The Role of Science in Our Unique Society

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PERHAPS A WORD OF WARNING will not be out of place at the outset—a word of warning addressed to any members of this audience who are not members of the Association. To the scientist I need hardly say that, as retiring president of the American Association for the Advancement of Science, I am in no sense a spokesman for science or the scientist. Quite the contrary. The tradition in this Association, as in all other scientific gatherings, is that everyone speaks for himself and only for himself. Election to office provides a platform, sometimes a few hearers, but not always followers or believers. I open with these obvious remarks, for in large measure what I have to say may seem not only heretical but objectionable to many of my scientific colleagues. Therefore, I emphasize the tradition by which an officer of this Association may in his views represent a minority position—even as small a minority as one.

Tonight I am supporting the thesis that in the United States during the next few decades science may well play a determining role in the outcome of affairs; there is no heresy here—only a platitude, I am sure. The same statement might be made by a speaker in London, Paris, or Moscow making the appropriate national substitution for the words "the United States." Every industrialized nation is dependent on applied science for the continuing welfare of its economy and, alas, for the military security of its frontiers and cities. In my opinion, however, there is a special sense in which science is called upon to help with our national problems here in this country. Furthermore, it seems to me that a special group of sciences is involved. These are concerned with the study of man and, it may be noted, function differently in various nations, depending on the cultural pattern and the ideology; physics and chemistry are the same on both sides of the alleged iron curtain—not so, social psychology or anthropology.

What Is Science?

Before developing the basis for these dogmatic statements I must tax your patience by explaining briefly what I mean by science and why I refer to this republic of free men as a "unique society." Addressing myself once more to any in the audience who are not scientists, I must caution you that there is no agreement whatsoever as to the definition of the words science, scientists, or scientific method. Prof. H. Dingle has recently written: "When we contemplate the ideas of the essential nature of science which are most prevalent and operative today we find a situation fit to make the angels weep!" He might have added that when one uses the adjectives "pure" or "applied" in connection with science, the angels depart, for there is almost certainly a violent argument in the making.

For example, there are those who believe passionately that all rational and relatively unprejudiced inquiries are scientific. Such people often maintain that, in theory at least, there is a continuous transition between those problems which yield to the labors of the scientific investigator or the engineer on the one hand, and on the other, all the vexing questions which confront men and women in factories, offices, and political gatherings as well as in the nursery, the kitchen, and the garage. A distinguished member of this Association whom we all hold in the highest esteem has written: "Men and women effectively trained in science and *in the scientific method usually ask for the evidence,* almost automatically. They have some of the experience and more of the critical judgment necessary to evaluate the evidence." One cannot help wondering where the author of this categorical statement obtained *his evidence.* I should have supposed that only a very exhaustive study of reactions and attitudes of many people with and without scientific training of various sorts could possibly supply the data from which such a generalization could arise. As far as I am aware, no such study has as yet been made. Perhaps here is an illustration of what certain types of scientists might accomplish and thereby clarify our thinking on an important educational issue. But I am getting far ahead of my story. Let me return to this question of defining science.

I ventured to propose some years ago that the secular learned world might be conveniently trisected. Supporting myself as best I could by quoting Francis Bacon (and only slightly misrepresenting his point of view), I suggested that we would do well in this century to distinguish between (a) accumulative knowledge, (b) philosophy, and (c) poetry. The

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operational test to distinguish the first area from the other two is relatively simple and quite obvious. Whenever it can be said with some assurance that earlier writers or practitioners, if brought to life today, would recognize the superior position of their successors, then we can speak of accumulative knowledge. By such a test one distinguishes between Plato on the one hand and Archimedes on the other, or between Milton and Harvey, or between Immanuel Kant and Newton.

Large portions of history and philology as well as all of archaeology fall under this definition of accumulative knowledge, as do the physical and biological sciences and mathematics (including symbolic logic). Our increasing knowledge of man as an individual and as a social animal and all of the practical arts from mining through agriculture to government are likewise included, provided, of course, there has been real progress. This whole vast field may be called science if you choose; the German word "Wissenschaft" is often used in just this way.

I think, however, that this broad use of the word science is apt to be confusing. The word science has very definite connotations to laymen. These are today connected with only one branch of accumulative knowledge. Therefore, I suggest we define science historically by equating it with the extraordinary activity which arose in Italy in the 16th Century and spread to the rest of Europe in the 17th, and which in our time has flourished and proliferated with so much vigor. Around 1600 there was a change in point of view among learned men which was so marked as to be revolutionary. It was so regarded by the leaders of thought of the 17th Century, who often spoke of the "new philosophy," meaning by that, experimental and observational science.

I place science within the area of accumulative knowledge, therefore, instead of regarding it as coextensive with it. According to my view, only in very recent times did science emerge from the other human activities which had been accumulating knowledge for thousands of years (though I recognize, of course, that one traces a sort of prenatal history of science back to the Greeks and even further). The characteristic of the new philosophy of the 17th Century was that it sought to deal with those ideas or concepts which arose from controlled experiment or observation and in turn led to further experiment and observation. Science, thus defined, is to be regarded as a series of interconnected conceptual schemes which arose originally from experimentation or careful observation and were fruitful of new experiments or observations.

The test of a new concept is not only the economy and simplicity with which it can accommodate the then-known observations, but its fruitfulness. Science has a dynamic quality when viewed not as a practical undertaking but as a process of developing conceptual schemes. Science advances not by the accumulation of new facts (a process which may even conceivably retard scientific progress) but by the continuous development of new and fruitful concepts.

The definition of science I have chosen, I should like to emphasize, is entirely independent of the field of inquiry or of any application of the knowledge obtained. Parallel with the development of science in the last three centuries and a half there has been a rapid development of the practical arts. At first the two activities were largely independent in spite of the hopes of Francis Bacon and the new philosophers. Improvements in the art of working metals, of growing food, of making glass and ceramic materials, and even in increasing the destructive power of weapons, was little affected by the early scientific work. It is not until we get into the 19th Century that we begin to see anything like the practical influence of scientific progress to which the first scientists so confidently looked forward. And it is only in the 20th Century that we have seen so close an interaction between advance in science and progress in the practical arts as to result in some popular misunderstanding about the relation of the two.

Advance in Science and Progress in the Practical Arts

Since the role of science in any society today is intimately associated with the application of scientific knowledge, I am going to take the liberty of pursuing still further an inquiry into the relation of advance in science to progress in the practical arts.

It is as though we were dealing with a continuous spectrum. At one end we may place the changing conceptual schemes arising from experiment and giving rise to experiment (pure science, if you will); at the other end we place the improvements in the practical arts that have been proceeding for millennia. Not until about 1600 does the pure science end of the spectrum become visible. While this end increases in width and intensity for the next 200 years, so likewise the opposite end continues to glow brightly. Then the intervening space narrows, and in this century the intermediate zone becomes full of glowing lines connecting the once totally disparate ends with each other.

The procedures of the scientist are now used daily to solve immediate problems which were once solely within the province of the skilled artisan. Though we can still recognize the two ends of the spectrum to which I referred, the intermediary zone now occupies the main position. For not only has "pure" science invaded the practical arts, but the practical arts have penetrated deeply into science. In many areas one

cannot distinguish between the "techniques" of the scientist interested only in new conceptual schemes and those of the experimenter interested only in an improved industrial machine or process.

If we turn our attention from the physical sciences to the biological, we find a similar phenomenon. How difficult it is today to draw the line between pure and applied science in such fields as biochemistry, physiology, and even bacteriology! The application of new ideas and new tools developed by the physicist and chemist to the study of biological problems has been one of the most successful undertakings of the last three decades. Is this "pure" science or "applied" science? Who can say? Within each subdivision of the subject matter one can recognize a whole spectrum of activities ranging from the search for a broad understanding of certain biological processes to immediate concern with a very specific case. Certainly, the interplay between investigators pressing for solution of medical and agricultural problems and those concerned only with fundamental studies is today very fruitful. There is no room for argument as to which is a superior activity. Neither the clinician nor the chemist can afford to look down his nose at the other fellow. They are too busy cooperating, one with the other.

This was not always so. In the middle decades of the 19th Century, the cleavage between scientists and practitioners was much greater than in our time. This was so both in the physical and biological sciences. Clerk Maxwell's public comments on Alexander Graham Bell's telephone is a case in point. The physicist reviewing the inventor's work left no doubt in the audience's mind who was top dog in any hierarchy that mattered. Even Pasteur could be regarded by his contemporaries as a promising young chemist gone astray. Like Humphry Davy before him, he was working for the doctors; but, unlike Davy, he came into this sad occupation not as a piece of youthful folly but as a mature man. (But unlike Davy's experience in Dr. Beddoes' pneumatic institute, Pasteur's mixture of chemistry and biology in the 1870s proved fruitful for that branch of applied biology which is concerned with diseases of animals, including man.)

The pendulum has now swung very far to the other side—too far, some scientists would say. Today investigations concerned with disease rather than with basic concepts in biology are apt to receive popular acclaim and, what is more important, large financial backing. The applications of physics and chemistry fill the newspapers and to a surprising degree even the scientific journals. Is there danger that in the present fusion of pure and applied science the tradition of the investigator interested *only* in the conceptual schemes will be so weakened as to disappear? I am inclined to think so. If this happens in any country, the effectiveness of the application of the physical and biological sciences to practical problems will soon diminish greatly. For the history of the last half century shows that only by a continuous development of the pure science end of the spectrum (to continue the metaphor) can the practical arts, including medicine, advance at their present speed.

The Degree of Empiricism in a Given Science

To my mind we need to analyze the present situation, not by attempting to classify the various sciences and their subdivisions into pure and applied science, but by examining closely each separate undertaking. I have suggested in a paper on "Science and the Practical Arts" that we need to inquire as to the degree of empiricism now present in any branch of science. The cases I quoted as examples were classical optics and chemotherapy. In the former the conceptual scheme employed has wide validity, the degree of empiricism is very low. In the latter the concepts are few and of limited application, progress toward a new drug is still very much of a "cut and try" affair, the degree of empiricism is high. Practical consequences of considerable importance flow from such an analysis of the various sections of different sciences. But it is not with these consequences that I wish to deal here. Rather, I should like to suggest that unless progress is made in reducing the degree of empiricism in any area, the rate of advance of the practical arts connected with that area will be relatively slow and highly capricious. Thus, in terms of new machines, new weapons, new drugs, new ways of improving public health, studies designed solely to provide a better understanding of the fundamentals are thoroughly worth while.

Therefore, rather than debate endlessly about pure and applied science, we might do well to emphasize the need for more satisfactory and wider conceptual schemes in almost every field. Recognizing that some practical problems cannot wait on the outcome of efforts to lower the degree of empiricism of the science in question, nonetheless we can hope that not too large a share of scientific effort will be directed to immediate ends. The history of science shows, I believe, that at times a wider understanding has come about by the piling up of new but limited concepts, each representing but a slight advance, yet, when taken together over several decades, making a highly significant improvement in the scheme. Sometimes these new developments have been intimately associated with the solution of practical problems. (Pasteur's work is the example which comes to mind.) At other times this approach has been relatively unsuccessful, and only by considering the problems in splendid isolation from any practi-

cal considerations were the new concepts evolved which later proved to be of enormous practical significance.

The Importance of Fundamental Research

If one looks at the whole range of industry from the manufacturing plant through the development group to the research laboratory from this point of view, the long-range significance of certain types of endeavors becomes clear. If one looks at agriculture, medicine, or public health in the same way, the importance of reducing the degree of empiricism in almost every field of science becomes manifest. Therefore, a society interested in machines, new materials, better foods, and greater health—in short, an increasing standard of material welfare—will devote a considerable share of its intellectual manpower to long-range as well as short-range scientific programs.

If I were addressing an audience of nonscientists, at this point I would insert a paragraph or two in order to underline an obvious point. The kind of work which leads to the development of new conceptual schemes (pure science, if you will) is almost impossible to plan. One might put it this way: short-range programs in science can be planned and assessed in terms of the calculated risk. Long-range programs, by their very nature, represent much greater gambles, but the consequences of success are correspondingly great. This is the field, therefore, for the individual worker or the small team who are neither expected to show results nor confined to a plan of action specified in advance. In short, this is why we need professors of science of the highest caliber in our universities, and why these men should be well supplied with funds. To argue further on this subject here, however, would be to force the proverbial open door.

Special Needs of Our Unique Society

It is long past the time when I should revert to the subject of this address, namely, "The Role of Science in Our Unique Society." Up to this point I have indicated how significant was science for *any* modern industrialized nation. I have likewise pointed out how closely interwoven is progress in science, regarded as a purely intellectual undertaking and advance in the practical arts including medicine. Now I should like to consider the special situation of the United States.

According to my view, the society that has been developed in this country is unique. It is similar to other democracies in many respects, but because of our special history we have certain ideals that are a product of our past. Our solidarity as a nation depends on our acceptance of these ideals and a concerted effort to move continuously toward the social goals implied. This is no easy matter, however. The complexities of modern society are great. For the future welfare of this society, we require, therefore, the services of a group of able scientists whose numbers now are few. These men, in turn, need to have developed very rapidly new tools and new concepts, for at present the degree of empiricism in their endeavors is far too high. Unfortunately, the group of sciences I have in mind, unlike physics or chemistry or the classical aspects of biology, have no long record of success behind them viewed either as a dynamic development of conceptual schemes or as aids to practical-minded men. Nonetheless, I am convinced that this is the strategic time to stimulate and encourage these endeavors. Specifically, certain types of work in sociology, anthropology, and social psychology seem full of promise. The point of view of the younger men in these fields (and I emphasize the adjective younger) indicates that the time is now at hand when rapid advances will be forthcoming, and from these advances will flow practical consequences of great value to this Nation.

It would seem obvious that the best minds of the country should be devoted to a study of the many problems arising as a consequence of our endeavors to keep our society prosperous, strong, and democratic. It is my belief that methods have already been developed to a point where studies of society by competent scholars can provide basic information to assist all those practical men who struggle with the group of problems we list under the head of human relations. Both fundamental investigations as to the nature of man and society and immediate studies of specific problems are required. The cooperation between medical men and psychologists should be strengthened. Whether psychiatry is to be classed as a subdivision of psychology or of the medical sciences is of little consequence; in emphasizing the importance of the sciences of psychology, anthropology, and sociology here tonight, I am using these designations in the widest sense. I assume that the newer approaches to many of man's individual emotional problems will involve the physiological as well as the psychological approach.

The Future of the Sciences of Man and Society

My confidence in what may be accomplished flows from my assumption that advances in the science of man and society will go hand in hand with fruitful applications of the present techniques and concepts. Relatively few people realize how much progress has been made in the last decade and what techniques are now available to assist in the solution of practical problems. But it is the future which is exciting, for I imagine that even the most enthusiastic psychologist or anthropologist would readily admit that at the present moment the conceptual schemes at his disposal are the equivalent of what chemists and physicists had

in the late 18th Century. As a consequence, in every case of the practical application of the sciences concerned with human behavior, the degree of empiricism is very high.

As in the medical sciences in recent years, many of the practitioners should be the very ones to advance the science. If a chemist may be bold enough to give advice to younger colleagues in a far-distant field, I would say the life of Pasteur affords a relevant analogy. As a scientist and as a practitioner, he solved immediate problems and likewise reduced the degree of empiricism in those branches of biology he made his own. Do not be misled by the divorce of theory and practice which characterized the work of Newton, Clerk Maxwell, and even Darwin. There are times and places when even the purest science cannot make progress in the ivory tower. On the other hand, one may express the hope that the ultimate consumer, the general public and the practical men, will not press too strongly for immediate results. Projects concerned with applying the knowledge now at hand must not be so numerous or exacting as to prevent a sturdy effort to decrease the degree of empiricism in the methods now in use. In short, the long-range as well as the short-range programs require adequate support.

Value Judgments as Premises in Certain Sciences

The statement is often made that science is neutral as far as value judgments are concerned. This is one of those three-quarter truths fully as dangerous as half truths. Let us consider the medical sciences today. Investigators and practitioners concerned with human disease almost unconsciously accept a set of values which set limits to their activity on the one hand and on the other serve as powerful spurs to their endeavors. This fact seems to be overlooked when the neutrality of science is proclaimed. Much more than the Hippocratic oath is involved. Only in a society where life is considered preferable to death and where health is glorified would funds flow freely for the study of disease. Only where the sanctity of each individual is so strongly felt that it is regarded as a paramount duty to save every life possible at whatever cost would physicians, surgeons, and medical scientists act as they do today. Our standard of medical care and our desire to raise it is based on a series of value judgments. Let me make it plain—I am not questioning the assumptions. I am merely pointing to the existence of these postulates basic to all work in the medical sciences. I do so, for I believe the situation is analogous in the case of those scientists who are investigating human behavior and human relations; but the analogy has not yet been fully realized.

The assumptions of the medical men and their allies are by now fairly well accepted in modern industrialized nations, though in practice the value placed on human life certainly is subject to wide variations. The assumptions essential for the proper functioning of the psychologist, anthropologist, and sociologist in our unique society, however, are, I believe, as special as the history of this society itself. The equivalent of the Hippocratic oath which these men might well subscribe to would therefore be related closely to the type of society in which they propose to operate. The English and the American versions even might vary at several points, but the essentials would be the same. Totalitarian nations, however, would use the techniques developed by these scientists for very different ends; and their use would condition the further advancement of the sciences themselves. Powerful tools are in the process of being forged by the scientists who study man as a social animal. These tools can be used to further or to destroy certain types of behavior and certain social patterns. Therefore, it is essential for the men themselves to clarify in their own minds their own standards of value in many matters, just as, long ago, the medical profession settled certain issues which confront those whose knowledge includes the key to the life or death of an individual in distress.

Making the Bias Explicit

A study of the writings of the last 50 years makes it evident that the myth of the neutrality of science has been used as a smoke screen for reactionaries and radicals alike. For example, within recent times some who wished to see a tight class structure develop in the United States have analyzed society in so-called scientific terms. Likewise, those who wished for a socialistic state can quote the results of modern investigators of society for their own ends. My objection to these procedures stems less from my lack of enthusiasm for the objectives than from the failure of the authors to be explicit as to their premises. Gunnar Myrdal has faced this question squarely and said: "There is no other device for excluding biases in social science than to face the valuations and to introduce them as explicitly stated, specific and sufficiently concretized value premises."

I am inclined to think that, to forward their own work as scientists and practitioners, those concerned with the sciences of man might well join together and issue a proclamation. Or if that is too much to hope for, recognizing the importance of rugged independence among learned men, at least as individuals, each one might make his position clear. Of course, it is for the men in question to formulate their own Hippocratic oath; nevertheless, to illustrate what I have in mind, I venture certain suggestions.

The Postulates of Our Unique Society

I believe a very large majority of the citizens of this country would be willing to subscribe to a common set of postulates as to what we desire to accomplish in the coming years. The goals of equality of opportunity, a minimum of class distinction, a maximum degree of individual freedom, and a wide distribution of centers of initiative are inherent in the American tradition. Would not all of us be happy if we felt certain that a decade hence the United States would be appreciably nearer those historic goals? So it seems to me. Therefore, the set of social ideals corresponding to these goals might form the basis of agreement among the scientists in question. All concerned with medical science, however objective and neutral they may claim to be, are urged forward with a desire to improve the public health and a firm conviction they will do so. Likewise, the scientist concerned with human relations and the structure of society must have conviction as to the practical objectives of the practitioners in his field and a belief in the possibility of accomplishing at least some of the objectives they have in mind.

I have drawn a parallel between the application of modern science to the ancient art of healing and the application of certain sciences (still young) to the likewise ancient art of counseling human beings as to how to live and work together. If there be any merit in my analogy, the reason why I spoke at the outset of basic differences in these sciences between totalitarian countries and our own needs no elaboration. Biochemists, physiologists, and pharmacologists would be either out of place or enlisted in strange services in a society which regarded it essential to eliminate by death all infants except the physically robust, all the sick and wounded, and all above 60. (The comparison, to my mind, is far from being entirely fantastic.)

Without laboring the difference between the study of man and society here or, let us say, in Rumania, I should like to explain in more detail why I think our unique society has special need at this moment for the scientists in question.

The Problems Ahead

The United States, unlike almost any other country, has not arisen from a state founded on military conquest. Therefore, we have nowhere in our tradition the notion of an aristocracy entitled to rule by right of birth. Run through the other democratic nations of the world and, if you recall their history, you will see how striking is our exceptional origin and growth. Neither political nor economic nor social privilege comes to one by right of birth according to our American ideals. On the contrary, the members of each new generation are supposed to start from scratch. Merit alone should win. Cynics may shrug their shoulders and say this is theory—the facts of modern American life are far different, and likely always to remain so.

We must admit that sneers of this sort expressed by men who pride themselves on being hard-boiled realists are sometimes heard. Those who express such ideas fail to realize that in an open society ideals are goals. Almost by definition they never can be realized in practice. But we can recognize whether we are moving toward them or retreating. The ideal of equality sums up much of the uniqueness of American society to which I have referred already. This ideal, coupled with our adherence to the principles embodied in the Bill of Rights and our inherent belief in fair play and tolerance, makes a pattern which many of us have in mind when we use such phrases as "the American creed." In spite of the vast discrepancy between those ideals and the facts of life, I am convinced that we are not a nation of hypocrites. But unless we can demonstrate by collective action that we are making progress toward the goals implicit in our ideological pattern, we shall have difficulty maintaining the solidarity of the country. The morale of a nation, no less than that of any group of men or women, depends on agreement as to the ends for which all labor.

It is no simple matter to move appreciably toward the goals in question—the historic goals of our unique society. Industrialization as well as size present us with problems of terrifying complexity, not to mention the unfavorable posture of world affairs. Our economy is based on private ownership and the profit motive; we desire to keep this economy flexible with as many competing units as modern industrialization permits, and with as much independence for both management and labor. Yet there are few who advocate today the old doctrine of "hands off" private enterprise. The complexities of modern society have made the public a party to what once seemed a strictly private matter. The machinery of government is today meshed into our industrial life. The problem is to see how we can operate our private enterprises and our political institutions so that our society will be in fact competitive and thereby increasingly productive.

Grave problems of fundamental policy confront us as a nation at this moment; they will continue through the coming years. I have no illusion that basic national issues can be handled by any group of scientists in the way problems of design of bridges and machines can be treated by engineers. Nor do I believe that in the near future many policy questions which must be resolved by governmental officials, business executives, or labor leaders can be handed over to scientists to find an answer which is "right." Most of the decisions must be made on the basis of experience coupled with the advice of competent analysts and those whom I

have ventured to call social philosophers. The point of view of scientists may be of assistance in these matters, and the results of their investigations should be of increasing value. But the types of problems where one can hope for immediate assistance from the social psychologist, sociologist, and anthropologist are for the most part somewhat limited in their scope; they involve human relations and those tensions among individuals and groups which have been so much intensified by the conditions of modern life.

The need for reducing these tensions as part of the process of improving and humanizing industry is evident. What is less well understood is the applicability of the newer points of view to the planning of public education and providing that our secondary schools will serve the welfare of the community. In short, policy makers in government, business, labor, and education must be increasingly aware of the assistance they can receive from those who study man and society as scientists.

Let me illustrate by a brief consideration of our public schools; they are a concrete manifestation of our belief in the idea of equality of opportunity. We believe they should be ladders by which youths with varied talents may reach satisfying employment with everyone entitled to a fair chance. Every year some two or three million of our youth mature, leave school or college, and look for jobs. Unless each year this annual crop of youngsters can be fitted into our economy, we shall fail to keep our society prosperous and dynamic. Therefore, our educational system must be heavily involved in the whole question of guidance and of placement. The specific problems will vary from city to city, from state to state. Here is a case where we are beginning to have sound knowledge and can look forward with considerable assurance to further improvements in the methods. Here is a case where the welfare of the Nation depends on our skill in solving a whole host of detailed human problems.

I could go on and list similar instances concerned with education, group relations, social organization, and personal adjustment to show how in our society we have special need for a vastly improved science of man. The empiricism of the past may be a sufficient guide for the masters of a police state, but an open society with our ideals requires other instruments and a wider understanding of modern man. We would be wise to expect no miracles and not to harass ourselves or the scientists by shrill cries for speed. My crystal ball yields me no secrets as to the future of the world. Conceivably, we may all be blown up by atomic bombs within the next few years, as some of my colleagues seem to think. Their reasons for this dire prediction, however, appear to me to be quite inadequate. I prefer the contrary assumption. I have faith that we shall be wise enough to escape a global war. I likewise believe that we shall move forward to still greater strength and prosperity as a democracy, and that the morale of the Nation will continually improve as we demonstrate that our American ideals are no mere myths or legends. And in this all-important undertaking, I have confidence that the skill and wisdom of the scientists cooperating with practitioners will play an important part. Those who concur in some such estimate of the potentialities of this country will surely agree with me that science will play a leading role in the future of our unique society of free men.