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SCIENCE AS A SOCIAL INSTITUTION

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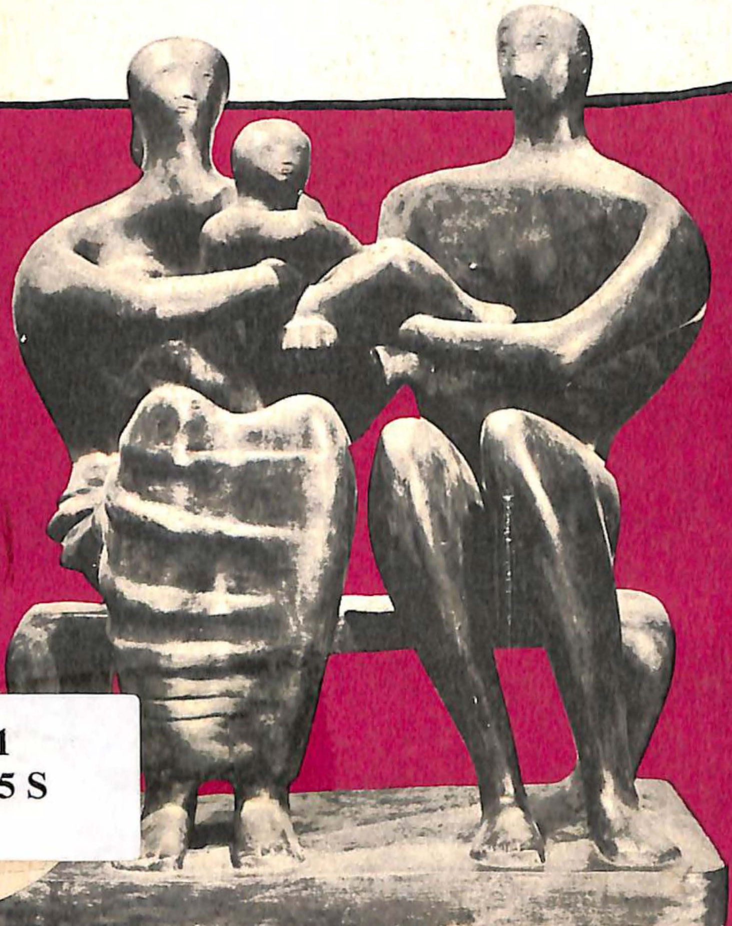

RANDOM HOUSE

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SCIENCE AS A SOCIAL INSTITUTION

Science as a Social Institution

AN INTRODUCTION TO THE SOCIOLOGY OF SCIENCE

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Editor's Foreword

Social science perhaps inevitably develops its own cultural lags. A case in point is the striking contrast between the spectacular rise of modern science as a major social institution and the short shrift given this subject in sociology textbooks. The latter, to be sure, include discussions of the nature of scientific method and viewpoint (and frequently chapters on technology), but, with very few exceptions,* they omit any systematic consideration of the institutionalization of science and scientific norms and of how science and scientists have become an inseparable part of a burgeoning and increasingly strategic organizational component of modern society. Surely today these matters merit at least the space and careful attention that the authors of numerous general texts devote to, say, recreational and educational institutions.

Nor is this neglect confined to introductory textbooks. Current sociological literature on the institution of modern science is almost confined to a few outstanding researches in historical materials, notably those of Robert K. Merton, occasional essays in professional journals, and, since its publication in 1952, Bernard Barber's excellent *Science and the Social Order*. Professor DeGré's study joins those writings in helping to reduce a conspicuous lag in the sociological enterprise.

DeGré's interest in the sociology of knowledge, attested by his earlier publications in this area, provides the focus for his treatment of science. Science is not only a method of certifying knowledge, and a body of testable theory and tested fact; it embraces a distinct point of view about all that it studies. But this mode of study and point of view are anchored in a set of values, themselves the product of diverse historical and cultural circumstances. The depiction, in the first two chapters, of the seventeenth and eighteenth century "constellation" of political, economic, religious, and

* Chapters on science are to be found in Richard T. La Piere: *Sociology*, New York, McGraw-Hill Book Co., 1946, and Kingsley Davis: *Human Society*, New York, The Macmillan Co., 1949.

ideological trends that shaped modern science is an important lesson in the study of social change, informed by the author's use of relevant historical investigations. And the subsequent analysis of the social role of the scientist and of his functions in modern society draws upon—and brings together so as to enhance the interpretation—leads from the works of such sociologists as Max Weber, Karl Mannheim, Florian Znaneicki, and R. K. Merton, as well as those of outstanding philosophers of science. Philosophical problems, as noted in the author's Preface, cannot be avoided in a study of this kind and are clearly discussed, though not resolved, of course, in the final chapter. Here, too, DeGré faces questions involved in the conception of "science as morality"* and clarifies issues rooted in the interconnections between the approach of science and the individual life.

Science as a Social Institution, then, brings into sharp focus several interrelated philosophical, moral, and sociological problems. These highly important problems have no easy answers, as Professor DeGré makes clear. But their presentation within a framework of institutional analysis and the precise conceptual apparatus employed throughout the study contribute substantially to its usefulness as an introduction to the sociology of science.

CHARLES H. PAGE

* Cf. George Simpson: *Science as Morality*, Yellow Springs, Ohio, The Humanist Press, 1953.

Preface

This study is to an extent an analysis of frontiers, in this case the unsettled border-line area that distinguishes but not quite separates the realms of sociology and philosophy. My topic is the sociology of science, which, provisionally defined, is the investigation of the way in which society and science reciprocally influence one another. As such, my subject forms part of a broader field: the sociology of knowledge. As is the case in studies of this area, problems of epistemology and the logic of science inevitably appear and must be confronted. Whether or not they have been faced successfully I shall leave to the judgment of the reader, who I hope will be stimulated to see his own sciences in a wider social and philosophical perspective.

I wish to acknowledge my indebtedness to the Institute for the Unity of Science for the impetus derived from its annual meetings to investigate this area of knowledge; to Professor Charles H. Page, for his invaluable editorial suggestions for improvements in organization of the material; and to my wife, Muriel DeGré, to whom this essay is gratefully dedicated.

GERARD DEGRÉ

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SCIENCE AS A SOCIAL INSTITUTION

CHAPTER ONE

Science and Social Structure

Language, Culture, and Institutions

When we examine the wide variety of institutional arrangements in which man, in his various cultures and societies, has demonstrated his capacity for social invention, we may at first despair of achieving anything more than a catalog of his curious customs. As long as man was content merely to record the facts of his everyday experience, no matter how meticulous the record may have been, he was not as yet producing science. His observations may have provided the raw materials of science, that is, the empirical data from which sciences might eventually be constructed. But not until he was ready to generalize about his experiences, to interest himself in a class of objects rather than in the particular thing at hand, in a word, to abstract from the world of concrete experience, did the possibility of a genuinely scientific approach emerge.

The preoccupation of prescientific man with highly particularized phenomena is amply illustrated in his language. With the few exceptions that can be found in any generalization, there appears to be a strong inverse correlation between the degree of cultural complexity (in regard to technology, institutions, and interaction with other peoples) and the tendency to use highly particularized nouns denoting specific objects rather than classes of objects. In cultures such as those of the Australian aborigine, the Chukchi of Siberia, and the African Bushman, there exists a rich complexity of noun forms. There may be, for example, a variety of words meaning "my house," "my mother-in-law's house," "my father's house," "my wife's uncle's house," but at the same time no word to express the abstract notion of "house" in general. Edward Sapir presents a threefold classification of languages into analytic, synthetic, and polysynthetic types, of which the last is the most highly concretized, defining these classes as follows:

> An analytical language is one that either does not combine concepts into single words at all (Chinese) or does so economically (English, French). In an analytical language the sentence is always of prime importance, the word of minor interest. In a synthetic language (Latin, Arabic, Finnish) the concepts cluster more thickly, the words are more richly chambered, but there is a tend-

ency, on the whole, to keep the range of concrete significance in the single word down to a moderate compass. A polysynthetic language, as its name implies, is more than ordinarily synthetic. The elaboration of the word is extreme.[1]

This last group of languages, the polysynthetic, especially illustrates the difficulty of arriving at generalized scientific assertions in those cultures whose approach to life is largely confined to highly particularized experiences. It is not that the language itself inhibits the development of abstract knowledge, but rather that both the paucity of scientific knowledge and the polysynthetic structure of the language reflect a type of culture that does not provide a congenial milieu for the elaboration of the abstract concepts that are a necessary condition for the development of the sciences.*

Anthropology has demonstrated that a functional approach to cultural phenomena can be highly fruitful in showing how the principal institutional sectors of social life exhibit a pattern in which the subsistence institutions, the familial arrangements, and the interpretations of man, society, and the natural world around him form a relatively integrated whole. The particular weight which is attributed to these factors of social determination may vary with the philosophical and methodological assumptions of the investigator. There remains, nevertheless, considerable agreement concerning the functional interaction of the institutional parts of the social whole which marks a particular tribe, people, nation or larger cultural region.

For our purposes the institutional patterns of a culture may be divided into three main categories:

1. *Primary institutions* define those established modes of procedure without which no society would be capable of maintaining itself. The most important of these include both subsistence and familial institutions: the first to keep the present members of the culture group alive by hunting, fishing, agriculture, herding, and the like; the second to provide for new generations of members, through marriage systems of polygyny, polyandry, or monogamy, as well as those institutions governing relations of parents and children, siblings, clans, gens, and so on.

2. *Secondary institutions* more clearly define the established arrangements and power relationships which emerge from the formalization and stricter implementation of the primary institutions. These include, for example, the economic systems of slavery, feudalism, capitalism, socialism, and others; techniques of political control, as manifested in types of authority, war, and government; and systems of class, caste, and prestige conferring social status.

* For a recent discussion of the social functions and implications of language, see Joseph Bram: *Language and Society* (Studies in Sociology), New York, Random House, Inc., 1955.

3. *Tertiary institutions* are oriented primarily toward man's attempt, through symbols, rituals, ideologies, and other intellectual and creative activity, to achieve a greater degree of understanding, appreciation, and control of his natural, social, and private world. Herein fall his art, religion, language, mythology, play, magic, and science.

This tentative classification and definition of social institutions provides some important clues for our investigation of science as a social institution.*

A sociology of science studies the functional interdependence of the sciences with the other aspects of man's larger culture, and at the same time the internal structure and dynamics of science as a tertiary institution, including its norms, organization, personnel, and status within society. But a short study of this kind cannot treat all aspects of a sociology of science. Its more limited aim is to demonstrate what may constitute a sociological approach to the sciences and to indicate important areas where a consideration of the social roots, as well as the social consequences, of a scientific world view may prove fruitful in understanding some of the more pressing problems of social structure and social change.

The Concept of Constellation

We have seen that, together with religion, mythology, art, and philosophy, science is a social activity through which a society interprets the cultural and natural world. As such, the sciences form part of the tertiary institutions of a culture, being influenced by the larger *constellation* of stresses and strains, cultural values, technological accomplishments and needs, and over-all definitions of life goals that characterize the social group, society, and world situation in which they are operative.

The term constellation has been deliberately selected to designate this complexity, for it provides us with a concept that is useful in arriving at a preliminary orientation to the basic approach of the sociology of science. In the first place, the use of the term constellation is in itself an example of how concepts derived from obsolete sciences, in this case astrology, may still have utility in the analysis of an entirely different order of phenomena. In its original astrological usage, constellation referred to the conjunction of astral events which, by occurring at the time of an individual's birth, supposedly in some way determined both his nature and the course of his life. The propositions and assumptions of astrology are no longer acceptable, of course, from the viewpoint of the modern sciences. Nevertheless, as Karl Mannheim has pointed out, the term constellation in a newer sense

* An informed discussion of the concepts of culture, function, and institution is provided by Ely Chinoy: *Sociological Perspective: Basic Concepts and Their Application* (Studies in Sociology), New York, Random House, Inc., 1954.

"may designate the specific combination of certain factors at a given moment, and this will call for observation when we have reason to assume that the simultaneous presence of various factors is responsible for the shape assumed by one factor in which we are interested."[2]

From this point of view the refurbished concept of constellation, divested of its earlier unverifiable astrological meanings, is a convenient tool. In the investigation of the social role of scientific ideas, it directs the investigator to examine their development in terms of the *constellation* of social and historical factors which determine their emergence at particular times and places, the reception which they obtain, and their larger effects on the economy, politics, and mores of the given sociohistorical situation.

When we view the sciences within their historical and institutional context, we can begin more fully to understand some of the paradoxes that the history of science presents. The classic example is the stultification of Greek and Hellenistic science, which, in spite of tremendous advances in the logical organization of its subject matter, always remained on the threshold of a modern world view. Farrington has brilliantly described in his *Greek Science*, covering about five hundred years of scientific thought from Aristotle (322 B.C.) to Galen (A.D. 199), the important strides that had been made in the assembling of empirical data, the classification of facts, the logical analysis of propositions, and even the beginnings of a theory of experimentation.[3] Yet the application of this growing body of knowledge to technological problems, to the further discovery of causal connections, to the meeting of agricultural and manufacturing questions, was surprisingly meager. Why was this the case? Farrington tells us that the causes that operated to inhibit the development of the potentialities of Greek science are not to be sought in individual factors, for the Greek men of knowledge certainly were not lacking in skills, talents, and intellectual powers. They are to be found rather in the structure of a social order in which "science had become a relaxation, an adornment, a subject of contemplation" of a privileged minority.[4] Underlying the divorce of scientific theory from the scientific practice of the time and creating a situation in which even "professions like those of architect and medical doctor were on the edge of respectability," was the slave system, which was well-nigh universal in the ancient and classical civilizations. The prevalent attitude that the pursuit of scientific knowledge was the special preserve of an educated leisure class, while the daily application of scientific empirical knowledge in such areas as mining, road building, the manufacture of dyes, and other technical pursuits was the business of plebeians and slaves, stood in the way both of the development of a more fruitful and empirically oriented scientific theory and a more rationally organized and conceptually sophisticated technological activity.

If we study the classical world in more detail, we are struck by the fact that a much larger amount of scientific activity was present in Athens and the cities of Ionia than in the military-agrarian city-states, of which Sparta is the best-known example. Here again our analysis is enriched if we focus on the constellation of factors that differentiate Sparta from Athens. Howard Becker provides us with highly pertinent concepts for such an analysis.[5] Sparta was a "sacred" society, characterized by a relatively high degree of mental immobility and isolation from other communities. Sacred means that Sparta was tradition-bound and strongly unreceptive to new ideas. This unreceptivity was tied up with the limited amount of contacts between Sparta and the outside world, the former subsisting primarily as a self-contained, agricultural-military community.

The contrast between Athens and Sparta brings out the consequences of the extended trade and colonization of the Athenian city-state. Here is the accessible, mentally mobile, highly secularized society, a society in daily contact with new ideas supplied by merchants from foreign lands, as well as the commercial contacts of Athenian businessmen in foreign ports. In the words of Becker: "Commerce and the stranger! They go hand in hand." In contrast to the deeply rooted suspicion which was felt by Sparta for the stranger, the Athenians welcomed the foreigner. The ideological role of the stranger cannot be underestimated:

> He brought with him new folkways, new mores; his frequent shifts of domicile strengthened his own detached commercial tendencies, and this detachment communicated itself to the peoples among whom he temporarily sojourned—not being himself emotionally bound by the established ties of kinship and locality, his cool disinterestedness came to lessen the unifying warmth of the in-group. He possessed a certain objectivity . . . He was free from local conventions . . . He subjected everything to rational scrutiny . . . thus practicing a certain habitual abstraction that caused him to acquire an intellectual bias and to communicate that bias to others. Surely there is some significance in the fact that the stranger . . . appears in conjunction with commerce, using "that most interesting of all abstractions, money" (Simmel), and with phonetic writing, then the most abstract of all methods of recording human speech. *Abstraction and mental mobility go hand in hand.*[6]

Here indeed was a cultural milieu in which scientific speculation could take root and in which a secularized viewpoint greeted with much less antagonism the attempts of thinkers to come to grips with the secrets of nature. Concerning social questions, however, the spirit of free inquiry ran into difficulties, as witness the trial of Socrates on charges of impiety. But even in this area we can be certain that the amount of social constraint to conform to the official mores and traditional norms was considerably less than was the case in Sparta.

These cases illustrate some of the basic concepts and a fundamental phase of the approach of the sociology of science. To examine science as a social institution means in the first place to consider it within the constellation of sociohistorical factors present in a particular culture. The course that science takes is not independent of the socioeconomic system in which it is enmeshed; thus a slave economy, we have seen, encouraged a science that failed to overcome the gap between theory and application, thereby stultifying both the theory and the practice. Within the same socioeconomic structure, moreover, the relation of a society to other societies has far-reaching consequences for its scientific development. The more a culture is exposed to new ideas through contact with diverse civilizations, the greater are its propensities to explore new areas of scientific investigation. The development of trade itself fosters increased knowledge in the sciences related to navigation, such as astronomy, oceanography, cartography, meteorology, and mathematics.

On the other hand, the development of the sciences is in continuous interaction with other segments of the thought system of a culture. The significance of the attitude of religious authorities and religious dogmas for scientific advances need only be cited here. The political power of the government both encourages and discourages scientific work. In recent times, industry has learned that funds made available for scientific research can pay handsome dividends. Most important of all, perhaps, the universities, in their commitments to the importance of research, have provided a congenial atmosphere for the accumulative development of scientific knowledge.

Our approach, then, incorporates the sociological conception of a dynamic (and partial) equilibrium of social institutions mutually interacting and developing within the larger framework of the socioeconomic structure as it exists in space and time. The historical dimension should never be neglected, nor on the other hand should it be emphasized to the point at which every social situation appears to be altogether unique. The task of the sociology of science is to develop concepts sufficiently abstract to permit different cultures to be compared in the analysis of their scientific institutions, while at the same time remaining sufficiently concrete so that the historical growth and interconnections within a specific society will not be lost.

The Medieval Constellation and the Beginnings of Modern Science

As in the case of other organized social activity, scientific work is not diffused throughout the culture and its population as a whole. Generally it is carried out by particular persons in specified places, within the framework of the institutionalized norms that define both the activity itself and its social function and status.

Science as a social institution incorporates both material and nonmaterial culture traits. With the development of the division of labor in society, specialized agencies such as the university, the observatory, the laboratory, and the research foundation are established for the purpose of training scientists and encouraging their work.

The rise of the great universities in the Middle Ages, coupled with the increasing scarcity of slave labor on the one hand and the fruitful interchange of ideas with the Arabic world on the other, provided a strong stimulus to scientific development. By the twelfth century, the traditional curriculum had been greatly enlarged to encompass a variety of technical scientific subjects:

> Thus theoretical arithmetic studied the basic principles of numbers used in reckoning by the abacus, as in commerce; theoretical music studied the abstract harmonies produced by voices and instruments; theoretical geometry considered the basic principles put into practice in measuring bodies, in surveying, and in using the results of observing the motions of heavenly bodies with the astrolobe and other astronomical instruments; the science of weights considered the basic principles of the balance and the lever. Finally, the science of "mathematical devices" turned the result of all the other mathematical sciences to useful purposes, for stone-masonry, for instruments for measuring and lifting bodies, for musical and optical instruments and for carpentry.[7]

This concern with the interconnections between the mechanical arts and the theoretical sciences stands in strong contrast with the viewpoint of most of the highly educated thinkers of classical antiquity, in which the social gulf between unlettered craftsmen and aristocratic speculative philosophers did much to retard the emergence of the empirical sciences. In this connection, it may be noted that three elements combine to create the most fruitful development of the sciences: first, speculative theories which provide the hypotheses for scientific investigation and the integration of factual observation; second, logicomathematical tools of reasoning which make possible the analysis, classification, and generalization of data; and, finally, but at least of equal importance, the application of scientific theory and logical analysis to the control and observation of the empirical materials of the external world. It was in this last, in scientific practice, in experiment, in techniques, where the Graeco-Roman intellectual world, in spite of its genius in theory and mathematics, failed the crucial test. This is not to deny the concrete achievements of antiquity in such fields as medicine, engineering, and applied mechanics, but rather to underline the inescapable basic contrast in point of view, in cultural values, which differentiated so markedly the Greek man of knowledge from his medieval and especially from his modern (seventeenth century to the present) counterpart.

Returning again to the medieval university, we are struck by the awakening emphasis on empirical knowledge. Crombie provides a wealth of examples taken from the twelfth-century institutions of higher learning. The medical school of the University of Salerno required for graduation a five-year course in human anatomy and surgery. At the University of Chartres, the arts course included in its reading lists a "high proportion of works on surveying, measurement and practical astronomy."[8] Not much later Oxford placed strong emphasis on mathematical subjects, not only Euclid's *Elements*, but astronomy and optics as well. Significantly, optics was studied from a text only recently translated from an Arabic source, Alhazen's *Optica Thesaurus*, and astronomy from what was probably Gerard of Cremona's translation (c. 1175) from the Arabic version of Ptolemy's *Almagest*.

An important consequence of this emphasis on mathematical reasoning and its application to empirical problems was that by its very practice the habit of abstraction and generalization so essential for the development of the sciences took root in scientific thought. Sociologically, the practice was rooted in the need for regularization of the affairs of Church, state, and commerce. The calendar of feasts and of the daily life of the monastic orders increasingly required more exact quantification of time, helping to bring about in the thirteenth century the mechanical clock with geared wheels. Of equal, if not greater, importance in furthering the growing interest in mathematical knowledge were the changes that had been taking place in the world of business:

> Commerce changed during the Middle Ages from a barter economy based on goods and services to a money economy based on abstract units, first of gold and silver coinage, and, later, also of letters of credit and bills of exchange. The problems arising from the dissolution of partnerships . . . and in connection with interest, discount and exchange were one of the chief incentives to mathematical research.[9]

This same preoccupation with standardization based on mathematical abstraction was reflected in other areas as well, especially in cartography, as shown in the extensive development of Portolan charts for the use of navigators, and in attempts to standardize measures of length, weight, and volume. A final example is to be found in the arts, where serious concern was shown for the mathematical problems involved in questions of perspective in painting, and in harmony, scale, pitch, and symbolization in music.

We can see, therefore, that the science of the Middle Ages arose from new sociohistorical conditions which gave it an orientation that had been largely (but not entirely) absent in the classical world outlook; that is, a greatly increased emphasis on the application of scientific knowledge to the solution of problems relating to the control of man over his physical environment. The strongest force in this changing emphasis appears to have been the breakdown of slavery as a source of power. The reasons for this breakdown cannot occupy us in this study. Suffice it to say that religious factors (particularly the attitude of the Church to slavery as unchristian), demographic factors (especially the depopulation of cities), economic factors (for example, self-subsisting agrarian communities) all played contributing roles. Second, the increased interaction of Christian Europe with the Arabic world made available a great new heritage of heretofore lost classical knowledge, as well as those extraordinarily important new tools: the zero and the Arabic system of number notation (earlier taken from the Hindus by the Arabs). Third, the revival of commerce with its attendant stimulation of thought by intercultural contacts, as well as the needs generated by commercial activity for standardization, quantification, and an improved marine technology constituted an essential condition for scientific growth. Finally, the growth of industry through the application of water power and wind power and new methods of harnessing animal power all further contributed to the rate of obsolescence of slavery and hence to the emergence of modern science.

The constellation of these factors produced, as we have seen, a new emphasis in the medieval university and a new type of scholar oriented to a much more intimate relationship of theory and practice in his scientific work. In the ideological sphere, the medieval emphasis on the rationality of God and the rationality of the natural universe emanating from the divine rationality, which finds its greatest spokesman in St. Thomas Aquinas, implanted, as Whitehead has pointed out, habits of precise thought and a conviction that the natural world possessed an order which could be discovered.[10]

Along with this shift in norms concerning the appropriate activities of the man of knowledge, a change closely connected with the replacement of the mysticism of the earlier Church thinkers by a newly discovered rationalism, there was a great increase in the scientific material culture traits of society. Especially significant traits included: the unprecedented expansion of scientific treatises, work books, and the like, further accelerated by the invention of printing type; the production of earthenware and glass apparatus for alchemical research; the development of lenses for optical studies and their later applications in microscopy and telescopy; the assembling of a greatly expanded pharmacopoeia for medical use, manuals of anatomical and surgical information, and a compilation of diagnostic aids arising partly under the impact of the Black Plagues which ravished Europe.

These, then, were important conditions stimulating the unprecedented development of science as a vital part of the institutional structure of the Middle Ages.

CHAPTER TWO

Social Change and the Cultural Norms of Science

The Seventeenth-Century Synthesis

The development of modern science began in the sixteenth and seventeenth centuries. The classical and medieval periods had already provided the foundations of both the rational and empirical methods. Although these achievements were impressive the sciences nevertheless had remained more or less peripheral to the larger cultural goals of these earlier periods. The classical period suffered from the relative divorce of theory and practice; the medieval period, concerned as it was primarily with otherworldly cultural goals, of which salvation, grace, sin, charity, revelation, and faith were important components, could at best exhibit only a quite secondary interest in the problems of a science of nature.

Prior to the seventeenth century, considerable progress had been achieved in mathematical reasoning and in the elaboration of a natural philosophy based on common-sense observation and daily experience. Nevertheless, the systematic use of experiment as a tool of discovery was unusual.

With the important exception of chemistry (which for several centuries had had at its disposal laboratories and a wide variety of glass equipment, distilling apparatus, mixing and blending vessels, and furnaces producing temperatures adequate for the experiments of the time), the creation of specialized equipment and places for scientific inquiry mostly did not occur until the seventeenth century.[1] The grinding of lenses by machinery, which made possible such instruments as the microscope and the telescope; the pendulum, which greatly refined the measurement of time; the basic instruments of the physical laboratory, such as the thermometer, the barometer, and the air pump—all of these are products of the seventeenth-century scientific revolution.

Although the astrological laboratory was perhaps the oldest of the specialized agencies for celestial observation, the modern astronomical observatory became possible only with the invention of the telescope early in the seventeenth century. The telescope was developed as an astronomical instrument by Galileo in 1609, attaining a magnification of thirty-three diameters by 1610. This invention had far-reaching consequences, for it made possible empirical testing of the implications of the Copernican theory.

The most important events leading to the transformation of science during the seventeenth century, however, were not exclusively the creation of the instruments for scientific observation. Coupled with the development of these material culture traits, a transformation of the subjective, psychological approach of the scientist to his subject matter was taking place. This new orientation was based on two significant changes: first, the belief that mathematics could provide the instrument to make the natural world completely intelligible, and, second, the growing conviction that observation and experiment are the most dependable methods for the acquisition of scientific knowledge.

The first of these, the recognition of the importance of mathematical analysis, has its historical and cultural origins, curiously enough, in two somewhat opposed strains of the medieval tradition. The deep conviction, represented in the work of St. Thomas Aquinas for example, that the universe is an ordered cosmos based on the rationality of God leads directly to the reliance on logical reasoning so characteristic of the Scholastic synthesis. From the form of the syllogism, it is but one short step to the form of the mathematical equation. Although the demonstration of the logical basis of mathematics in such modern works as those of Bertrand Russell and Alfred N. Whitehead has come to fruition only within the last hundred years, the congeniality of the mathematical method for the rational mind has its roots in antiquity.

Antiquity also provided the source for the development of a countermovement within the medieval world view to the dominant Aristotelian Scholastic rationalism. This second strain is to be found in the mysticism of the Neoplatonists. Paradoxically, the mysticism of the Platonic Gnostics stimulated a strong revival of the Pythagorean interest in numbers and the belief that numbers furnish the key for understanding the universe:

> The natural revival of Platonism to combat the regnant Aristotelian scholasticism had ultimately a profound influence in stimulating a scientific interest and in pointing out mathematics as the key to the interpretation of nature. For the Neo-Platonic writings so eagerly perused were full of that Pythagorean faith that somehow numbers, so mysterious and so clear, are written deep into the heart of nature. The secrets of the world, their readers learned, are to be deciphered by tracing the mathematical in all things, from the elements to the overarching heavens that control our destinies. Just as in the ancient Alexandrian world this faith had led on the one hand to fantastic symbolism and mathematical mysticism, and on the other to the practical achievements of Greek

astronomy and Archimedean physics, so now once more this Platonism brought forth both the wildest speculation and the uncanny intuition of what was destined to be the course of sober science.[2]

But mathematical philosophy by itself would have remained sterile were it not for its marriage with the slowly emerging methods of observation and experimental inquiry. The collaboration of careful observation with mathematical cosmology is well illustrated in the astronomical partnership of Tycho Brahe (1546–1601) and John Kepler (1571–1630). To the latter, Brahe had bequeathed his extraordinary and unique records based upon painstaking observations of planetary motions. Kepler, the heir to this rich scientific inheritance of observational data, devoted the rest of his life to the search for the mathematical equations which would both account for Brahe's observations and at the same time demonstrate the "Harmony of the World" and the "simplicity and ordered regularity of Nature":

> Kepler was convinced that God created the world in accordance with the principle of perfect numbers, so that the underlying mathematical harmony, the music of the spheres, is the real and discoverable cause of the planetary motions.[3]

This passion for mathematical precision led Kepler eventually to the discovery of the elliptical shape of planetary orbits and the three laws of planetary motion. Later, these discoveries were to serve as a basis for the astronomy of Sir Isaac Newton.

It is not the intention here, however, to present a biographical study of the great men in the history of science, but rather to investigate the development of the sciences in their sociological and historical context. For it is only through such an investigation that we can begin to understand the broad social currents to which individual scientists responded so brilliantly and which they brought to fruition in their work.

Social Change and New Interpretations

We have seen in the last chapter that by the end of the Middle Ages a new emphasis on applied knowledge had begun to gain momentum. This was a period in which very significant changes were taking place in the social structure of Europe. The development of trade had led to the re-emergence of the town as a focal point of economic life. The businessman, the banker, and the guild craftsman began to challenge the ascendancy of the landed aristocrat, the knight, and the monk as the favored social types. The castle and the monastery were declining in economic, political, and social importance, and great city-states, of which Florence was an impressive example, were moving to the center of the historical stage. The self-contained economy, based on the manor with its relatively static, mentally immobile, and personalized socioeconomic organization, was being challenged by a new urban economy of profit, money, and impersonal market relationships.

Production for an expanding market provided a stimulus for invention, discovery, and more efficient productive methods. The social position of the artisan, the craftsman, and the artist-engineer underwent a gradual transformation, so that the traditional distinction between manual and intellectual labor, the mechanical and the liberal arts, began to be effaced, and the universities themselves, as we have seen, made use of the experimental techniques of the artist and the guildsman. Experimental science could now thrive in a culture in which intellectual and mathematical training were combined with knowledge and application of manual techniques. In the accomplishments of Galileo, to cite the outstanding example of an individual scientist, we find the fruits of an education which brought together the rational and the experimental methods.

Also stimulated by these social trends and of equal importance was the increasing replacement of the interpretation of nature in terms of purpose or *teleology* by the emphasis upon cause and effect. Medieval Scholasticism, in spite of its well-developed deductive methodology, remained faithful to a purposeful view of nature which stressed final causes, substantial forms, and occult qualities. Its interpretation of the world was primarily qualitative, not quantitative. The Scholastic search was for the symbolic meanings of physical events and answers were sought for questions of "Why?" rather than "How?" When an eclipse of the sun occurred, medieval man characteristically looked upon it as a portent, a kind of celestial symbol, which was to be understood on the basis of its hidden significance for man, his community, and his aims and goals.

Though this teleological mode of interpretation may have been philosophically and poetically satisfying, it was inadequate for purposes of scientific control and prediction. The occult qualities, being hidden from observation by definition, were of little use for the development of scientific hypotheses that might be tested by controlled experiments. Furthermore, they could not be applied in any concrete way to the solution of the specific problems that were engaging the attention of a growing number of artillery specialists, engineers, architects, artists, physicians, metallurgists, and other craftsmen.

In contrast, analysis of cause and effect was yielding results, providing a method that could be tested by experience, observation, and experiment. Hence causal studies began to supersede teleology, although it never succeeded in fully replacing the latter in the popular mind, in metaphysical theory, or in the poetic consciousness:

The discarding of teleological explanation may be illustrated by two well-known instances. The Scholastics, with Aristotle, explained the falling of bodies by the theory of natural places. Each body was supposed to have its correct place to which it moved when it had been brought to a wrong one. Obviously inanimate bodies were conceived as though they were cattle striving to the accustomed stable. As the theory of natural places did not give any information on the empirical details of falling, it was of no use to artillery men of the modern era who wished to level their guns correctly. It had to be replaced by Galileo's law of falling bodies and his calculation of the parabola of projection.

The working of suction pumps was explained in the late Middle Ages by the doctrine of *horror vacui*. Water was supposed to rise in pump barrels because nature had an antipathy to empty space. Since the well-diggers of the new era could not calculate from this theory how long they might make their pipes, two pupils of Galileo, Viviani and Toricelli, experimented on pipes filled with mercury, and discovered and measured atmospheric pressure.[4]

The Impact of Political and Economic Trends

The rationalistic ordering of nature according to principles of cause and effect and the desire for prediction and control were closely paralleled by significant historical trends in the economic and political spheres. Of special importance for the growth of modern science were the changes taking place in the political thought and practice of the emerging nation-states.

The gradual breakdown of feudalism went hand in hand with the rise of the middle class of merchants, bankers, and manufacturers who were replacing the feudal lords in the strategic commanding position of economic life. In the earlier stages, this new middle class threw its weight behind the royal authority as against the sectionalism, local autonomy, and special privileges which had been characteristic of the feudal, manor-based economy. The desire of the kings to extend the royal power coincided with the needs of the merchant group for more predictable and uniform conditions of economic activity. Thus, for example, the king, having at his disposal the taxes of the merchants, could build up a fleet, which, in addition to being an instrument of dynastic policy, served to protect merchant shipping from piracy. In a period during which piracy on the high seas was rife, the importance of a royal navy for the expanding export trade is apparent.

The extension of the authority of the crown also insured, to a much greater degree than had been possible under feudal conditions, that some degree of domestic tranquillity and internal peace was present within the boundaries of the kingdom. Merchants could now ship their wares from one part of the country to another with less danger of having them fall prey to bandits and robber barons.

At the same time, the introduction of a more uniform system of exchange greatly facilitated the flow of goods through the establishment of a national currency, which gradually replaced the local currencies of feudal principalities and duchies. Closely coupled with the standardization of money was the stimulation to the movement of products by the building of roads, the dredging of canals, and the breakdown of provincial customs barriers.

These developments were symbolized in the sphere of thought in the idea of the rule of law as contrasted with the feudal-aristocratic idea of the rule of men of sound instinct. The rule of men appeared to the businessman as an invitation to capriciousness and favoritism, and therefore certain to lead to an intolerable unpredictability in the sphere of law, contracts, and commercial relations. The establishment of royal courts and eventually of a codification of law made possible a much more calculable system of economic relations, supported by the juridical system of the nation-state.

These various but related historical trends incorporated a system of cultural values that was exceptionally congenial to the creation and acceptance of the new world view of the men of science. The rationality of business enterprise found its counterpart in the rationality of the scientific method. The control of nature as the end of science echoed the control of community and economy brought about by the mercantilist coalition of king and merchant burgher. The rule of law acted as the principle that brought together the cultural goals of an order of nature and a social order, both dedicated to the mastery of man over his physical, economic, social, and political environments.

The country which perhaps best illustrated this process of a developing national unity was seventeenth-century France. At the same time, Holland was emerging as a great commercial power, having challenged successfully the might of Spain. The philosophy of nature propounded by Descartes in France found ready acceptance in the educated groups of both of these nation-states and paved the way for Newton's *Principia*, which was published in England in 1687. England, having resolved her most pressing political and religious struggles, joined France and Holland in the latter part of the seventeenth century as one of the leading centers of the intellectual revolution that was to change so radically man's conception of his place in the universe, and that would have been impossible, we should remember, without the earlier scientific renaissance of the Italian city-states.

The Influence of Protestantism

Historically, the growth of the nation-states and the expansion of commercial enterprise were accompanied by the development of what Max

Weber termed the "worldly asceticism" of sixteenth-century Protestantism, especially in its Calvinistic branches.[5] This new religious orientation influenced many phases of secular life, including science.

Although the medieval world view had given an important place to rationalism, its main emphasis remained on reason as a tool for the understanding of the world rather than as a means for its transformation. But the theology of Calvinism encouraged the idea that it is the Christian duty of man so to change the world that it would exhibit more perfectly the rationality of the divine will. While Calvinism stressed that man is but the passive instrument of the predestined ends which God had foreordained, nevertheless the Calvinist religious mentality stimulated the conviction that success in secular affairs gave proof of the individual's election to salvation. Intense and dedicated scientific activity, no less than business enterprise, served as a guarantee against the temptations of idleness which, by distracting man from his calling, might prove him to be, in his own eyes as well as those of his fellows, among those predestined to eternal damnation.*

This special combination of asceticism with intense activity in the rational business of this world gave the radical sects of Protestantism a psychological advantage over Catholicism in experimental science as well as in business enterprise. For where Catholic science was predominantly contemplative, the new science was empirical and pragmatic in orientation. Where Catholic businessmen were more interested in speculative enterprises based on expectations of a quick profit allowing one to retire to a life of aristocratic and cultivated leisure, the Puritan businessman typically stressed the rational, systematic, and continuous accumulation of wealth as a calling worthy for its own sake.

Convincing evidence of the correlation between Calvinist Protestantism and the growth of modern science is presented by Robert K. Merton, among others. Merton investigated the relationships among religion, science, and technology, noting, for example, that the number of Puritan contributions to the *Philosophical Transactions* during the seventeenth century was proportionately larger than those of the scientists of any other religious denominations, and particularly as compared with those of the Catholics.[6]

Protestantism provided another perspective which, emerging with the breakdown of the traditionalistically oriented feudal economy, also served as a spur for the development of experimental science. This was the challenge to authority and tradition, in part a consequence of the Protestant

* See Elizabeth K. Nottingham: *Religion and Society* (Studies in Sociology), New York, Random House, Inc., 1954, Chap. 5, for a discussion of the social implications of Calvinist doctrine.

Reformation itself. This challenge to the authority of the Catholic Church in the theological sphere made the critical examination of the views of the ancients and the Scholastics in the sciences a considerably simpler task. The habit of questioning traditional beliefs took root in an increasingly larger area of social and cultural life: economic, ecclesiastical, philosophical, and scientific. More than ever it came to be demanded that scientific assertions should be based upon observation and experiment. The authority of an Aristotle, a Ptolemy, a Galen, or of an Angelic Doctor was no longer considered sufficient grounds for the credibility of a scientific proposition. Propositions of both traditional authority and of common sense were put to the test of experience. A statement which could not be empirically verified, in the words of a famous advocate of the new viewpoint, David Hume, should be committed "to the flames: for it can contain nothing but sophistry and illusion."[7]

The development of a skeptical attitude toward authority was closely associated with the positive evaluation of individualism as a cultural value. The Protestant Reformation shifted the emphasis in the religious sphere from salvation through the mediation of the Church and its sacraments to the much more highly personalized sphere of the direct relation of man and his individual conscience to God. Similarly, the point of view of the seventeenth-century scientist reflected this shift in value orientation. He too demanded that only his judgment, backed by the experience of his senses (and the observations of other scientists), was adequate for the determination of truth. To this day, the scientist characteristically regards with suspicion any attempt of extrascientific groups, economic, political, or religious, to pass judgment on his work or to attempt to control the methods or subject matter of his investigations.

The consequences of individualism and antiauthoritarianism as new cultural norms are most apparent in the economic sphere, where the congeniality of this new orientation is obvious. The belief in individualism represented the growing conviction of businessmen that they knew best how to conduct their enterprises so as to maximize profits and minimize losses. The traditional restraints imposed by community, church, manor, and guild were gradually being loosened. Once the middle classes had gained a fair degree of economic independence, they could break their temporary alliance with the crown and establish their own state, as they did most dramatically in the Cromwellian Revolution in England and the great French Revolution.

These changes in socioeconomic power relationships were intimately connected with the changes that have been described in cultural norms and ideology, including religious, philosophical, and scientific points of view. Questions of priority in these matters need not detain us here, for we can look upon the process as one of continuing changes of interrelated factors. The shifting power arrangements provided a congenial milieu for the reception of new religious ideas and scientific discoveries, which in turn further accelerated the development of new political and economic institutions. Inasmuch as cultural forces and institutional structures are mutually interactive, changes in one area of social life will influence other areas in varying degrees and in response to broader historical developments.

The Cultural Values of Modern Science

This chapter has indicated the interrelationships of some of the important historical changes—social, economic, and political—that brought about, and at the same time were influenced by, new cultural values, as reflected in philosophical and religious attitudes. The interaction between institutional alterations and the emerging cultural values becomes the methodological starting point for the explanation of the new world view of science. Our approach, then, is one that interprets a social phenomenon, in this case modern science, as the product of both the objective sociohistorical situation and the subjective attitudes and cultural goals present in the situation.

The cultural values that developed during this recent historical period and that are of particular importance in helping to understand the emergence of the modern scientific world view may be summarized as follows:

1. *Rationalism:* the development and refinement of logical and particularly of mathematical tools of reasoning.
2. *Empiricism:* the increasing emphasis on observation and experiment as a method of verification and for obtaining new knowledge through sense experience.
3. *The logicoexperimental method:* the combination of deductive reasoning and mathematical methods with the experimental approach of empiricism.
4. *Belief in the rule of law,* both in nature and in society: in this view society is a part of nature.
5. *Pragmatism:* the utilization of knowledge for transformation and control, rather than contemplation and wisdom for their own sake.
6. *Worldly asceticism:* in the scientific sphere, the development of norms of systematic, dedicated, and disinterested pursuit of knowledge as a calling.
7. *Skepticism* with reference to authority and tradition.
8. *Individualism:* reliance on the reasoning, judgment, and experience of the scientist, rather than on political or religious tests for scientific truth.

These cultural values did not emerge in a social vacuum. They were closely interrelated with new constellations of economic and political power. They manifested themselves in a reorganization of social attitudes which gave a new direction to man's search for knowledge. They provided new norms for the evaluation of knowledge and, at the same time, called into doubt some of the most cherished beliefs and practices of the classical and medieval world views.

Of particular significance here is the change of perspective, the development of a new focus of inquiry, in the light of which certain problems which had been considered of extraordinary significance lost their appeal and were replaced in the consciousness of thoughtful men by a different group of problems. This shift in what was considered valuationally relevant helped to make possible the emergence of the modern scientific world view, with its rationalistic standards of judgment, its empirical approach to scientific inquiry, and its pragmatic conception of the relation of science to nature and society.

Whether this new approach was more conducive to the attainment of truth, more satisfying to man in his attempt to orient himself to his cosmos, or more calculated to lead to his moral perfection, are questions which cannot be dealt with from the standpoint of a sociology of science. Answers to these questions inevitably become a function of the standards of metaphysical, aesthetic, and ethical judgment to which the individual subscribes. Although the sociology of knowledge may attempt to discover the social roots of these standards of judgment, it cannot pass upon their final validity. These matters are discussed in the final chapter of this study.

CHAPTER THREE

The Scientist and His Social Role

Magician, Gnostician, and Scientist

The focus of this discussion now shifts more directly upon the scientist in his relationship to the scientific enterprise and upon the sociological role which he is expected to play as a member of a social group.

In observing societies, when we find almost any degree of division of labor, even of the most rudimentary sort, we may feel quite certain that we shall discover a small group of persons whose main job, as defined by both their culture and themselves, is the discovery, systematization, elaboration, justification, and application or dissemination of knowledge. Many of these individuals are not engaged in scientific work in the sense in which we define such work today. The significant fact to bear in mind, however, is that from the point of view of the society within which they perform this role, their activity is regarded as providing genuine knowledge, not only of a theoretical nature, but, which is often considered of greater importance, knowledge that permits control of both natural and superhuman forces.

It is in this sense that magic, as Frazer has pointed out, is the science of preliterate peoples.[1] In contrast with religion, which usually is concerned more with propitiation and veneration, magic has as its goal the achievement of material effects—effects which are considered to be highly useful and beneficial to the individual and to the group.

How in this case, then, is science to be distinguished from magic, if the goal in each case appears to be identical: the discovery and use of knowledge in order to give man a greater mastery over his natural and social environment and himself? Probably the only valid general distinction that can be made is with respect to the means which magic, as compared with science, is prepared to employ.

The magician in his work attempts to make use of both natural and supernatural forces. His procedures are based partly on traditional folklore, partly on common-sense everyday observations (for example, that lightning is followed by thunder), and mainly on the use of formulas, names, incantations, mysterious substances, and the like. He believes that the proper use of the latter techniques will give him control over supernatural forces, whether impersonal ones, such as *Mana* (supernatural power as a sacred and dangerous attribute of objects) or personified in such *Anima* as demons, spirits, deities, ghosts, or elves possessing wills of their own. Other aspects of magic, particularly such phases as homeopathic magic (involving the principle that like produces like), should possibly be considered as examples of poor science rather than exclusively magical. These latter devices are based on what we would regard as simply mistaken causal connections attributed to the natural world, not on the manipulation of the superhuman and the supernatural.

The main distinction between magic and science, then, would appear to be the place of supernaturalism in their procedures. Magic generally attempts to control the world through the almost mechanical manipulation of the supernatural; science, on the other hand, attempts to interpret and control the natural world by exclusively naturalistic (although not necessarily empirical) explanations and procedures.*

Irrespective of their procedures, magicians nevertheless may be classified along with theologians, physicists, sociologists, philosophers, physicians, biologists, psychologists, and representatives of other disciplines as men of knowledge. All of these specialists devote a considerable portion of their working activities to the cultivation of knowledge. In this respect, they stand in contrast with those groups whose main social role is, for example, the defense or expansion of the community's living space—warriors; or the production and distribution of goods and services—farmers, merchants, industrial workers; or imaginative expression in the creative arts—painters, dancers, musicians; or the somber exercise of power—kings, senators, judges, and executioners. In contradistinction to these other occupational groups, we designate the magicians, priests, philosophers, and scientists as *gnosticians*, that is, those who are specialists in knowledge.

The scientist, then, is a variety of the species gnostician. His main functions include the discovery of new facts about the natural world and the biological and social environments, the systematization of knowledge into a coherent theoretical system, and the application of this knowledge to the solution of practical problems with which men living in social groups within specific environments and possessing certain life goals are faced.

The number of these functions that the scientist may perform as a member of the larger social group of gnosticians may overlap considerably, and, to be sure, most scientists at some time or other engage in one or another of these activities. Nevertheless, this differentiation serves at least two purposes. First, it provides analytical distinctions that help us clearly to recog-

* For a recent discussion of magic, science, and religion, see the previously cited Study in Sociology, Elizabeth K. Nottingham's *Religion and Society*, pp. 34–40.

nize the different activities which are involved in scientific work itself. Second, recognition of the different phases of the scientific role aids in distinguishing the effects of divergent cultural interests on the basis of the type of emphasis which appears to be predominant in the attitude and work of the scientists of a particular culture within a given sociohistorical situation.

Requirements of the Scientific Role

The first type-role of the scientist can be designated, following the usage of Florian Znaniecki, as the *explorer*.[2] The scientist is mainly concerned, in his function of explorer, in discovering new features of that dark continent which we call the external world. His activity in some ways is analogous to that of a navigator who can never come close enough to land at his destination, or even within sufficient distance of his objective to be able to make out all of the features of the landscape. He is constrained, therefore, to make use of a wide variety of gross observations, indirect approximations, hypothetical experiments, frequent soundings, and provisional interpretations.

On the basis of the discoveries of the explorer, the *theoretician* plays the role of a cartographer. At best he can hope to construct a chart which will be relatively isomorphic (same-shaped) to the area under investigation. To the degree that his chart corresponds to the actual topography, we may say that he has approximated a true mapping of the coastline, and to the same degree will it be useful to the helmsman who wishes to navigate the same waters. This second type of scientist, the theorist, has the tasks of integrating the data of knowledge into a coherent, logical structure and of formulating hypotheses to be tested by further explorations.

The third function of the scientist is that of *technologist*, of applying the theoretical knowledge derived from empirical exploration to the solution of specific human problems. Of particular significance in technological practice from the viewpoint of the larger structure of scientific activity is that technology acts as a check, a test, a continuing process of verification of the degree of correspondence and applicability of scientific theory to the empirical world. At the same time, the formulation of new technological problems is itself a spur to increased exploratory and theoretical activity.

Following this general classification of the various type-roles which the scientist may play, we shall examine his relationship to the larger associational and institutional structure which provides the social situation within which the scientist carries on his activities. Znaniecki once more has provided us with a very useful conceptual scheme for the analysis of the scientist in his social role.[3]

In the first place we must consider the social person who engages in scientific work. The expression social person reminds us of the fact that we are not dealing with isolated individuals in a social vacuum, but rather with specific persons who are members of a wide variety of social groups of which their professional group is but one. Like other persons, the scientist generally has a family, some kind of orientation to political questions, and he may be affiliated with a church. In addition to these more formal associations, he may participate in broader social groups of which he is somewhat less conscious. For example, in the United States today he will more often than not be of middle-class background and will tend to share some of the patterns of thought that are characteristic of this larger social grouping. On a still wider scale, the scientist is a member of a national community, sharing the culture of his country and of his times, and this too is apt to affect his behavior patterns and attitudes.

These various group allegiances exercise an influence on the scientist and his work, a fact that is implicitly if not explicitly recognized in the training of scientists whenever emphasis is given to the need for elimination of bias, the development of objectivity, or the supranational nature of scientific work. This stress on objectivity not only refers to the scientist's technical and professional procedures, such as carefulness in observation, precision of measurement, and so on, but reflects a tacit recognition of the fact that the scientist is subject to the pressures of a wide variety of extrascientific influences, social and historical.

Value-Relevance and Value-Judgments

The fact that the scientist is a part of a nexus of social relationships and that in his work he will naturally tend to respond to problems which arise out of the cultural and technical demands of his society and of his group does not mean that he will be unable to carry on effective work. The very fact that certain areas of human experience come to be regarded as critical and of particular significance is in itself often a spur to research.

This point may be expressed more technically by saying that certain objects of investigation acquire *value-relevance*, that is, they come to be considered of importance under specific sociohistorical circumstances. The latter may account for the fact that these areas become interesting to the scientist, thereby motivating him to focus his attention upon them. The effect of these motivating factors results in the search for knowledge in areas which might otherwise have remained unexplored.

Value-relevance, therefore, plays a significant part in the selection of the problems of the sciences. It should be observed, however, that although the selection of problems of research may be determined, within limits, by social and cultural factors, neither the content nor the validity of the knowledge thus obtained is to be evaluated on the basis of their sociohistorical and cultural genesis. This question will be dealt with at greater length in Chapter Four.

Value-relevance should be carefully distinguished from the presence of *value-judgments* in scientific work.[4] The latter are of primary concern in the appraisal of the effects of psychological and sociological factors on the objectivity of the scientist. What is involved here, of course, is the fear that the personal preferences and biases of the investigator may color his work and prevent an accurate description and analysis of the thing at hand. The suspicion that this may constitute a greater danger for the historian and the social scientist should not lead us to believe that the natural scientist is entirely free from the intrusion of value-judgments.

In this connection, the discipline and training of the scientist are crucial. The purpose of scientific education is not to neutralize the scientist so that nothing retains sufficient subjective appeal to interest him, but rather to guarantee, as much as is humanly possible, that once he has set himself the task of investigating some phase of the world, he will conscientiously do his best to depict it as it is, and not as he would like it to be. Using our earlier analogy, objectivity in this sense may be defined as the rigorous attempt to map the coastlines of the world of experience as accurately as possible with the theoretical and observational tools at hand, without introducing nonexistent but charming lagoons or arbitrarily excluding unpleasant reefs.

We should be careful, as well, to distinguish between the distortions of reality which may arise either from the unconscious operation of bias or from the deliberate attempt to deceive or conceal for political, economic, or other ends and the sincere and explicit attempt to transform reality so that it will be more amenable to human purposes. It is perfectly legitimate for the scientist to state that such and such a disease is caused by the presence of a certain virus in the blood stream and then to describe a technique for combatting the virus in order to bring the patient back to health. Here a theoretical statement of what is (disease x is caused by virus y) combines with a normative statement (disease x is undesirable) so as to produce a technological statement (we can eliminate disease x by attacking virus y by the use of treatment z). The normative statement implies that something should be done about it, that is, that the disease should be eliminated. The technological statement provides the point of attack on the problem posed by the normative statement. The theoretical statement provides the rational basis for the technological solution.

On the basis of these considerations, we may make certain technological statements of a sociological nature with reference to the problem of the training of scientists in such a way that the operation of bias will be at a minimum. If as social persons they are subject to the prejudices of their culture, class, generation, political group, religious affiliation, and so forth, and if we consider these implicit biases to be undesirable because they may interfere with the objectivity of research, what concrete steps may we take in the education of scientists in order to reduce these effects?

In the first instance, we may place considerable reliance on the methods of research and analysis as they are now operative. The instructions and directions that are part of any good laboratory course in the physical sciences are illustrative of the emphasis on precise observation that is essential to the study of the natural world. Their use engrains habits of studying objective phenomena as they are given to our senses directly or with the aid of scientific apparatus. In addition to reliance on observation, scientific training stresses the testing of hypotheses by appeal to experiment and other techniques of verification and, at the same time, underscores the importance of making use of theory in the interpretation of the results of observation.

The social sciences introduce the students to other techniques of objective verification, such as the systematic utilization of historical documents, procedures of research design in the study of population characteristics, and *ex post facto* experiments. The greater complexity and unpredictability of social phenomena themselves sharpen the awareness to a wide variety of methodological and philosophical problems related to the theory of scientific inquiry. And the fact that human evaluations are much more closely related to human problems means that students of the social sciences as compared to those in the physical sciences are precipitated earlier and more directly into questions of bias and objectivity, value-relevance and value-judgment, and the contrast between empirical description and normative evaluation.

The education of all students of the sciences, however, should require at some stage of their scientific training that they focus on the broader philosophical problems relating to the interrelations of the sciences (both physical and social) with one another and with the world that they attempt to describe, understand, and interpret. Of equal importance is the orientation of the student to the place of science in society and to the interaction between scientific activity and cultural, economic, and political phenomena. In this area, courses in the history of science, the anthropology of science, magic and religion, the sociology of science, and the wider study of the relationship of thought and society—the sociology of knowledge—should be an essential part of the training of both natural and social scientists. For it is only through studies of the historical, sociological and sociopsychological dimensions of knowledge that the student can develop the conceptual apparatus that alerts him to the social determinants and cultural compulsives in his own thinking. Unless he is prepared to cope with these matters, they can seriously interfere with the objectivity of his work.

The scientist, then, as a social person, shares in some degree the larger preoccupations of his group and of his times. This fact may have both negative and positive consequences for science itself. The positive side lies in the impetus given to research by the value-relevance of certain problems. The negative aspect of the relation resides in the unwitting distortions which may arise in the scientist's work because of the operation of implicit value-judgments. One important corrective to the latter, which is possible within the framework of a relatively free society, is the training of scientists in the broader philosophical and sociological aspects of their profession. Moreover the social structure itself, to the degree to which it encourages the free exchange of ideas and the juxtaposition of viewpoints, furthers the self-correction and extension of knowledge. Only freedom of expression, of research, of contradiction, and of competition of ideas provide for the confrontation of different viewpoints, value-relevancies, and divergent cultural goals without which the sciences are in danger of becoming authoritarian, official and tradition bound.*

The Social Circle and Its Demands upon the Scientist

The scientist as a social person participates in and is responsive to what Znaniecki has termed his social circle. The physician, for example, typically finds his social circle (which is not to be confused with friendships or social cliques) in his patients and his colleagues, all of whom share specific values. These values constitute a bond of common interests, in this case the values positively ascribed to hygiene, health, therapy, and the practice of medicine. In the same way, the shaman, the priest, and the prophet, though differing in their respective social roles, share with the circles of their followers certain common commitments to religious values.

The relationship of the social person to his social circle illustrates the major role of mutual aid that, as Kropotkin so eloquently argued, has played a vital part in the development of social life. In the nineteenth century, under the influence of the application of the Darwinian concepts of natural selection and survival of the fittest to the analysis of society, competition and conflict became overemphasized at the expense of the cooperative

* A recent discussion of the relationship between social values and social science is provided by George Simpson: *Man in Society* (Studies in Sociology), New York, Random House, Inc., 1954, esp. Chapter Six.

aspects of social organization. Of sociological significance here is the fact that the views of Social Darwinism were congenial to the highly competitive atmosphere of the Victorian period.

The relationship of the man of knowledge to his social circle, however, is intrinsically a noncompetitive one. The social circle's interests are primarily common or shared, not like or distributive interests.[5] These common interests mean that the social circle that is directly involved with the activities of the scientist is seriously concerned with his training, qualifications, and personality traits. These are matters that the members of the circle consider essential for the proper fulfillment of the role that is to secure and further their common interests.

Qualifications of this kind vary greatly with the type-role being performed by the scientist and change with different circumstances. Certain occupations, for example, the Catholic and Judaic priesthoods, restrict participation on the basis of sex. Within the area with which we are primarily concerned, the sciences, there has taken place some breakdown of traditional barriers against the acceptance of women in scientific roles, but the number of women engaged in scientific work still remains proportionately quite small.* At the same time, more and more stringent requirements of formal academic preparation, possession of advanced university degrees, successful completion of qualifying examinations, and, in some fields, licensing by governmental authorities, have become increasingly prevalent. Religious qualifications have been, as compared with other professions, relatively nonrestrictive in the scientific field, although there are evidences that Jewish scientists in America have better employment opportunities in the academic and government fields than in private industry.[6]

On the other hand, the twentieth century has witnessed the introduction of something relatively new in the evaluation of the acceptability of the scientist and his work: political tests. Thus it was reported that the great physicist Heisenberg, originator of the indeterminacy principle, was suspended from his duties as a university professor on the grounds that he had offended both his students and the Nazi authorities in Austria for having made a complimentary reference to the theories of Einstein. This flagrant example of political anti-Semitism as a device for silencing the free expression of scientific ideas was only one of many in Hitler's Third Reich. In the Soviet Union we were recently presented with the spectacle of strong political pressure being applied to biologists to orient both their teaching and research along the lines of the officially approved theories of Lysenko;

* "In 1947, for example, the A.A.A.S. estimates that only about 1% of its 33,000 members were women. In that year only 2 of the 350 elected members of the National Academy of Sciences were women." If we exclude engineering, women constitute about 7 per cent of the total in the mathematical, physical, and biological sciences. Bernard Barber: *Science and the Social Order*, Glencoe, Ill., The Free Press, 1952, p. 137.

while on the other side of the iron curtain at least one American professor was dismissed for his strong support of the Lysenko theories.

Political pressures of this sort can go far in making the scientist, who dares to run counter to them, unacceptable to the social circle within which he is to carry on his functions. The Jewish physician in Nazi Germany soon found himself not only deprived of his position on the hospital staff but without his private patients as well. In the Soviet Union, the physicist who gave the works of Mach serious consideration in his lectures soon found himself addressing empty halls. In contemporary United States, the social scientist who approaches his subject matter from the viewpoint of historical materialism, although he need not fear a knock at the door from a representative of the Gestapo or N.K.V.D., nevertheless may seriously jeopardize his career in teaching, in industry, and certainly in government service.

A further requirement of the social circle is brought out in the observation that "there are upper and lower age limits for every role; the majority of roles imply certain somatic racial characteristics and definite, though variable, standards of external appearance."[7] Many of the characteristics considered desirable are not formally stated, but they operate nevertheless to decrease the probabilities of advancement of those who do not possess them. These qualifications generally reflect the ethnic-aesthetic norms of the culture, and those who more closely approximate them increase their life chances, particularly in those professions in which they are in extensive contact with other people, especially clients. It is the tacit recognition of the role of personality and somatic factors that at times leads vocational counselors to encourage some individuals to enter areas of scientific work—for example, some aspects of research—in which the need to influence and work directly with other people is at a minimum.

The qualifications as well as the personality characteristics expected of those who wish to carry on certain social roles operate as stereotypes through which the person is evaluated by his social circle. Although these socially sanctioned traits may be greatly diversified (so that the qualities of a "go-getter," for example, which might be positively evaluated in a salesman may be negatively judged in an individual on the research staff of a museum), they nevertheless exhibit within each circle a strain toward conformity. The business manager is expected to be shrewd and efficient, the research historian must know the techniques of documentation, the university professor is expected to be both scholarly and able to establish rapport with his students.

These qualities are examples of traits which are necessary if the social role is to be carried on effectively. But, as we have seen, the strain to conformity may apply as strongly to personality and somatic characteristics which, objectively viewed, are largely irrelevant to the performance of the role. Or the social circle may attach a disproportionate emphasis to more overt but less essential characteristics, as when the physician with the winning bedside manner captures the patients of a better diagnostician who lacks the charm of his competitor. Finally, it should be remembered that the cultural norms of various social groups exercise constraint through the establishment of personality norms. The individual who fails to conform to these norms—in speech, dress, humor, religion, politics, sex, and a myriad of other ways—may also fail to meet the expectations of his immediate social circle, irrespective of how irrelevant they may be, technically, to his professional competence.

The Social Status and Social Function of the Scientist

The person who meets the requirements, professional and otherwise, of his social circle enjoys a definite social status, that is, "his circle grants him certain rights and enforces these rights, when necessary, against individual participants of the circle or outsiders."[8] The most important of these status-conferring rights is the privilege of carrying on specific activities as a member of one's profession: to practice medicine, to plead a case in law, to carry on research in atomic physics, to teach political science at a university, to fill a prescription as a pharmacist. By the same token, those who lack status qualifications may not engage in the activities restricted to it under pain of severe social, and in some cases legal, sanctions.

In addition to the privileges of professional practice, social status may confer upon the individual certain territorial rights: the privilege of using laboratory facilities, of conducting research in libraries, of using an office or a lecture hall, of participating in professional meetings at certain times and places. The extraterritoriality of embassies is perhaps the most extreme case of territorial rights attached to social status. This case is historically related to the special territorial privileges of certain universities of the Middle Ages, according to which the civil authorities were denied the right of access to the university grounds unless permission was granted by the rector. The university, as well as the Church, at one time had the right to grant territorial asylum, which today inheres in embassies or on foreign shores. These rights probably derived in part from the early close connection between the university and the Church, and reflected the fear that the royal authority might attempt to interfere with the area of jurisdiction reserved to the ecclesiastical authorities. Irrespective of their origins, the early territorial rights of the university helped lay the foundations for the tradition of academic freedom and the freedom of science.

Social status also confers upon the scientist the "rights to use certain material values regarded as necessary for his subsistence on a level commensurate with his role."[9] These rights refer to such matters as housing, salaries, fees, royalties, and payments in kind, with which the scientist is rewarded for carrying on the status conferring activities.

For example, the American scientist's average earnings are greater than those of most occupational groups, although definitely below the higher echelons of the business hierarchy. Moreover, his monetary rewards, deriving principally from three sources, university, governmental, and industrial employment, vary considerably from one area to another, as the following table (based on 1948 figures) indicates:[10]

Annual Income	*Academic*	*Government*	*Industry*
Under $2,000	8%	—	1%
$2,000–4,000	20%	10%	10%
$4,000–6,000	33%	35%	31%
$6,000–8,000	18%	32%	24%
$8,000–10,000	10%	16%	15%
Over $10,000	11%	7%	19%

These differences in income should not obscure the fact that nonmonetary advantages and disadvantages reside in each realm of employment, including, for instance, the presumably larger range of freedom in the lowest paid academic area.

Compared with monetary income, of decreasing importance today are some of the more ornamental attributes of the scientist's social status, including titles, orders, decorations, insignia, and the privilege of certain forms of dress, such as the cap and gown of the professor. Nevertheless, the continuing social and psychological significance of such status symbols and rewards is illustrated, for example, by the conspicuous use of honorific prizes in Soviet Russia (as well as cash awards) and, again, by the great prestige of the Nobel awards and similar distinctions which are highly esteemed by both scientist and the public at large.

Professional social status carries with it the prestige, authority, and recognition which play an important part in regulating the relationship of physician and patients, teacher and students, lawyer and clients, research director and staff members. Moreover, certain scientists of high prestige and administrative ability nowadays occupy a strategic commanding position in the organization of contemporary American science. Thus during the World War II period, men of the caliber and reputation of James B. Conant, Vannevar Bush, and Karl T. Compton largely determined the policies and selected the key scientific personnel of the Office of Scientific Research and Development, the government agency that headed the American war effort in the area of scientific research.[11]

Relatively high social status and associated authority, it should be stressed, are requirements for certain immunities which permit the relatively autonomous activity which is necessary for the fullest scientific exploration. In other areas of social life, similar immunities reflecting social status have resulted in the strengthening of a more pluralistic organization of society. Illustrative of these immunities is the traditional independence of church and state, protecting the ecclesiastical authorities from the interference of the power of government in matters of religion, and at the same time, preventing the monopolization of religious authority by any one religious group. Of equal importance are academic immunities for which the universities have long struggled in order to maintain freedom of teaching and research, unhampered by political, economic, or religious pressures.

Closely related to his social status and the immunities with which it is sometimes associated is the individual's social function:

> He is regarded as obliged to achieve certain tasks by which the supposed needs of his circle will be satisfied, and to behave towards other individuals in his circle in a way that shows his positive evaluation of them.[12]

This means that the scientist, as a social person, is expected to produce results and that the evaluation of these results lies not only with his peers, but also with the social circle of laymen with whom he is associated and upon whom he is partly dependent. Thus the physician who does not meet the expectations of his patients in effectively prescribing for them would find himself operating within an increasingly narrowing social circle.

It is especially important to note that the more closely related the work of the scientist is to concrete problems formulated by specific circles, the more his work is circumscribed within the framework of the solution of these specified problems and the more rigorously his work is evaluated by the social circle concerned. In large measure this is why there may arise a severe discrepancy between the theoretical importance of a piece of research, as judged by fellow scientists, on the one hand, and, on the other, the impatience for practical results that may be demanded by government agencies, private industry, or specialized research foundations.

The sociological concepts of role, status, social circle, and social function form an analytical framework which we have applied to a preliminary analysis of the social position of the scientist. As a social person, he is responsive to the constellation of objective social forces and cultural values of his society. And, as emphasized in the preceding chapter, certain kinds of cultural emphases and types of social organization are more congenial than others to the development of a positive evaluation of scientific work.

The position of the scientist as a social person, as we have seen, is influenced by the sociopsychological characteristics which are demanded by the groups within which the scientist carries on his activities. Of particular importance among these groups is the immediate social circle concerned with his work, consisting of clients, patients, employers, colleagues, research directors, and the like.

The social status of the scientist, then, derives from both individual and collective factors. The individual factors relate to the way his own work is ranked by his colleagues in the field. From the viewpoint of the sociology of science, however, we are more concerned with the social status of the scientist as a member of his profession, that is, the collective evaluation given to scientists by their society, as well as differences in ranking accorded to particular sciences. The latter situation is illustrated by a recent study of the evaluations of a sample group of Americans. This study reports that the role of scientist ranks eighth on a listing of over forty occupations, while priest, for example, ranks twenty-first, lawyer eighteenth, and army captain thirty-second.[13] This sampling of popular attitudes suggests that the social position of the scientist in the United States is, in large part, a consequence of American conditions, and that one task of the sociology of science is the study of comparative social ratings in various societies of the scientific role.

In all societies, the social function of the scientist is responsive to his over-all social position and is judged by his success in performing his function, both by his social circle and by the larger social forces and culture goals of his society. When he has the confidence of a broad public so that facilities are provided and support given to his work, and when he is free from the restraints of political, economic, or religious orthodoxy, the relative importance of his function increases for the society as a whole.

CHAPTER FOUR

Knowledge, Science, and the Individual Life

The Validity and the Sociology of Knowledge

The scientific method has proven itself to be extraordinarily successful in realizing its goals of explaining natural events in terms of its conceptual scheme, in predicting the probable course of future events within reasonable time and probability limits, in verifying hypotheses through observation and experiment, and in controlling as well as adapting phenomena for specific human purposes. The desirability of doing any of these things reflects human judgments that are themselves consequences of broadly accepted cultural norms. We have seen that these norms themselves are more likely to emerge under certain sociohistorical conditions than under others. What bearing, if any, does this sociological dimension of scientific knowledge have on the question of the validity of this knowledge?

The very formulation of this question provides a clue to the answer. For inasmuch as the criteria of truth to which the sciences subscribe operate as cultural norms for the determination of truth-values, then the validity of scientific propositions is warranted by rules internal to the sciences themselves, independently of extrascientific considerations. This does not deny the fact that external factors, for example, sociohistorical conditions, play an important role in the development of the internal norms of science. Indeed, a considerable part of this essay has been devoted to an examination of the social determination of scientific means and ends. The point is rather that once the norms of science have been established, these norms themselves determine the validation procedures within the sciences, rather than questions of social utility, cultural acceptability, and political or religious ideology. The latter may define in large part the limits within which the sciences may operate, and they may even dictate the areas to be investigated. They do not, however, establish the truth-value of scientific propositions, whatever the attempts may be to distort, conceal, exaggerate, or in some other way constrain scientific knowledge.

The usual formulation of the autonomous truth-value of scientific statements is the rule which states that the individual or social origins of a proposition do not give us any information about its truth or falsity.

Logicians speak of the genetic fallacy and the *argumentum ad hominem* as fallacious methods of reasoning, precisely because these ways of arguing attempt to discredit the validity of a proposition by discrediting the individual or group by whom it is stated.

Can we declare confidently and unequivocally, however, that the social or individual genesis of a proposition has no bearing whatsoever on the question of its truth or falsity? For example, assume that we are told something by an individual whom we know to be addicted to lying or exaggeration. Let us suppose that we are told by this habitual liar that it is raining outside. We have reason to suspect, on the basis of previous experience, that this individual may now be lying. Therefore we are inclined to disbelieve him, and we find out for ourselves whether or not his statement is true by looking out of the window. Be it noted, nevertheless, that we do not determine truth-value even in this case on the basis of who makes the statement, but rather on the basis of empirical observation, that is, by looking out of the window (or by obtaining reports from more reliable informants).

Two different propositions are involved in this case. The first proposition, "Mr. X is an unreliable informant," is tested by observing the accuracy of his statements over a period of time. The second proposition, "it is raining outside," is tested by direct observation, by indirect observation through the use of suitable instruments, or by weighing reports made by other human observers. The important fact to be noted, however, is that the second proposition, "it is raining outside," is neither proven nor disproven by the demonstration of the truth or falsity of the first proposition, "Mr. X is an unreliable informant." On the other hand, if it has been established that Mr. X is unreliable, we are less likely to accept his statements about the weather, but we are not informed through this process about the actual state of the weather.

By extending the form of analysis used in this simple case to the question of the sociological determination of knowledge in its broader aspects, we are in a better position to understand the sense in which social determination has an important bearing on the problem of knowledge. At the same time, we can minimize the danger of the genetic fallacy.

Karl Mannheim points out how the social position of particular groups within a society disposes them to become more aware of certain questions than other groups, and consequently to be more likely to work out answers to such questions.[1] This is a case of the operation of what we have called value-relevance. Obviously, the fact that a particular group provides the answers to questions which are of value-relevance to it does not in itself guarantee the truth of these answers. On the other hand, we are constrained to answer in the affirmative the question: "Are members of this group more likely to produce adequate answers to certain questions than those of some other group who would benefit from concealing the answers from themselves as well as from others?"

The confusion to be avoided here is the assumption that because we have demonstrated something about the sociological roots of a proposition, we have thereby proved something about its logical validity or empirical truth or falsity. It should be clear by now that all we may have succeeded in demonstrating is the greater probability that certain groups will arrive at relatively valid statements, which is quite different from establishing the truth-value of these statements. To accomplish the latter, we must follow the verification rules of the conceptual scheme with which we are operating. In the case of science, this means the use of observational data, interpretative and analytical frameworks, and logicomathematical methods of demonstration.

We can summarize the preceding discussion by stating that the sociological study of knowledge involves the analysis of why different groups at specific times and under specified conditions are likely to be concerned with certain problems and why they are likely to attack them from certain points of view rather than from others. The sociological-existential dimension of science, then, investigates the relationship of scientific ideas to the individuals, groups, and cultures which play a role in their formulation. The logical validity of scientific (and other) ideas, however, is determined by syntactical rules and not by their social origins, even though these rules develop within a sociohistorical matrix. In contrast to the sociological analysis of ideas, logical analysis refers exclusively to the relation of propositions to other propositions within logical systems.

Finally, material or empirical truth refers to the relationship of propositions to observation-statements, in other words, to the relationship of ideas to things. Here again truth-value is to be found only in the rules of empirical verification, not in the social genesis of propositions.

Effective analysis requires that we keep in mind the distinctions between these three dimensions of knowledge in general and scientific knowledge in particular:

1. *Existential*—the sociological, psychological, historical, and individual roots and implications of knowledge;

2. *Logical*—the syntactical relationship of propositions to one another, both in logic and in mathematics;

3. *Empirical*—the relationship of propositions to the world which they attempt to describe and explain.

Of these three, scientific method traditionally has been preoccupied with the last two dimensions of knowledge: formal (or logical) and material (or empirical) truth. The sociology of science focuses upon the existential dimension of knowledge. By analyzing the development of the sciences in their sociohistorical centext, the sociology of science can greatly enrich our understanding of science as a social institution, responsive to the broad currents of historical change and deeply involved in the total life of man and his culture.

The Quest for Knowledge and the Social Order

In Chapter Three, the question was raised concerning the bearing of value-relevance on the problem of the evaluation of the content and validity of scientific knowledge. There it was pointed out that although the selection of the subject matter of the sciences is highly responsive to extrascientific considerations, brought about, for example, by political, economic, and religious circumstances, neither the content nor the validity of knowledge can be evaluated purely on a sociogenetic basis.

Again, the preceding chapters have stressed that cultural goals, changing socioeconomic conditions, religious considerations, and practical needs have all played a part in focusing the attention of scientifically minded men on specific problems for research and interpretation. (A recent dramatic example of the sociocultural determination of subject matter for scientific research is the nuclear developments in the technology of war.)

Similarly, the implications of existential origins for the problem of scientific validity were touched upon in the preceding section. We have become aware of the fact that social conditions as reflected in cultural norms may play a role in the establishment of the criteria of scientific validity. Once established, however, these criteria themselves provide the standards of scientific judgment.

Now we add a complex but essential proposition: that the content of knowledge, in the sense of the level of events which provides the basis of experience, and which is discovered because of its value-relevance to the investigator, exists independently of the culturally conditioned knowledge of it. In other words, it is our knowledge which is determined by existential factors, not that which our knowledge is about.

The preceding considerations are based, as the reader may recognize, on certain postulates of the author's philosophy of science. This is to say that we are making the assumptions:

1. that a real world exists independently of our knowledge of it;
2. that this real world is to an extent knowable through a process of approximation; and
3. that knowledge is true to the degree to which it approximates or is isomorphic to the structure of reality.

On the basis of these postulates we can now construct a formal working definition of truth using as our model that of the mathematical limit which is approximated but never reached. The use of this heuristic device helps us to overcome the implications of a naive relativism which has often been attributed to the sociological investigation of the existential roots of knowledge.

True knowledge is that knowledge which the knower would have if the propositions which he formulates about the objective reality were exactly isomorphic to that reality. Our definition, it will be noted, does not restrict knowledge to scientific knowledge alone, nor does it undertake to define the nature of reality. It is intended to apply to the work of any gnostician, whether scientist, magician, philosopher, technologist, or theologian.

It is, of course, unlikely that any individual or group ever has been or ever will be in a position to obtain true knowledge as defined above. The formulation, however, of a criterion of true knowledge as the limit of the knowing process, that is, the knowledge which the knower would have if he actually knew what is the case, enables us to postulate further that, under certain conditions, certain individuals and groups, having certain interests and frames of reference and employing certain methods, are in a better position to approximate correct knowledge of the case than members of other groups.

If this formulation is correct, the proposition follows that anyone's opinion is not as valid as anyone else's. The value-relevance of certain areas of reality for specific groups occupying specific positions in social time and space already guarantees that they are more likely to obtain accurate knowledge about the phenomena that interest them than would be the case if they focused their attention elsewhere. By the same token, they are more likely than other groups to be blind to other areas of experience in which they have no interest, or to areas of fact that might tend to undermine their position in society or to cast doubt on the basic assumptions of their ideology and philosophy of life.[2]

In the social sphere, therefore, we have the analog of the space-time coordinates of modern relativity physics. Just as we have learned to take into account in astrophysics the physical position of the investigator in the evaluation of his observations, so we must also learn to take into account the cultural and historical components of knowledge which derive from the social position of the scientist.

If the selection of the subject matter of knowledge as well as the conceptual apparatus of interpretation are bound up with existential factors of social position and cultural norms, then it becomes very important for the scientific enterprise that the broadest confrontation of opposing standpoints be encouraged by the society's institutional arrangements. For it is only by the juxtaposition of conflicting and partial viewpoints that we can expect a more inclusive world view to arise. In other words, the limitations of perspective arising from the situational determination of what is considered valuationally relevant by divergent social groups can be overcome only when each group is compelled to take into account in its own thinking the insights derived by other groups occupying different positions in the social order.

Therefore a pluralistic society based on the mutual opposition of conflicting interest groups, one which is organized so as to prevent the monopolization by any one group of the media for the dissemination of thought, provides the optimum conditions for the expansion of knowledge. This holds true not only for specific societies such as our own, but for the broader constellation of peoples as well. The divergence of cultural goals between East and West, Moslem and Christian, Mediterranean and Nordic, Marxist and capitalist, libertarian and authoritarian, furnishes a continuous challenge of ideas to which each group must accommodate itself. The parochialism of limited cultural perspectives can thus be overcome through the development of a wider basis of knowledge arising out of a process of acculturation and mutual interstimulation to which each group must bring its own culturally determined insights and capacities.

The Approach of Science and the Individual

This concluding section will indicate briefly some of the implications of the scientific point of view for the individual as a unique personality and as a member of a social group. It is especially important that these implications should be made explicit at a time when the impact of science upon the lives of men and of societies is a matter of growing concern. But our focus remains the scientific approach itself. Certain features of this approach must be noted before turning to some of their broader implications.

Both the physical and the social sciences, in so far as the latter are patterned on the same model, abstract from events certain characteristics or features about which scientific generalizations can be made. (Science, therefore, as will be stressed shortly, is unconcerned with unique, particular, or unrepetitive phenomena.) Moreover, as a science matures, its general propositions become more and more inclusive, reaching, in the case of the most developed science, physics, such an abstract and all-embracing generalization as $E=MC^2$. The natural sciences seek to show, then, the order, the regularities, of the phenomena of nature by subsuming the latter under scientific laws and incorporating them into a highly generalized conceptual framework.

Furthermore, these abstract general propositions of science generally take the form of statements of probability, not necessity. Thus the trends within contemporary science show that the deterministic Newtonian view of a cosmos governed by absolute laws of nature has been superseded by a relativistic world view marked by patterns of probability. This latter development does not destroy the validity of determinism as an assumption underlying causal analysis. It shifts the basis of scientific determinism, however, to problems of large numbers and frequency distributions.

Current discussions in the philosophy of science have made us aware, as well, that determinism operates as a useful methodological assumption of the sciences, that is, as a postulate of research. But such questions as whether or not the universe is really determined, undetermined, or possibly both in its essential nature, are now recognized as being metaphysical questions which lie outside the domain of the sciences.[3]

In this connection, we may refer to the well known Heisenberg indeterminacy principle. Roughly stated, the principle holds that the path of an individual electron is unpredictable, because the process of observation itself affects the behavior of the phenomena under investigation. This observation underlines the probability character of modern physics. At the same time, the unpredictability of the behavior of a single electron in no way destroys the possibility of arriving at physical generalizations. For although individual electrons may behave unpredictably, a population of electrons in an atomic field structure performs with a very high degree of statistical regularity, which makes it possible to arrive at physical laws of a sufficient degree of probability to closely approximate unity. The generalizing sciences deal at all times with such collective phenomena, and with the probable patterns of behavior of populations, whether of electrons, fruit flies, or human beings.

The generalizations of the biological and the social sciences, although their probable error, to use a statistical concept, is considerably higher, are of the same order; they do not apply to the actions of unique individuals. The biological sciences are concerned with the typical, the average, the normal, the recurrent, as are such sciences as economics, sociology, and psychology. The student of the social sciences is aware of their preoccupation with rates, distributions, correlations, and other measurements of aggregates. This preoccupation was stressed many years ago by Emile Durkheim in his classic study, *Suicide* (1897), in which the author insisted that the sociologist's concern is not with the reasons why any particular individual takes his own life but rather with questions about differential suicide rates in various groups and the interconnections between such rates and other social and cultural phenomena.[4]

The focus of science upon rates, patterns, and persistencies and changes of structures (whether social or nonsocial) has important implications for the human individual. The person who believes that he can escape the responsibility for his own actions by invoking scientific determinism (by declaring, for example: "I am a product of my biological heritage and of my social environment and therefore I am not responsible for what I do") exhibits little understanding of the nature of scientific determinism. Scientific laws do not declare that all individuals behave in a specified way under certain circumstances. Rather the scientific generalization characteristically states that for a particular population there exists a probability that certain behavior patterns are likely to be present. A particular case may deviate to a lesser or greater degree from the expected behavior of the group taken as a whole.*

For example, experts on social disorganization have demonstrated that certain areas of modern cities in the United States are marked by higher rates of juvenile delinquency than others. One can even predict with a fair degree of accuracy the number of cases of delinquency which will appear each year in some localities. But the most extreme delinquency areas also occasionally produce individuals who become justices of the federal courts. Although the probability of an individual reared in such an area becoming a judge is considerably smaller than that of his becoming a delinquent, it is clear that the individual is not necessarly constrained, because he lives in a particular urban area, to become either a delinquent or a federal judge. Here again probability principles apply to the group as a whole and not to the individual case. The life pattern of each individual is the result of a large number of forces, some arising from conditions that the individual shares with others of the same cultural and economic milieu, others deriving from the unique constellation of factors that mark the life of a particular individual, and still others emerging from specific decisions made by the individual at certain strategic points in his life.

Contemporary social thought increasingly rejects a social physics based on an antiquated mechanistic model of the physical world. The conception of the individual as an active agent in the transformation of his environment has largely superseded the view of man as a passive instrument of inexorable environmental pressures. Both the new physics and the new social science, as they may be called, are highly suspicious of a metaphysical determinism that, in the nineteenth century, could prompt a Laplace to state that he could predict the entire future of the universe if he knew the present position of every particle in it.

Thus the natural sciences have come to recognize that their propositions, either implicitly or explicitly, are probability statements. The latter are no

* It is also clear that if a sufficiently large number of individuals deviate from the norm the probability pattern itself will be modified.

longer viewed as absolute laws governing the behavior of the world from the smallest quanta to the expanding universe of the astrophysicists.

The social sciences, impressed by the greater variation of the phenomena which they study, discovered quite early in their development the enormous significance of the probability approach to their subject matter. Almost simultaneously with the appearance of Auguste Comte's program for a science of society in the first half of the nineteenth century, appeared Adolphe Quetelet's *Sur l'Homme* (1835), outlining the application of the statistical method to the study of man's physical qualities and of his moral attributes as well. To this day, the social sciences have remained largely sciences of group phenomena. Thus the concepts of sociology pertain, as Max Weber has pointed out, to the probability that certain types of social action have taken place, are taking place, or will take place.[5] Sociological generalizations about social classes, cultural patterns, associations, pressure groups, nationalities, and the like refer to the greater or lesser likelihood of certain kinds of attitudinal and action patterns being present or absent.

This approach of science (both social and natural science, as we have noted), emphasizing probabilities and patterns of action, carries with it an important implication for man's individual life.* For example, the statistical fact that within a particular society the average middle-class family consists of husband, wife, and two children is no guarantee that a particular family will be so constituted and, at the same time, imposes no moral obligation on any specific family to have two children. Again, if the average age of marriage is, say, twenty-one, the individual is still free to marry earlier, later, or not at all. Statistical facts of this kind are examples of social facts, to use Durkheim's terminology, not individual facts. The former are the result of the interaction of many individuals and their sociohistorical situation. Whether or not each of these individual acts is free or determined is irrelevant for the sciences, and indeed not amenable to scientific investigation. It would seem, nevertheless,—and this generalization is probably subject to scientific study—that individuals who believe that they are free and act accordingly are more likely to maintain their freedom than individuals who, denying the existence of free choice, surrender their liberties without a struggle.

From these considerations we conclude that the sciences leave the questions connected with universal determinism or indeterminism open to the judgment of each individual to decide as he confronts his own life situa-

* I do not wish to deny the possibility of the development of individualizing sciences in contradistinction to the traditional and current emphasis on generalizing sciences. For example, certain trends in history, genetic psychology, interpretative sociology, and existential social philosophy point in this direction. My discussion throughout has been centered primarily on science in its more general usage, as it has developed within the positivist, rationalist and empiricist tradition.

tion. For these are questions of ethical choice, political loyalty, theological belief, and metaphysical standpoint—areas in which the sciences of nature and the sciences of man can claim no competence. The social sciences may attempt to analyze the general consequences and conditions associated with members of specific groups taking one position or another on these questions. The point is, however, that the sciences cannot tell the individual which position he ought to take, or which consequences he should seek or avoid. But these, perhaps, are the most important questions that each individual must decide for himself. For it is through these choices and commitments that he finds the personal meaning of his life and the basis of responsibility for his acts. *

FOOTNOTES TO THE STUDY

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11. Cf. Barber, *op. cit.*, pp. 122–23.
12. Znaniecki, *op. cit.*, p. 12.
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Chapter Four. KNOWLEDGE, SCIENCE, AND THE INDIVIDUAL LIFE

1. See especially Karl Mannheim: *Ideology and Utopia*, New York, Harcourt, Brace & Co., 1936.
2. Mannheim's *Ideology and Utopia* is in large part a detailed and systematic analysis of this point.
3. Cf. Hans Reichenbach: *The Rise of Scientific Philosophy*, Berkeley, University of California Press, 1952; see also the publications of the Institute for the Unity of Science.
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