Scientist and Public

Why is the scientist, once a "natural philosopher," now considered a barbarian by many educated laymen?

René Dubos

Let me say, by way of introduction, that I do not have the professional knowledge of the historian, nor have I ever engaged in true historical research. The most I can claim is a long and continued interest in the *results* of historical scholarship, and a willingness to use them for guidance in some of my scientific studies. Thus, I speak not as a contributor to the history of science but, rather, as a consumer and, at best, a devotee.

A report published last July in *Science* [**132**, 68 (1960)] provides a striking illustration of the relevance of historical knowledge to the social attitude of the scientist in the modern world. *Science* devoted five pages to the report of the AAAS Committee on Science in the Promotion of Human Welfare. "Having become a major instrument in political affairs," the report states, "science is inseparably bound up with many troublesome questions of public policy. That science is valued more for these uses than for its fundamental purpose—the free inquiry into nature—leads to pressures which have begun *to threaten the integrity of science itself*" (italics mine). It is very timely to consider this statement in its historical context because the issues that it raises can be traced to the writings of a man whose quadricentennial we are celebrating this year—namely, to Francis Bacon (1561–1626), who has been called the first statesman of science.

Bacon

So much has already been written concerning Sir Francis Bacon, Lord of Verulam, Grand Chancellor of England—still assumed by some admirers to be the real Shakespeare—that I need mention here only the particular aspects of his role as prophet of modern science which have a direct bearing on the present topic. Bacon's own contributions as a scientist were trivial, and whatever the merit of the inductive method which he advocated, it was not original with him. Yet, his name deserves to survive in scientific history because, through the vigor of his convictions and the splendor of his language, he became the symbol of the belief that science is an infallible instrument to solve practical problems. Scientific knowledge, he claimed, would permit man to recapture his dominion over nature and thus to regain the happiness that was Adam's before the Fall. Furthermore, Bacon helped spread the doctrine, then unorthodox, that to improve the lot of man on earth is the real justification of science. In his words, science is not "for pleasure of mind . . . but for the benefit and use of life"; its "true and lawful goal . . . is none other than this: that human life be endowed with new discoveries and powers."

Bacon was not, of course, the first one to have become aware of the practical potentialities of science. He was but the eloquent voice of the many forces that converted Europe from the scholastic acceptance characteristic of the Middle Ages to the dynamic attitude associated with the Renaissance and the Reformation. But granted that he acted chiefly as the voice of his age, he had a creative influence, nevertheless, through helping Europeans to realize the social power of science. He acted as a gadfly, and sounded a call to organize life for the scientific era. In his words, he "rang the bells which called the wits together."

Not only did Bacon preach that science is power, he also imagined in his Utopian *New Atlantis* the first model of a society based on scientific wisdom, a sort of blueprint for the modern world. The measure of his originality is provided by the fact that no other creator of Utopia has described anything comparable to the community of scientific scholars that constituted "Salomon's House," the ruling body of "New Atlantis." His imaginary commonwealth was organized to make use of technology in every department.

A New View of Knowledge

It is certain that, directly or indirectly, Bacon's description of "Salomon's House" influenced the organizers of the scientific academies that sprang up during the 17th and 18th centuries. The emphasis on the practical aspects of science appears, for example, in a letter by Robert Boyle, who was one of the first members of the "invisible college" which eventually became the Royal Society in 1660. In this letter Boyle stated that he had been studying "natural philosophy, the mechanics, and husbandry, according to the principles of our new philosophical college, that values no knowledge, *but as it hath a tendency to use*" (italics mine). And Bishop Thomas Sprat, the author of the first history of the Royal Society, published in 1667, referred to Bacon with the statement that "there should have been no other preface . . . but some of his Writings." The French Encyclopedists also acknowledged their indebtedness "to the immortal Francis Bacon . . . to consider the just and extensive Views of this prodigious Man; the Multiplicity of his Objects; the Strength of his Style; his sublime Imagery; and extreme Exactness; we are tempted to esteem him the greatest, the most universal and most eloquent of all Philosophers. . . . It is to this great Author we are chiefly indebted for our Encyclopaedic Plan."

Thus Bacon symbolizes, even though he obviously did not initiate, a very profound change in the attitude of man toward knowledge. In the past, science had been primarily concerned with the search for law and order. It was

The author is professor and member of the Rockefeller Institute, New York, N.Y. This is the George Sarton Memorial Lecture, delivered 27 December 1960 at the AAAS meeting in New York.

theoretical rather than practical—an adornment of life. After Bacon, knowledge increasingly became an instrument to achieve mastery over nature. First in the Western countries, then all over the world, this attitude became identified with progress and civilization. The statement attributed to Karl Marx applies well to scientists in all modern societies: "Hitherto philosophers have sought to understand the world—henceforth they must seek to change it."

Science and Public Policy

At this point I might be expected to discuss the manner in which the ever-increasing role of science is presently affecting its support and organization. And indeed many perplexing questions are arising at the point of contact between science and society. They concern the policy makers of science, the scientists who produce it, and the public who uses it—in other words, all of us. Most scientists believe that science progresses best under conditions of absolute freedom. And yet, can scientists really hope to retain freedom in the selection of their problems, in the conduct of their studies, and in the applications of their findings, now that they are in the process of becoming public servants? Is it not likely that politicians and even statesmen will increasingly adopt toward science and scientists the attitude symbolized by Clémenceau's opinion of soldiers—"War is too serious a business to be entrusted to generals"? Important as these problems are, I shall not consider them here, because I want to focus my attention on another aspect of the interplay between scientists and public which is rarely discussed—namely, the cultivation of science for knowledge's sake.

Improvement of Man's State

Not only did Bacon urge that the proper object of science is the improvement of man's state, he even went so far as to suggest that there is something almost sinful in the use of science for purposes other than the practical. "Knowledge, that tendeth but to satisfaction," he wrote, "is but as a courtesan, which is for pleasure, and not for fruit or generation."

The attitude toward science implied in the preceding quotation is not uncommon among practicing scientists today, and indeed it conditions their views on the "social implications" of their professional activities. In the usual discourse, these implications refer almost exclusively to the practical uses of scientific knowledge, little to its philosophical relevance. Two stories, concerning Faraday and Pasteur, illustrate the extent to which this attitude affects the public behavior of scientists. It is told that Faraday once received the visit of an important person in his laboratory at the Royal Institution, shortly after he had discovered electromagnetic induction. He gave a demonstration of the phenomenon to his visitor, who was apparently unimpressed and inquired, "What is the good of this discovery?" To which Faraday is alleged to have replied, "Someday, Sir, you will collect taxes from it." Pasteur also used the lure of practical applications in undertaking to convince his students of the importance of scientific studies. At the University of Lille, in 1856, he recounted that Franklin, on being asked about the use of a certain discovery, merely replied, "What is the use of a new born baby?"

The statements attributed to Franklin, Faraday, and Pasteur imply, of course, an awareness of the social power of experimental science. The answer, "What is the use of a new born baby?" clearly symbolizes the faith that scientific discoveries are not an end unto themselves, that they hold in potential many further developments, not all of which can be readily predicted because so much depends on future circumstances. And the suggestion that taxes will someday be collected from a new scientific fact is but a more concrete and worldly statement of the same faith. It expresses the belief that almost any scientific discovery will eventually be converted into some process or product which society can use, and for which it is willing to pay. But Franklin, Faraday, and Pasteur did not tell the whole truth, because they did not express completely their own attitude toward science.

Faraday

Faraday was an active member of a very strict sect of the Nonconformist Church. His lofty religious ideals and his urge to pursue as far as possible the spiritual implications of his scientific work led him to abandon all industrial consultation work and to renounce the monetary and social advantages that he could have derived from his immense fame. Yet, while he properly emphasized the usefulness of science in the practical affairs of man, he rarely voiced his inner conviction that science is an attempt to understand the universe as much as it is a technique to exploit nature; that—to use an expression of which he was fond—science is, above and beyond everything else, "natural philosophy."

Pasteur

As for Pasteur, it is often claimed that his scientific work originated from a concern with practical problems—for example, that his studies on fermentation had their basis in attempts to improve the quality of French wines and beer, or that his interest in infectious processes developed from efforts to save the production of silkworms in France. Nothing could be further from the truth. In reality, as I have shown elsewhere, Pasteur began his scientific life as a purely theoretical investigator, and he was already a famous scientist when he began to work on practical problems. From 1847 to 1857 his dominating scientific interests had no apparent practical significance; they dealt with the bearing of molecular structure on optical activity, and of stereoisomerism on the origin of life. A few years later he became engrossed in other abstract thoughts concerning the biochemical unity of life. As time went on, however, he yielded more and more to the social pressures of his environment and devoted the largest part of his productive life to practical problems of fermentation and disease. He became increasingly involved in using science as a technological instrument rather than as a discipline for understanding the universe. Repeatedly he expressed gratification at seeing that his labors would help man to gain mastery over the physical world and to improve human life. "To him who devotes his life to science," he wrote, "nothing can give more happiness than increasing the number of discoveries, but his cup of joy is full when the results of his studies immediately find practical applications."

There is no doubt, in my opinion, that Pasteur was aware that his involvement in practical problems interfered with the pursuit of his deeper scientific interests. He tried to justify his partial neglect of theoretical studies by the statement, "There are not

two sciences. There is only science and the applications of science and these two activities are linked as the fruit is to the tree." Yet, despite these brave words and regardless of immense success and popular acclaim, he must often have regretted the choice that had been imposed on him by the *Zeitgeist.* Time and time again he stated that he had been "enchained" by an inescapable forward-moving logic that had led him from the study of crystals to the problems of fermentation and contagious diseases. Yet, the desire of his early days to work on problems of deep philosophical significance apparently remained with him as a haunting dream. His grandson, L. Pasteur Valley-Radot, has recently told a moving story which reveals the pathetic intensity of this inner conflict during Pasteur's later years.

"He seemed to me serious and sad. He was probably sad because of all the things he had dreamed of but not realized. . . . I remember one evening, at the Pasteur Institute. He was writing quietly at his desk, his head bent on his right hand, in a familiar pose. I was at the corner of the table, not moving or speaking. . . . He stood up and, feeling the need to express his thoughts to the nearest person, even a child, he told me: *'Ah! my boy, I wish I had a life before me! With how much joy I should like to undertake again my studies on crystals!'* To have given up his research on crystals was the eternal sorrow of his life."

Conflict for Today's Scientists

Many modern scientists suffer from the schizophrenic attitude exemplified by Faraday and Pasteur. Fortunately, one particular aspect of science helps to minimize the inner conflicts generated by this attitude—namely, the fact, mentioned above and universally recognized, that it is often difficult to disassociate the theoretical from the practical aspects of science. Nevertheless, the conflicts are not entirely resolved by this interdependence of theory and practice. The uneasiness of scientists on this score is revealed by the observation that, whereas they claim among themselves that their primary interest is in the conceptual, not in the applied, aspects of science, in public they justify basic research by asserting that it always leads to "useful" results, meaning by this the development of processes and products that can be converted into social good, wealth, or power.

Like Faraday and Pasteur, scientists seem to find it somewhat embarrassing to admit in public that detached intellectual curiosity and a desire to understand the universe is one of the objects of science, whether or not "useful" results ever follow. Yet, despite Francis Bacon's claim that "knowledge, that tendeth but to satisfaction is but as a courtesan . . . ," the attempt to justify science only by its worldly products is fraught with dangers. Not only does it compromise the intellectual honesty of the scientific community, for reasons that need not be discussed here; in my opinion it also helps to foster among lay people some contempt for science itself.

The "Antiscience" Movement

Many are those in the course of history who have expressed doubts as to the ultimate value of natural sciences—from Socrates' skepticism to the talk of the bankruptcy of science so common around the turn of the 19th century. But these doubts did not necessarily mean hostility; rather, they expressed impatience at the fact that, despite oft-repeated promises, science had not solved the riddle of human nature and destiny. Far more dangerous, it seems to me, are the expressions of contempt for science as an intellectual discipline, and for scientists as thinkers, that have appeared repeatedly during the past few decades. Along with admiration and awe for the power of science there exists presently in the lay public, as pointed out by Margaret Mead, a curious mistrust of the scientist himself, as if he were something scarcely normal or human. This modern attitude toward the scientist is not far removed from that of primitive people toward the shaman or medicine man, whom they regard as an individual essential to the group but who is feared and often hated.

As typical of the hostile attitude toward science and scientists, I shall consider two books, published, respectively, in 1913 and 1930—namely, *The Tragic Sense of Life,* by Miguel Unamuno, and *The Revolt of the Masses,* by Ortega y Gasset. Both books have been translated into several languages and are still widely read and quoted today; they represent, and have spread far and wide, several aspects of the antiscience movement.

Unamuno and Ortega

Unamuno and Ortega recognize, of course, the contributions made by science to human safety and comfort. But while they appreciate the merits of aspirin and motor cars, they are very little impressed by the kind of intellectual process involved in the technology that has produced these conveniences. Most scientific thinking, according to them, corresponds to a performance of a rather low intellectual order. Just as ancient societies used slaves for the affairs of everyday life, so do modern societies produce and use scientific technicians for the same end. It is interesting to note here that, consciously or unconsciously, Unamuno and Ortega have accepted Bacon's claim that the scientific method is so mechanical and foolproof as to be readily and effectively handled by small minds.

As is well known, Bacon considered that induction, with absolute objectivity, was all that was needed to advance scientific knowledge and to convert it into social power. In fact, he had such confidence in this method that he thought it could be used, with success, almost blindly and by men of little talent. "My way of discovering sciences," he wrote, "goes far to level men's wits, and leaves but little to individual excellence; because it performs everything by the surest rules and demonstrations." Needless to say, few are the scientists today who believe that important discoveries ever result from the mere accumulation of facts. But by the general public the "scientific method" is still regarded as a more or less mechanical formula, different in quality from other creative processes. Indeed, Ortega and Unamuno seem to have taken to the letter Bacon's statement that "brutes by their natural instinct have produced many discoveries, whereas men by discussion and the conclusions of reason have given birth to few or none." As an extension of Bacon's aphorism, it seems worth while to quote here at some length from the several pages that Ortega devotes, in *The Revolt of the Masses,* to the low intellectual caliber of scientists and their discoveries.

"The actual scientific man is the prototype of the mass-man. Not by chance, not through the individual failings of each particular man of science, but because science itself . . . automatically converts him into mass-man, makes of him a primitive, a modern barbarian. . . .

"Experimental science has pro-

gressed thanks in great part to the work of men astoundingly mediocre, and even less than mediocre. . . . The reason of this lies in what is at the same time the great advantage and the gravest peril of the new science, and of the civilization directed and represented by it, namely, mechanization. A fair amount of the things that have to be done in physics or in biology is mechanical work of the mind which can be done by anyone, or almost anyone. . . . The work is done . . . as with a machine, and in order to obtain quite abundant results it is not even necessary to have rigorous notions of their meaning and foundations. . . .

"The specialist . . . is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant, because he is a 'scientist,' and 'knows' very well his own tiny portion of the universe. We shall have to say that he is a learned ignoramus. . . . Anyone who wishes can observe the stupidity of thought, judgment, and action shown today in politics, art, religion, and the general problems of life and the world by the 'men of science.' "

Scientists having become so mechanical in their activities and so unconcerned with philosophical and truly intellectual problems, it is not surprising that, in Unamuno's words, "science does not satisfy the needs of our heart and our will." Not only does it not deal with the problems of the real man "of flesh and bone" but it "turns against those who refuse to submit to its orthodoxy the weapons of ridicule and contempt."

Thus, according to Unamuno and Ortega, the modern scientist is thoroughly dehumanized, does not see beyond his specialized techniques, and has no awareness of worth-while human goals. Science fails to deal with the problems that are the real concerns of mankind, and furthermore it stultifies all higher aspirations by fostering and satisfying the mass aspects of human nature. Lest there be an illusion that the antiscience movement is peculiar to Latin countries, I shall quote other remarks, originating from the Anglo-Saxon world. In Scotland, some 25 years ago, W. Mac Neile Dixon asserted in the Gifford lectures that "science is the view of life where everything human is excluded from the prospect. It is of intention inhuman, supposing, strange as it may seem, that the further we travel from ourselves the nearer we approach the truth, the further from our deepest sympathies, from all we care for, the nearer are we to reality, the stony heart of the scientific universe." This indictment should be supplemented with a related thought from an American author, "Science might almost be defined as the process of substituting unimportant questions which can be answered for important questions which cannot."

Sources of Misunderstanding

Scientists are inclined to find the reason for the antiscience movement in the fact that the public does not have the training or the ability required to appreciate the intellectual distinction and morality of scientific thought. But the possibility might be worth considering that the scientists themselves have a share of responsibility in this misunderstanding because they do not convey to the public the nobler aspects of the scientific heritage. It seems to me that some scientists have a tendency to exhibit pride of intellect in speaking of the "scientific method," as if it were something esoteric, superhuman in its power and precision, whereas in reality it is a very human activity supplemented by the use of specialized techniques. Instead of bragging about the purely professional aspects of a "scientific method" that we really cannot define, should we not emphasize more than we do the spiritual, creative, and esthetic aspects of all great scientific advances?

Scientists defend basic research in public by asserting that it cannot fail eventually to yield practical results, but they rarely advertise that knowledge per se is also a precious fruit of science. There is truth, of course, in Farrington's statement that "man makes his mental history in the process of conquering the world," but it is also true that science, like philosophy, has been pursued for its own sake, or rather, for the sake of intellectual satisfaction and of increased understanding. Long before there was such a thing as industrial technology, Ptolemy experienced the kind of intellectual intoxication that only knowledge can provide. "I know that I am mortal, a creature of a day; but when I search into the multitudinous revolving spirals of the stars, my feet no longer rest on the earth, but standing by Zeus himself, I take my fill of ambrosia, the food of the gods." In a similar mood Kepler also exclaimed, "Eighteen months ago the first dawn rose for me, three months ago the bright day, and a few days ago the full sun of a most wonderful vision." And at the end of his life Pasteur spoke lovingly of "the charm of our studies, the enchantment of science."

The Layman's View

The motivation which makes great scientists emphasize in public the practical worth of their studies and not their loftier intellectual goals is probably the wish to gain public approval. But there is no evidence that the public would not recognize and respect a purely intellectual motivation. In fact, it seems to me that whenever laymen have exhibited any interest in science they have been just as eager to learn of its philosophical aspects as of its practical applications. True enough, little is known of the manner in which the popularization of science was undertaken in past centuries and of the extent of its success; there does not seem to exist any thorough historical study of this interesting aspect of scientific communication. Nevertheless, there readily come to mind the names of many celebrated scientists who achieved great popular acclaim by bringing theoretical knowledge to lay audiences.

Public Response in the Past

Probably the best known, and certainly one of the first, of the science popularizers was Bernard de Fontenelle (1657–1757). He made his literary reputation with the *Entretiens sur la pluralité des mondes* and continued to hold the limelight with his more austere accounts of the achievements of scientists and of the "Académie des Sciences." According to his historian, L. M. Marsak, Fontenelle's writings had as many readers among the general public of the court and the bourgeoisie as among the learned; they went through six editions in his lifetime, and through six more by 1825. Fontenelle mentioned, of course, the practical potentialities of science, but what he emphasized was its humanistic quality, its contribution to enlightenment. He urged his readers to recognize that "Nature is never so admir-

able or so admired as when it is understood," and that it is at least as important for scientists to help the public rid itself of errors (*fausses merveilles*) as it is for them to proclaim true marvels. Would that all science reporters observed this admonition in our times! Although it would be out of place to write here at greater length of Fontenelle, I cannot forego quoting Marsak's appreciation of the magnitude of his achievement. "If the nineteenth and twentieth centuries have held up the businessman and engineer for emulation, it would not be an exaggeration to say that Fontenelle spoke for the civilization of the Enlightenment when he put the scientist in the niche that had formerly been reserved for the artistic creator of the Renaissance or the saint of the high Middle Ages." In addition to educating the public, Fontenelle helped create a friendly environment that eased the task of the scientists.

At the end of the 17th century and through the 18th century people came to Paris from all over Europe to attend lectures given by famous scientists. In London, the Royal Institution, with its lectures and demonstrations, long remained a fashionable rendezvous. In Germany, Helmholtz found it worth while to devote much time to presenting various aspects of theoretical science to the general public. Many other examples could be given to show that scientists have found, on many occasions, responsive audiences eager to learn not of processes and gadgets but of ideas and general laws. As evidence I need only quote a statement made by John Tyndall in Boston at the end of a highly successful tour during which he had lectured before lay audiences in the United States. "What, I may ask, is the origin of that kindness which drew me from my work in London to address you here, and which, if I permitted it, would send me home a millionaire? Not because I had taught you to make a single cent by science am I here tonight, but because I tried to the best of my ability to present science to the world as an intellectual good. . . . It is specially on this ground of its administering to the higher needs of the intellect; it is mainly because I believe it to be wholesome, not only as a source of knowledge but as a means of discipline, that I urge the claims of science upon your attention."

Public Response Today

It will be objected, perhaps, that times have changed, that the public is no longer interested in the large intellectual aspects of science but is concerned only with what technology can do for human comfort. Although this objection cannot be refuted convincingly, a few facts seem to be incompatible with it. For example, many of the books on science for the general public which became best sellers during recent decades dealt not with practical problems but, rather, with large theoretical themes of anthropology, biology, physics, astronomy—nay, even of mathematics—which could not in any way be practically useful in the conduct of the readers' material life. Here, again, an objective study of public response would be enlightening and could provide useful guidance for the popularization of science.

Earlier in this discussion I used the names of Miguel Unamuno and Ortega y Gasset to symbolize the movement which is often called antiscience. This was unfair to these authors because they are, in truth, the voice of humanity begging scientists to remember that man does not live by bread alone. They express, also, the fear of those who see science identified exclusively with power and technology at a time when it is beginning to reach populations which have never known it under any other guise. It should not be forgotten that in the Western world science was part of the culture for several centuries before it came to be used extensively for practical ends. Today this cultural heritage conditions, to a certain extent, the manner in which science is pursued and employed in the countries of Western civilization. In contrast, science is being introduced in the underdeveloped parts of the world not as a cultural pursuit but merely as a powerful and convenient tool—to be used at best for the production of material wealth, at worst for destructive purposes. It seems to me that scientists and science writers betray a public trust when they neglect to emphasize the disinterested aspects of knowledge and are satisfied instead, with claiming that all discoveries eventually prove of practical use. On the one hand, this is not necessarily true. On the other hand, this attitude ignores the fact that today, as in the past, men starve for understanding almost as much as for food. In the long run, the exclusive appeal to utilitarianism may well endanger the future of science and its very existence.

Understanding and Power

It is obvious, of course, that during recent decades science has improved the lot of man on earth even more successfully than Francis Bacon had anticipated. It is equally true, however, that for many centuries before the modern era, science had enriched mankind with a wealth of understanding at least as valuable as material riches. Scientists, like other men, win esteem and contribute to happiness more effectively through the exercise of wisdom than through the practice of power. And it is good for them to remember that, long before they had achieved technological mastery over nature and thus had become servants of society, their functions as high priests of natural philosophy had given them ancient titles of nobility which they must continue to honor.