CRITERIA FOR SCIENTIFIC DEVELOPMENT: PUBLIC POLICY AND NATIONAL GOALS

A Selection of Articles from *Minerva*

Edited by
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INTRODUCTION

EDWARD SHILS

Science policy in the form in which is it practiced today is a new thing in human history. This does not mean that earlier societies and epochs had no scientific policies at all. Princely and ecclesiastical patrons of the *ancien régime* frequently attempted to further learning and science by their patronage, and they even did so with quite particular intentions in mind, such as the improvement of navigation or hydraulic engineering. Their intentions toward science were, however, superficial. They were also discontinuous and fragmentary. They had no sense of responsibility for its many-sided development because they had no responsibility for such development. They presupposed the ongoingness of a world of science with a life of its own, which they could influence marginally by prizes for research already done, by rewards for inventions made with the inventor's own resources. Those who reflected on the value of science for improving the material and moral qualities of human life recommended support either for science in general or for particular fields of technology.

They had no concept of science as an internally differentiated and interdependent whole. They were consequently not apprehensive that their "science policy" decisions and actions in one field of science might have a negative or an insufficiently positive bearing on other fields of science. And they did not, apart from interest in practical applications for certain military and economic problems, believe that particular fields of science had strategic significance. Until the French Revolution they did not conceive of scientific actions as being parts of a single social system. Since they did not see scientific activity as forming a whole, they could not think of strategic decisions that might affect more than the specific fields in which the research they wished to support was performed. Science was an already existing phenomenon that could be appreciated, adopted, used, and rewarded. It could not be generated or steered. Regarding science as having a self-generating existence, they did not generally interest themselves in the training of scientists. Higher education and science were not regarded as integrally connected with each other—perhaps because until the nineteenth century, they were not so connnected with each other.

In the past, the actions of the patrons of science and of those scientists who owned whatever resources they needed for their own work certainly

influenced the development of science. The influences they exerted were not, however, concerted. There were nearly as many separate decisions as to what should be investigated as there were invesitgators. The concert that existed was the unintended result of the reciprocal responsiveness of approximate equals, none of whom had any authority over the others except for that of intellectual superiority. There were indeed social mechanisms that influenced the growth of science. But these mechanisms did not operate through the authoritative decisions of a corporate body or bodies which took as their main task the guidance of the course of science. Nor was it thought that there should be. That is why science policy in the contemporary sense did not exist.

As long as the choices about what should be studied were widely dispersed over the whole scientific population and their patrons, most of whom possessed the resources to attempt to do whatever they themselves chose, the problem of deciding, over large areas of the scientific scene and even over the totality of science, what was more important and what was less important, did not arise. These conditions no longer obtain. The context of scientific research has changed. The cost of scientific inquiries has increased greatly; each one costs much more than scientific inquiries used to cost, and the total number of inquiries has increased. The present age has at the same time witnessed the institutional concentration of the power to provide the requisite financial resources for almost every important activity, and, accompanying this, there has grown up the belief that it is right and necessary that the allocation of financial resources should be performed in that way.

The increased numbers of scientists and the increased cost of individual investigations have increased the total financial requirements of science. These increases of numbers and costs have practically overwhelmed the capacity of individual scientists to provide for their own research and thus to choose their research problems entirely on their own and in accordance with their own conceptions of what is important, against the background of the received tradition of science. The funds for science have had therefore to come increasingly from the state and from a relatively small number of very wealthy institutions, such as large industrial firms and philanthropic foundations. In relation to the total body of scientists in advanced countries, the number of sources of finances has greatly contracted. In underdeveloped countries, practically all support for research comes from a single source, the state.

This concentration of the capacity for financial provision to a relatively small number of very rich institutions and the corresponding shrinkage

of the centers of decision as to the fields of research to be cultivated have coincided with an increased demand for financial resources for many other activities, such as public health, welfare, education, housing, economic growth, defense, transportation, urban renewal, to say nothing of the demands of the vast body of public servants for their own maintenance. Although never as rich as they are now, these institutions are perhaps more conscious than they have ever been of the fundamental fact of scarcity. There is a scarcity of resources to do all the things for which the prospective beneficiaries of expenditure clamor.

Scarcity, in an epoch in which rationality and efficiency have to a much greater extent than heretofore become the criteria for the assessment of policy and performance, imposes the notion of priority. The growing rationality of the technique of budgeting, to say nothing of the Promethean aspiration to plan comprehensively for the future, has imposed a belief that resources should be allocated to diverse uses in accordance with the importance of those uses. Heads of expenditure have to be ranked in accordance with the intrinsic and instrumental value of the activities to be supported by the expenditure. Because science has only a relatively small political constituency, rational arguments rather than political pressure must be invoked to support its claims for a high place in the budget of governments. It, more than most of the activities that governments support, has to be justified by rational arguments about the advantages that flow from it. The fact that the active scientists and scientist-administrators who must provide these arguments are habituated to rational thought has meant that a rational cast of mind confronts the problem of priority. The facts that large expenditures are involved and that among the leading arguments are those who contend that support is justified by the economic advantages of scientific research have brought economists into the discussion.

In a convergent movement with this has grown the *systemic* mode of thought. There is a heightened sensitivity nowadays to the interdependence of events. Economic theory does not by any means enjoy a monopoly in the domination of governmental policies or public opinion, but the idea of an optimal allocation of scarce resources among alternative uses—of an allocation that strives to attain equality among the marginal products of the alternative uses of scarce resources—has taken root. Science too has come to be viewed in the light of this "optimum." There is now a belief that a "right order" of expenditure is conceivable and attainable, and this applies to science as well as to other fields of human activity. The systemic mode of thought postulates scarcity; it also postulates determinate patterns of interdependence among the variables, the

scarcity of which imposes "economy." The acknowledgment of a linear time sequence of processes imposes inescapable tasks on policies that aspire to rationality.

The conception of the comprehensive planning of society, and of the economy in particular, has added another fundamental ingredient to the combination of forces that has fostered the idea of a comprehensive and rational science policy. The notion that a whole society could be planned deliberately in a way that would shape it for a long time to come presupposed not only a pervasive knowledge of the present state of society but the ability to foresee the subsequent behavior of its component parts. The growing prestige of the idea of planning and the growing courage of those who would predict the future have strengthened the conviction that a rational science policy is necessary and possible.

The notion of a right order of scientific activities—of an optimal allocation of financial and manpower resources for science—would still not have become the object of science policy if it were not also believed that this optimum could be realized by deliberate central decision. Various spheres of culture have been subjected to efforts of central control in the past, and some continue to be. Literature and art are subjected to censorship; but in most countries the censorship is fairly marginal, and it is, in any case, negative. Propaganda for particular forms of literature and art and the offer of publication and distribution facilities only to works of a certain type and outlook represent a more positive effort to guide the content of literary and artistic output. Likewise, the religious sphere has often known intolerance and suppression of certain institutional manifestations of religious belief, and there have also been strenuous efforts to coerce the populace to accept the doctrines of one particular religion. But neither the control over literature and art nor the control over religion has been intended to foster the *development* of those spheres of culture. They were concerned rather to propagate or suppress *already existing* beliefs and practices. They were not intended to promote creativity. The intention to promote creativity—the nurturing of tendencies hitherto unrealized, the cultivation of the previously unknown—is the unique feature of contemporary science policy, in comparison with the "science policies" of the past and in comparison with policies in other fields of governmental action.

The present-day encouragement of the performance of previously unperformed acts appreciates that science has a life of its own, which, however much it can be affected from the outside, remains the essence of scientific activity. Science is acknowledged to possess an irreducible autonomy that cannot be replaced. This is a process internal to science; if

it is suspended, then science ceases to operate. All science policy can do is to influence the working of this autonomous system through decisions that grant (or withhold) financial resources, provide an *appropriate* administrative context, supply manpower, or set certain tasks. Once these are done, the autonomously systemic properties of scientific activity must be allowed to manifest themselves. This view of science and of the potentialities of science policy has now come to be accepted very widely, even by those who espouse a far-reaching and comprehensive planning of science.

These developments have come about piecemeal and in an uncoordinated manner. The science policies that have grown up as their result are characterized by a similar incoherence. Nonetheless, and perhaps even because of the very incoherence of present-day science policies, there is a genuine aspiration to make science policy more rational.

The science policy at which the present discussion of science policy aims is the deliberate effort to influence the direction and rate of the development of scientific knowledge through the application of financial resources, administrative devices, and education and training in so far as these are affected by political authority. The accomplishments of individual scientists constitute scientific development, and the exemplariness and persuasiveness of the performance of the greatest among them are certainly major determinants of the direction and rate of development of scientific knowledge. But the exercise of influence through the discovery and promulgation of new scientific knowledge is not the kind of influence that we mean when we speak nowadays of science policy. In science policy, the decision to influence and the action that influences are decisions outside the constitution of scientific activity itself. A decision of political authority to allow complete autonomy to every sector of the scientific community—as might be implied by Professor Polanyi's conception of the "republic of science"—would be an act of scientific policy. But the factual existence of such an autonomy, which resulted from the traditional dissociation of political authority from the scientific sphere, would be a consequence of science policy. A rational and comprehensive science policy involves the intention to influence scientific development through authoritative decisions,[1] which choose particular problems or whole fields

[1] One may speak of the science policy of a particular industrial firm as well as of the science policy or policies of a government. Yet one would not be likely to speak of the scientific policy of a particular scientist with regard to his own scientific activity. The concept of scientific policy refers to the macrosocial system of scientific activity and to decisions made outside the system of scientific activity as such.

of inquiry, or which fix the institutional setting within which scientists themselves choose the problems on which they will work or the fields which they wish to cultivate. The decisions might refer to narrow sectors, to broad sectors, or conceivably to science as a whole.

The justification for science policy is that the decisions it produces will be rational decisions taken in the light of the ends to be attained—the ends being the development of science and the application of scientific knowledge, that is, knowledge gained through systematic research for practical ends. The numerous particular decisions could conceivably constitute a more or less rational pattern or system of decisions.

At present, every country which has a substantial amount of scientific activity, even many of those which have very little, has something like an empirical science policy or, perhaps it would be more accurate to say, science policies. It is not, however, unjust to say that none has a rational and comprehensive science policy. None has a science policy in the sense which the papers which form this book seek to realize. What exists is a large amount of influence exercised by governmental and private bodies that are not themselves constituted by scientists; the decisions taken by these bodies are uncoordinated with one another, and most of them are directed not to the scientific system as a whole but to particular parts of science without much regard to their relation to other parts of science or to the educational system. Where attention is paid to problems of coordination, criteria of judgment and assessments of magnitude are extremely vague and are applied in a very inconstant way. Decisions are made on the basis of political considerations to satisfy domestic pressure groups, to build personal and departmental "empires," and to compete for international prestige, as well as on the basis of relatively well considered beliefs about the potential contribution of research to the realization of ends such as the improvement of industrial and agricultural and physical and mental health, and military technology. The increased frequency of decisions that affect science and that are made outside the scientific system itself has accentuated the demand and aspirations of scientists and science-administrators for better ways of making science policy, for a science policy that embodies some explicitly articulated and rational principles.

The idea of "planning of science" represented an attempt to rationalize science policy. The idea of the "republic of science" was likewise an attempt to introduce rationality into science policy. The most important thing that has emerged from the discussion in *Minerva* and elsewhere in recent years has been the acceptance of two independent and incom-

mensurable criteria of scientific choice: scientific value and practical value. The distinction is not a new one. It is roughly parallel to the distinction between pure science and applied science. It has similar parallels in the distinction between the immanent dynamics of scientific growth and the determination of the direction of scientific development by economic tasks. political motives, and so on. Another related distinction, formulated in the idiom of economic analysis but entailing similar substantive differences, is that between scientific research as a "consumer's good" and as an "investment." These distinctions correspond to the divergent outlooks which praise, respectively, the autonomy of science and the comprehensive direction of science toward technological applications.

The "planning of science" has turned out to have been a cover for varying combinations of arbitrary political imposition, individual and institutional "empire building," *laissez faire,* and sheer disorder. Complete *laissez faire* is patently impracticable in situations where decisions *must* inevitably be made concerning the allocation of huge sums of money for conflicting and competing scientific projects, where there is a single or very small number of sources of funds, and where there is an urgent and evident need for research directed toward the improvement of welfare in various fields of medical, industrial, and agricultural, to say nothing of military technology.

While it is clear that there are as yet no satisfactory principles of science policy capable of realistic and thoroughgoing application to the multifarious activities of science, progress is being made in their discernment and clarification. The progress is partly negative: it consists of the renunciation of the extreme positions which once claimed universal validity.

The abandonment of extreme positions is, however, only a necessary first step in any realistic approach to science policy. Once this step has been taken, the complexity and multiplicity of the situations about which decisions must be made are laid open to freer consideration. It is now seen that there is neither a single goal nor a unitary set of goals toward which science as a whole can be planned, that there is no single institutional arrangement that is equally appropriate to the development of all its parts, that there is no inevitable harmony between the development of all branches of science and every other social, economic, and political need, and that scientific development as such does not automatically and inevitably improve the welfare of mankind. It is now seen that scientific policy has never been planned in any way satisfactory to scientists and to those who hope that their particular ends, economic, political, social, and cultural, would be aided by scientific growth. In fact, it has never been planned at all as planning is understood by its proponents. Like

every other human activity, scientific activity exists in the context of a scarcity of funds and of personnel, and the ends that it might serve are in competition with each other.

The discussions of the criteria of scientific choice which are contained in this book represent the beginnings of a movement toward the more rational science policy that is felt to be so necessary. The theory of science policy is still very rudimentary. It is still very general in its reference to the whole range of scientific activities and those educational, technological, political, military, and administrative activities in which science is involved as cause and effect.

Nonetheless it is under way. The present collection of essays drawn from the first five years of *Minerva* attests to the efforts that have been made in recent years by science administrators and scientists, economists and philosophers, to bring the analysis of the problems of scientific choice to the point where it can begin to be useful. In its present stage at least, the theory of science policy offers no recipes or directives that can be confidently applied to particular decisions. It does, however, offer a clarification of some of the elements that are involved in decisions about expenditures on science. As such its promulgators may legitimately claim to provide improved general canons of judgment and guiding principles to legislators, administrators, advisers, scientists, and citizens who are required to decide what should be supported, to what extent, and in what manner.

For about thirty years, the conflict between the proponents of pure science and the proponents of applied science, between the liberals and the planners, has bedeviled the discussion of scientific policy. The most recent discussions, as expressed in the papers contained in this collection, have gradually ameliorated the tension between these two criteria and the policies of scientific development that were associated with them. As Dr. A. M. Weinberg shows in his papers, scientific choice requires the application of a combination of diverse criteria. The criteria of scientific merit, technological merit, and social merit might be contradictory to one another; a given research scheme might be high in scientific merit and low in the other two. The fact that these criteria are sometimes and perhaps even often incompatible does not mean that they are not equally valid.

Their validity does not render them capable of easy application. Even though they represent a considerable progress in the discussion, they are nonetheless vague and undifferentiated. It is, moreover, difficult to estimate probabilities of scientific or technological fruitfulness; it is at present impossible to assess the value of a scientific discovery in one field as

against one in another field, even within pure science. And how is one to assess the value of one plausibly predictable scientific outcome against the value of an equally plausibly predictable increment to human welfare arising from scientific research?

All this being granted, it seems to me undeniable that the essays in this collection which deal with scientific choice have broken new ground. They have made distinctions that have to be made and made possible more reasonable and wiser judgments. They are not yet a code of rational scientific choice. It might be that such a code of rational scientific choice cannot in the nature of things be attained. Yet it is certain that a closer approximation to that goal is possible. Even if a fully rational policy is unattainable, a more rational discussion of the alternatives of policy is attainable. These essays should be regarded as contributions to the movement in that direction.

The elucidation of the criteria of rational scientific choice does not exhaust the tasks with which such principles would have to cope. Organizational or administrative problems arise at once from every suggestion of a principle of choice. If the principle is to be wisely applied by decision makers, the latter will need qualified advisers. How should advisers be chosen and employed, what should be their powers, and how should the flow of their advice be organized? What should be the terms of reference of these advisers, under what conditions should they serve their own scientific intertst, and under what conditions, and how, should this latter interest be guarded against?

If research is to be applied for industrial, agricultural, or welfare purposes, where should the center of gravity of the decision-making machinery be located? Should it be located in the industrial, agricultural, or welfare departments or institutions that will use it? Or should it be kept separate from the "operating agencies," and, if separate, then in just what way? Regardless of the location of decision, how are laboratories and research institutions best organized to enhance creativity and efficiency?

Similarly, whatever the criteria of scientific choice to be applied, what are the best means of ensuring the flow of the right numbers of properly qualified and motivated research workers to those research projects which are chosen? How, in what sense, and to what extent can the future demand for research workers, science teachers, and so on, be predicted, and to what extent and how can their supply be planned?

For underdeveloped countries, many or most of the problems of scientific policy are the same as those of the advanced countries. There is one very important exception. This is the establishment of a scientific tradition, that is, the establishment of beliefs and orientations that heighten and maintain sensibilities and motivations and that prompt the selection

of important and appropriate problems for investigation and suggest the approach toward them in ways that permit their fruitful solution. Countries in which science is well established may take this for granted. All they need do is to see that there is a flow of young students into fields needing investigation and into institutions in which work is being done in those fields. The students will then become assimilated into the scientific tradition. Such conditions do not obtain in underdeveloped countries, and it is an obvious task of science policy in these countries to make the arrangements that will foster the establishment of such a tradition.

Thus it may be seen that the problem of scientific choice is only one facet, albeit a very crucial one, of any approximately rational science policy. Its further development stands in need of research and analysis in many ancillary fields, such as the newly developing subject of the sociology of science, which deals with the social structure of research institutions, and the social conditions of the growth of science, the new "science of science," which deals with rates and magnitudes of scientific growth, the psychology of science, which deals with the processes and conditions of creativity, the political science of science, which deals with the relations between politicians, administrators, and scientists, and that nameless field that deals with the optimal conditions for the translation of the results of research into economic growth. We need very much more exact factual knowledge about the community of science and its relations with the rest of society.

When I began *Minerva* in 1962, I sketched a wide-ranging agenda that embraced every aspect of the social, economic, moral, political, and administrative relations of scientific research and higher education: the influence of the increased demands of governments on science and learning, the influence of the increased munificence of governments on science and learning, the consequences of the increased demands of scientists for support for their boundless curiosity, and the increased demands of society for higher levels of welfare, which require continuous investment in research. Improved understanding of the relations between government and systematic and disciplined inquiry in science and scholarship was taken as the subject matter of *Minerva*. "By the improvement of understanding," I wrote on the opening page of the first issue, "it [*Minerva*] hopes to make scientific and academic policy more reasonable and realistic." I believe that the essays that follow show that we have not stood still.

The owl of *Minerva* has not waited for the shades of night to fall before taking flight. On the contrary, it has made itself into a carrier of light to illuminate a subject, the obscure complexity of which corresponds to its importance for our intellectual and material well-being.

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