminate the need for metaphysics, including a metaphysics whose field of discourse is science. Science should be able to “speak for itself” if its objects and methods preempt metacommentaries. All we need do, according to the most optimistic advocates of this position, is do science. Problems posed in the course of scientific inquiry/discovery should be subject only to solutions arrived at by those qualified to perform scientific activity. It is true that after Kant, with the exception of ethics, all philosophy is a discourse on science.²² Moreover, with the advent of logical empiricism and logical atomism, schools associated with the rise of what is sometimes called nonclassical physics -- the physics associated with relativity theory and quantum mechanics, although by no means identical with them -- problems in philosophy existed only to clarify the actual results of scientific inquiry at the level of language and discourse.

The distinction between philosophy, long viewed as a speculative inquiry, and natural science, in which speculation is strictly limited by scientific method to preexperimental hypothesis, has become increasingly blurred. For, just as philosophers have confined their work to interpreting scientific outcomes, scientists have felt constrained to become philosophers to make sense of their own work. Apart from a few relatively isolated figures (Alfred North Whitehead comes to mind), philosophy has been transformed into metascience, illuminating the most general principles that are said to derive from scientific practices.²³ Philosophy is no longer magisterial in its ambition to be the most general of the sciences; philosophers either have become metamathematicians insofar as logical inquiry defines their intervention, or have tried to enter the still unresolved disputes within science.

Speculative philosophy refuses to go away, despite its intentions, because physics, mathematics, and biology, the three sciences that have generated the controversy, are themselves rent. Nonclassical physics continues to make discoveries, but

the actors cannot agree on what they have found. Or, to be fair, they are unable to render clearly the significance of the products of scientific discovery because the framework of understanding is in contention.

This framework is by no means self-evident: in the torrent of commentaries on the significance of quantum mechanics and relativity theory, one may discern wide differences, even among those most responsible for the discoveries. This is another way of saying that science proves incapable of speaking for itself with a unified voice. This is not particularly new. Since the so-called Copernican revolution, both philosophers and scientists have felt the need to interpret the results of inquiry.

9. Their central interpretations are these:

a. Scientific theories are descriptions dictated by the real world. Taken together, they constitute a picture of the world as it actually exists “in nature.” The quotation marks are used because there is a question concerning what we mean by nature. Since Copernican/Newtonian science insists that objects and relations must be explained by purely natural causes, the conception of nature means simply the object of scientific knowledge taken in its totality. For these purposes, we need not address whether the real is identical with something called “material” reality. For realists who have gone beyond the naive implications of materialism, the main requirement is that a theory refers to something outside itself. Referentiality is regarded as the sine qua non of theorizing.

b. There are no laws of nature, only laws of science. In this way of seeing, science is defined by the rules of inquiry, mediated by the level of development of (i) its theoretical apparatus and (ii) the material apparatus, i.e., technologies of inquiry. Since these mediations inevitably overdetermine what we mean by fact (that is, facts are always both theory and technology dependent), no individual fact can be falsified/verified by means of experiment without taking into account its referent(s) which constitute themselves as traditions that have become conventions of inquiry.

c. The significance of quantum mechanics and relativity theory is that scientific theories refer to the relation between the “field” of inquiry and the tools of measurement, on the one hand, and to subject/object relations, on the other. The first formulation takes the position that theory is “objective” knowledge in Popper’s mode; the second reformulates the proposition in terms of interaction and mutual determination, in the manner of hermeneutic/dialectical analysis. In either case, the intervention of the “observer” is inescapable in the constitution of the field (I use the term “field” rather than “object” because “facts” refer to relations and relations of relations, rather than things). The second and third interpretations assume that uncertainty, which results from overdetermination, is both the consequence of shifting referentiality of the field and the referent of the social mediated by the subjects who engage in the process of scientific inquiry. That scientific facts are constituted socially as well as technologically infers that science is an intervention in both senses. This means that the object is constituted as a relation between the ends of scientific inquiry and its means. As Fleck demonstrates, facts are produced, not discovered.

10. To the degree that human sciences aspire to scientificity, they have felt obliged to parallel the epistemological and methodological norms of natural science. But what

these are in dispute within the human sciences. Weber adopted the probabilistic, uncertain stance of his contemporaries in theoretical physics. His theory of unintended consequences and his reflexive methodological comments were enframed by the same epistemic that gave rise to relativity. In his Protestant Ethic, he protested against historical materialism's a priorism in accounting for both periodicity and change. Weber contended that each historical situation manifested its unique determinations depending on the conjuncture of discourses. Thus, he introduces the "principle" of historical specificity, which would argue, in terms of relativity theory, for the significance of the signifier as well as the referent in determining the nature of social relations. At the same time, Weber holds to the view that rationalization is the distinctive characteristic of modern scientific/technological society, including its thought forms. As Mannheim points out, this is a universalistic, quantitatively determined thought mode and is identified with the Enlightenment. In consequence, science is posed against magic and religion, which become marginalized in the bourgeois world.

Mannheim argues that the Counter-Enlightenment, or romanticism, is a deeply conservative movement. But its insistence on the return of the suppressed cannot succeed in resuscitating the "irrational" dimension and making a place for it in the modern world without, at the same time, unwittingly rationalizing this dimension. For, to consider the so-called irrational and expose the elements of its reason as system is already to submit to the scientific worldview, since the process of legitimation nearly always entails demonstrating that the "other" conform, at least in a great degree, to science. In this connection, one may cite the experience of parapsychology, psychoanalysis, and other suspect sciences. In both of these cases, the controversy surrounding their findings turns on whether they can be shown to conform to the canon of experimental method and deductive/inductive reason. Consequently, their advocates are obliged to argue that the discovery of the "irrational" can take place only by means of normal, enlightenment science. Only a few of their proponents, especially of psychoanalysis, insist on the methodological validity of hermeneutic/dialectic procedures of investigation.

Durkheim introduces a classical conception of society in his insistence that it be treated as a fact, that is, as indivisible object. Rules for sociological method are construed objectively, with the investigator standing outside the field of vision.

This dispute has set the terms of theoretical development in the social sciences since the turn of the twentieth century. Needless to say, "normal" Anglo-American social science follows the objectivist account of Durkheim rather than the hermeneutic or dialectical accounts of Weberian and phenomenological paradigms, whether neo-Marxist or not. On the other hand, recent social theory in France, Italy, and Germany roughly follows the prescriptions of relativity and quantum theory in their respective insistences on temporal discontinuities, spatial indeterminacy, and historical construction of discursive formations in social phenomena.

11. If this is so, we can reconstruct the concept of the unified field, that elusive goal of the sciences, in another way. The relation among physical, life, and human sciences is not one of determination, even in the last instance, of the physical and biological over the social. Rather, each achieves unities within macrospheres and

microspheres but not necessarily between them. Further, there is an epistemic space that spans different discourses within a specific historical era.

12. Anthony Giddens has proposed that ideology be disconnected from the “philosophy of science” in favor of a concept of ideology considered “as a positive term, meaning something like an all-embracing and encyclopedic form of knowledge.” Yet, he goes on to urge that ideology “should be reformulated in relation to a theory of power and domination.”²⁴ I take this to be another sense in which the term “ideology” may be employed. A third is to define it as lived experience, the unmediated formulation of judgment -- practical, “useful,” interested, but surely not “false consciousness” or “bad” science in contrast to truth.

We have three meanings of ideology. The first, against which Giddens poses ideology/power/domination, is entwined with the problem of demarcation, how to distinguish science (truth) from nonscience (myth, religion, etc). I entirely agree that this should be a nonproblem. But it is not so simple: science and technology legitimate their privileged place by claiming to be the single source of reliable knowledge; their power/domination emanates from establishing demarcation. An enterprise that wishes to call attention to the character of science as a constituted discourse must address the problem of the elements that make up science -- not only its “ideology” in the sense of worldview, but the neutrality of its practice in relation to issues of power/domination. If my thesis is right that, as Giddens says, the mode of signification is “incorporated within systems of domination to sanction their continuance,” then science cannot be exempted from this study.

13. Science is a language of power, and those who bear its legitimate claims, i.e., those who are involved in the ownership and control of its processes and results, have become a distinctive social category equipped with a distinctive ideology and political program in the postwar world. The relation of science to the state is still one of subordination in both capitalist and state socialist formations, but this relation is now under attack by knowledge communities which increasingly perceive, even if they have not yet theorized, the elements of their autonomy. That science communities routinely declare their neutrality on political matters, especially on questions affecting the content of scientific knowledge, demonstrates not only the character of scientific and professional ideology, but a studied naïveté concerning the implications of accepting resources made available by the state for research and their own role in establishing priorities.

At the level of the economy, it has been apparent for the last century that science is central for the processes of economic reproduction, the manifestation of which, as the recent development of the high-temperature superconductor demonstrates, is the intimate link between the motivation for scientific discovery and the desire for technological application. A similar example is provided by the current AIDS crisis with respect to medical research. From a small group of underfunded scientists, AIDS is rapidly becoming the hottest property in the medical field as the state mobilizes scientists to deal with the crisis. As with military-related research, state priorities have the force of inexorability: the recalcitrant independent scientist had better be prepared to sacrifice her/his career or work in some subfield for which only marginal support is required.

The scientist wants his/her work to be thought of as both esoteric and socially useful in the long run. Esoteric work carries status probably because it symbolizes freedom -- in the form of distance from the dictatorial marketplace. It is more difficult to get a position as a theorist in an esoteric subfield where only modest support is required (mainly just a salary; perhaps some computer time too) than it is to get a position in a subfield more immediately connected to technology, where heavy support is required. Compare solid-state physics and cosmology, for example. One third of the 11,000 physics graduate students in the United States are in the single subfield of solid state physics, and all of them will be able to get jobs in that subfield. Even though there are only a handful of cosmologists, they will have a harder time finding jobs.

14. In turn, we may not theorize the character of the state without understanding that science is the discourse of the late capitalist and the “socialist” state. Science is rapidly displacing, as dominant discourse, the old ideologies of the liberal state -- chief among them, possessive individualism, which was based on the dominance of the market in the economy and the conduct of political affairs. This development coincides with the consolidation of bureaucratic power, whose rationality parallels that of science, or, to be more precise, is the ostensible social form of scientific rationality. Therefore, an alternative science would have to imagine, as a condition of its emergence, an alternative rationality which would not be based on domination.

NOTES

Chapter 12. Toward a New Social Theory of Science

1. B. F. Skinner, *Beyond Freedom and Dignity* (New York: Norton, 1971).
2. Loren Baritz, *The Servants of Power: A History of the Use of Social Science in Industry* (Middletown, Conn.: Wesleyan University Press, 1960).
3. I use “civil society” in Gramsci’s sense, “the ensemble of organisms commonly called ‘private’ that “correspond[s] to ... the function of ‘hegemony’ which the dominant group exercises throughout society” (Gramsci, *Prison Notebooks*, New York: International Publishers, 1971). Clearly, I hold science as a crucial element of hegemony, but it is also, increasingly, integrated with the “dominant” group rather than constituting a counterhegemony or a neutral set of practices.
4. Paul Feyerabend, *Against Method* (London: New Left Books, 1976).
5. See especially “Categorical,” in Richard McKeon, ed., *Basic Works of Aristotle* (New York: Random House, 1941).
6. See *The New Science of Giavonni Bettista Vico*, trans. Thomas Bergin and Max A. Fisch (Ithaca: Cornell University Press, 1968); Hegel, *Preface to Phenomenology of the Spirit* (London: Oxford University Press, 1980).
7. I use the male pronoun deliberately to signify the prevalence of men in top scientific managerial positions. See Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale University Press, 1985).
8. The division between the theorists and experimenters has been ably described by Sharon Traweek. Theorists are the higher status scientists whose work is, partially, interpretation of experimental results.

9. This is especially true for major research universities.
10. Karl Popper, *The Logic of Scientific Discovery* (New York: Science Editions, 1961).
11. Werner Heisenberg, *Physics and Philosophy* (New York: Harper and Row, 1958), p. 9: “we know the object of scientific knowledge only by the speculative means of axiomatic theoretic construction or postulation: Newton’s suggestion that the physicist can deduce theoretical concepts from the experimental data being false.” This theory, in common with the Duhem-Quine hypothesis discussed in chapter 9, has, nevertheless, escaped most natural and social scientists as well as their philosophical acolytes.
12. *Ibid.*, p. 169.
13. *Ibid.* For Heisenberg, Aristotle “creates the basis for scientific thinking.”
14. *Ibid.*, p. 180.
15. *Ibid.*, pp. 183---84.
16. See Maurice Merleau-Ponty, *Phenomenology of Perception* (London: Routledge and Kegan Paul, 1964).
17. We can observe this phenomenon graphically played out in the current AIDS crisis. While the years of pressure for preventive measures, rather than for chemical treatments exclusively, have yielded some new educational initiatives by state and local governments, instrumental science is concentrating on finding out how the virus operates so that a serum can be discovered. When the ecological issues are addressed, discussion is conflated with new calls for sexual abstinence.
18. See, e.g., Vincent Navarro, *Medicine and Capitalism* (Baltimore: Johns Hopkins Press, 1978).
19. Herbert Marcuse, *Eros and Civilization* (Boston: Beacon Press, 1955).
20. Herbert Marcuse, *One Dimensional Man* (Boston: Beacon Press, 1964).
21. Karl Popper, *Objective Knowledge* (London: Oxford University Press, 1972).
22. And even most contemporary ethical discussion labors to make its discourse scientific, although there are significant dissents from this effort.
23. See Alfred North Whitehead, *Process and Reality* (New York: The Free Press, 1929, 1969). Whitehead, who with Bertrand Russell helped establish the basis of philosophy for a theory of science at the turn of the twentieth century, argues in the Preface for speculative philosophy as a legitimate activity. Moreover, within the framework of an ontology, he argues for the primacy of “relatedness” and “becoming” as categories over “quality.” Yet, there is no doubt that Whitehead’s speculative cosmology claims to be an interpretation consistent with the latest developments of science.
24. Anthony Giddens, “Four Theses on Ideology,” *Canadian Journal of Political and Social Theory* 7, no. 1---2 (Winter/Spring 1983), pp. 18---21.