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PARADOXES OF SCIENCE ADMINISTRATION

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INTRODUCTION

Science is providing man knowledge with which to shape his environment. Technology, initially designed to serve a particular instrumental purpose, now modifies the society which produced it. The vitality of science and technology is an important objective in itself. But the influence of both on the life of society makes their guidance and administration a matter of paramount significance for public policy.

Widespread discussion of science, technology and public policy is a relatively recent development. Interest is growing in government, industry and the universities. The two papers in this volume, like others in the series, are intended as part of a continuing dialog, the purpose of which is to assist the individual and the nation in furthering human knowledge and putting it to use for the benefit of man.

V. P. Rock

FUTURE GUIDANCE AND LEADERSHIP IN SCIENCE AND TECHNOLOGY

by Shaw Livermore

THE PROBLEM

The United States since 1940 has entered upon a revolutionary era in science and in the affairs of its child, technology. In the uprush of accomplishment very little attention has been paid to the problem of attaining balance and far-seeing guidance of the total national scientific effort. Intent upon problems of today and tomorrow, we have set aside the careful probing and counter-discussion which must precede formulation of a true national planning policy in science.

Why should we be concerned with long-range management, or with carefully-wrought planning techniques, or with scrutiny of present allocation of resources between obviously competing goals? Scientists are doing well enough on their own, and are caring for these issues as they arise. The Federal Government is generously providing the critically-needed new resources to satisfy all agreed-upon needs. Industry is cooperating fully. The universities and foundations provide shelter and facilities that are unsurpassed in the western world. The Cold War is warmer. Why worry?

In a brief space we shall attempt to assay this curiously unique national impasse. We can set down a few guidelines for the needed future probing which the situation obviously should generate. It is not necessarily a _sequitur_ that we will include some preliminary replies to the two questions posed in the preceding paragraph. Of course we as a nation _should_ be concerned; if for no other reason, the examples elsewhere in the world of quite a different attitude are enough to support this rejoinder. Nevertheless, we can make no _a priori_ assumption that a structure of formalized management, formalized political or cooperative controls, mechanisms for effective scientific direction, a reorganized system for the allocation of scientific resources--are by any means obvious necessities. Both past performances and

the apparent logic of our national future may point to shying away from such solutions. The scientists themselves may be quite capable of running the scientific world (except in narrowly military or space-exploration matters). Only a loose rein need be imposed on what would remain an essentially laissez-faire approach plus a few public-opinion-oriented devices for surveillance. An alert scientific press and larger body of probing reporters might be enough. This would be about what we have now.

But we are not sure. The flow of resources through the administrative hands of science-aiding Federal agencies promises to grow and grow. The stake of universities and foundations in research undertakings will become more complex and intricate. Thousands more newly-trained experts will be involved as each decade passes. Will the present informal structure of relationships between scientists-as-scientists among themselves and with loose coalitions formed to conduct particular sub-projects, plus the patriarchal and benevolent aid of a few political and educational leaders, be enough to stand the tests of those approaching decades? The three-ring circus of today holds the patrons, but who is concerned with the programming of a new show under a far bigger tent?

The first step would be to appraise the complex effects of the immense expansion in both the volume and spectrum-range of scientific effort since 1940, during a mere quarter-century. We cannot do this within the scope of this paper. It has been well done in many other places. Coupled with the expansion has come an amazing solidification of public support for the astonishing expansion of the proportion of our total resources devoted to speculative science and to science harnessed into technological improvements, and for a proliferation of thousands of tiny individualistic projects that purport to be related to our national objectives. In such an analysis, we would have to give attention to the blurred fact that the public, or political leaders, or the opinion-elite of our land, have very little real comprehension of the huge engine they have so gladly accepted. And we would have to wrestle with a quite obvious second fact that the current methods of guiding this huge social outlay, and the methods of determining detailed choices and allocations within the massive total, are still experimental.

Such inquiries will have to be left for another forum. We need here to turn to something a little more prosaic. We need to place in perspective the institutional arrangements that we do have, the raw material from which we may gradually evolve an integrated structure of guidance and managerial leadership. In so doing we must first recognize that the task is one of tremendous complexity--within the term "science" are hidden scores of sub-areas of human knowledge and endeavor and aspiration. Thus the structure we tentatively envision cannot be some simple solution to a simple problem. Finally, we are not just dealing with specific military or space-exploration tasks of the moment, where a project and its step-by-step planning and completion can be reduced to a comprehensible program in isolation. What we must provide for, in the truest national interest, is a system of tactful and inspired leadership which will encourage and nurture scores of fate-determining ideas and dreams flowing from scores and thousands of speculative scientists. A "system" must provide for both these extremes.

What are the principal mechanisms under which scientific research is conducted? What are the potentialities of each of these as sources upon which to draw for a potential integrated structure of national leadership for the longer future?

The Edison-Image: Direct Sponsorship of Individual Researchers

The first and oldest concept of a social "system" for achieving scientific progress is of course what we term the Edison-image, or the dependence of society upon scores and hundreds of <u>individual</u> inventors and researchers. Theoretically, this view was supposed to encompass the lonely theorist in his ivory tower pursuing Einsteinian goals, just as much as it offered incentives and rewards to designers of industrial equipment or new chemical compounds. It is hard in this generation, however, to understand the Jeffersonian dream of a patent and copyright system which would serve society as well as he proclaimed it would. Nor do we now see the treatises on cycles-of-invention or the roots-of-invention which used to be so prominent in economic theory before 1930.

Our social interest in this direct-to-the-individual method is that of encouraging the birth and growth of innovative

ideas. This may require in the future a more sophisticated approach than the simple grant-in-aid or the obvious attraction of patent rights. Looked at in one way, we quite bluntly should have an institutional alternative to the pressures of joining a "group" somewhere, or of attempting to operate as an individual within the atmosphere and arrangements of a university science department. This possibility will be examined below.

American Industry and Its "R & D"

Extending far back in our industrial history are twin roots of the current claim of American private industry that it is fully capable of assuming a central role of management in future science research. From our earliest days industry was cast in the complementary role of handmaiden to the lonely inventor. This was especially marked in the middle third of the nineteenth century (despite the bitter experiences of Eli Whitney and other early inventors). The lure of a patent and copious royalties were the stimulus. For worthy ideas, alert industrialists would step in with royalties, fees, or outright purchases of basic inventions.

This became a decorative part of the American dream. But it was pretty well shattered by 1870--until Edison and Westinghouse temporarily revived the attractiveness of the inventor-private industry team. Schoolboys of 1900 were carefully told that a man like Edison combined the talents of a great entrepreneur with those of the indomitable inventor. He formed companies, made profits, and acted like a businessman. There were others: Bessemer, McKay, Eastman and Owens to name a few--many of whom gave their names to giant concerns. Vincent Bendix may have been the last of a great line. By 1915, with a few exceptions added, the idea of an "inventor" or the combination entrepreneur-inventor was pretty well blurred again. It was better to join a great industrial laboratory where teamwork and the resources of a great company would make dreams come true. The Charles Kettering story[1] became the new pattern. Today this idea has burgeoned into hundreds

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[1]Cf. Prophet of Progress (The Speeches of Charles F. Kettering), ed. T. A. Boyd (New York: E. P. Dutton, 1961).

of well-financed industrial research divisions. The fair-haired boy of "R & D" (research and development) is glorified as the new key to long-lived corporate success for old enterprises which can rejuvenate their tired products with new wonders and new breakthroughs.

The muse of history is a harsh mistress. She has refused to bestow more than token accolades upon industrial giants and the programs of research and development which they have so assiduously backed--slowly in the interval between the world wars, rapidly and in depth since 1950. For the years since 1955 or 1960 she may eventually relent and be more kindly. The record of really fundamental contributions from industrial research staffs in theoretical physics, in molecular biology, even in metallurgy and physical chemistry--has been quite sparse. The accomplishment is better in medicine, in pharmaceuticals, in physiological research and in electronics. But the combined output of all the Steinmetzes of American industry from 1900 to 1950 looks puny beside the great flow of pioneering and original work coming from American, Canadian, and British universities in the same five decades.

Looking at the latest twenty-year record of immensely expanded research and technological-change activity, we must perforce be impressed with the claim of American industry to be one key "manager" of society's efforts to nurture and channel research and harness its triumphs. Industry has long dealt with the managerial structure of interrelated activities, which, it is claimed, is essential for society's own protection and its self-interest in achieving "results." If the research-grant concept is wise and fruitful, industry can use it as well as government bodies. In pharmaceuticals, pesticides, plastics, fibers, metallurgy and a host of other fields there have been and are today many hundreds of industry-subsidized workers in college or foundation cloisters. On the other side of the fence, industry can claim a long experience in coping with the oddities and infirmities of the temperamental scientist. After all, General Electric and Schenectady in the early years of the century was a happy environment for Steinmetz. Nor should the particular tiny arc of the whole research circle in which a single individual concern chooses to expend its effort be the criterion of industry's ability. Nor that of two, three or four concerns. It must be the combined total of <u>all</u> companies' efforts, supported by American private stockholders en masse, which constitutes the comparative test.

Some obvious replies to this somewhat plaintive claim have become familiar to laymen and scientists alike in the past two decades. Students of our problem in maximizing society's effort in science simply say: (a) Too little effort in industry is aimed toward true or "pure" research in the best sense of that abused term; and (b) too much high-quality talent in the "R & D" activities of industry are sluiced off to mere design, styling, cost-cutting and competitive product-differentiation.

The Craft of Management

But what of the accumulated wisdom of American industry as a sourcebook for our task of creating an intricate and complex guidance mechanism for science and technology in the next half-century? Is its vaunted managerial skill transferable? Should industry's managers be the lead-horses in discussing and shaping the future "system"?

It must first be pointed out that the free-flowing literature on the craft of management as currently practiced in American industry passes over, around or under the world of scientists. There is only vague recognition of any special problems of management in the pursuit of scientific goals. Scientists have been subjected to the administration of industrial managers--with mixed emotions. Some leading managerial craftsmen have commented orally on the tribulations of managing large working groups of scientists or science-trained technologists in some of the large-scale research enterprises of industry, or in major military or space-exploration establishments operated under contracts. Yet, despite this neglect in the literature, many scientists and their technician aides in industry are practicing good management. They have grasped some new fundamentals about managing highly trained professionals, and of managing a group of peers engaged in a single enterprise. These may very well be copied by business craftsmen to the latter's advantage.

Nevertheless, the practitioners of management in the great world of American industry have an enviable record of accomplishment. Industry need only point to its record in World War II, when a war machine manned largely by businessmen was brought up to a level of power and efficiency far beyond that achieved in any other major combatant nation. This surprised and awed our military leaders, and even impressed some of the scientists who shared in the great task.

What then explains the obvious feeling among scientists that little is to be learned from the next door henyard? A major reason is that in the first six decades of this century there was lopsided emphasis upon industrial management as a craft to be applied only in the physical manufacture of tangible products. In the early blush of the "scientific" approach to management by Frederick Taylor and his dedicated followers, this was almost the exclusive emphasis. In later years it was partially corrected. But it was a combination of power and machinery, plus highly trained human operators and expert supervision, which Taylor wanted to be applied to the manufacture of specific end-products. In his system great emphasis was placed on planning, selection and training of staff and workers; coordination of a complex sequence of processes and functions; careful structuring of a detailed administrative and supervisory organization. Other pioneers worked hard to devise elaborate systems for incentive compensation of workers--at the cost of much of the confidence of union leaders.

But within the whole area covered by such craftsmanship, elaborated by advisory services and by engineering efficiency men, no room was left for the care and feeding of pure scientists or even for the lower levels of industrial laboratory denizens. The present high estate of research and development was very much a latecomer in the management scheme of things. Even in the post-1950 years of lush growth in scientific undertakings paid for by the industrial giants, the guidance and direction of scientists as a special kind of people seemed like one of the sidelines in the admired panorama of expert managerialism. It seemed akin to motivation packaging, or the Freudian classification of customers.....such matters could easily be delegated. Find a leader like Kettering, was the favorite solution--and turn all the problems over to him. His work could be integrated into the scheme of American business by setting up a staff division which would report to the proper line official--hopefully under a sensible and practical manager in the received image of a Kettering-type.

We need not accept such wide boundaries for the knowledge-producing industries (sharply contrasted with the physical-things industries) as Machlup has given us--practically half of all economic activity--to realize that the narrow production-of-physical-goods point of view in the managerial craft provides a very ill-fitting garment for our science-

oriented civilization. It will rapidly become even less comely. Aside from the strictly special world of pure scientific exploration and creative research--with which we are so much concerned here--there are other major regions of human endeavor in our society which supply far more relevant source material for a study of management wisdom than the business-industrial world can offer.

Just one example is the great engine of public and private education. Staffs of professionally trained teachers, researchers, and administrators operate effectively under principles of organization, stimulation, and leadership far more relevant than those given us by the business managers. Even more pertinent in some directions are the methods of the consulting firms who now serve business in so many specialties, or the medical practitioners in group practice, or the public accounting firms, or the publishing business in its creative aspects. These are just a sampling. Above all, scientists themselves working in foundations and in other situations where organization has been an essential weapon have blithely gone ahead to create their own craftsmanship of group management. Problems of inter-personal relationships and the techniques for their solution which industrial scientists have independently developed would be one of the most fertile grounds for study.

Perhaps all of these important innovators have been subconsciously drawing upon the oldest and most impressive example of an innovative managerial approach extant in our Anglo-American social history: the legal profession. Even skipping over six or seven centuries, the experience of large metropolitan law firms in recent decades is alone an illuminating example for study. How does society obtain a maximum degree of skilled service from a large and complex group of professional peers who vary in age, experience, and specialization, but are united by a common skein of ethics, education, and tradition?

Inheritors of the oldest and most sophisticated professional tradition, lawyers have long assimilated basic truths about group organization, among peers of equal training and equal professional qualifications. If the history of great individual law firms since 1870 is studied, we are struck by the lack of serious attention to the monistic form of organization, to the doctrines of scalar or "line" authority, to vapid distinctions between "line" and "staff." As a body

of peers joined together loosely but effectively in the pursuit of a common profession--but having discrete personal specializations within that broad goal--the lawyers have had no need for hierarchical levels of authority, or of professional managerial top-level control by non-lawyers. The analogy to the approach for men of science is obvious.

Any such analogy can of course be facilely attacked. It can be said that Anglo-American law is an old and well-established discipline, that there is little decision-making or need for wiser heads to "review" the proposals of the younger specialists, and so on. There is little need to test new hypotheses for theoretical exploration against the "practicalities" of the situation, or to choose among many alternatives in terms of limited resources to be applied. These are, of course, the commonly given reasons for placing our scientific effort under business firms as the proper social leadership for ensuing decades.

Burgeoning since 1945, disturbingly, have been new followers of the law-firm model in the inner world of business enterprise. Accounting firms, consultants in a host of specialties, market researchers, and experts in a host of new specialties, have all appeared and found followings. Many have a pseudo-scientific approach to their announced tasks--or even a truly scientific one in some cases. Our interest is easy to define: Organizationally they follow the law-firm model, not the hierarchical scaling of authority within their own large or small staffs. They are groups of peers, essentially, and as such give little aid and comfort to the traditional theorizing of the established craftsmen of management.

A most significant recent approach to the theory of both business and public administration is that of Victor Thompson.[2] He makes a convincing pathological diagnosis of the pervasive case in both business firms and major public agencies of "the boss who knows less than the specialists who report to him." Authority, increasingly, cannot rest on superior knowledge at the top. The old-time

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[2]See his Modern Organization (New York: Alfred A. Knopf, Inc., 1961), especially Chapters 3, 5, and 9.

generalist, the hard-hitting leader, is now propped up in his seat of power only by the casual tolerance of highly trained subordinates. The pyramid of hierarchical power has a clay cap. Some students of the American business managerial scene see in the flood of academic outbursts on the esoteric craft of management an effort to bolster failing egos in the ranks of the managerialists. Placing traditional monistic management on a pedestal is an obvious psychological response to the lapping tide of professional skills which steadily washes away the foundations of top authority. Both businessmen and public leaders in our technological democracy have long since lost any purely charismatic claim to their superior authority. They are threatened with the loss of a management power base which had been constructed on a social and organizational acceptance of superior wisdom. This is wilting under the rays of scientific and professional skill which will more and more sustain the real vitality of our great structures of corporate capitalism.[3]

Scientific and educational leaders of our society have long recognized the out-of-date nature of businessmen's monistic organizational principles. Most scientists would simply comment tolerantly that quarreling over their validity is silly. Of course specialists know more than titular administrators! Of course leadership in scientific enterprise rests on the mutual respect of worker and leader for one another's skills, intellect and training! Of course that respect rests on demonstrated capacity! Honored above most qualities are intuition and originality in laying out the joint tasks and objectives of a group, be it for one man or for a thousand. The key principles in scientific

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[3]The older ranks of business administrators find themselves beleaguered from a new direction. Ever since the famed Hawthorne studies in the decade before World War II, the apostles of a "human relations" approach to administrative management in business firms have been questioning the accepted power-base theory of older administrators and managers. The twin doctrines that organizational structures rest on the relations of people with people, and that individuals want above all to achieve a sense of belonging to a common group and sharing problems within a group relationship, have obviously engendered another corrosive attack upon old-fashioned managerial thinking. Cf. Motivation, Productivity and Satisfaction of Workers by Christenson Zaleznik and Roethlis Berger (Boston: Harvard Business School, 1958).

direction and leadership are first to maximize men's self-respect, and second to use in every possible context the principle of group-sharing or leader-associate ties in planning and executing projects. Finally, let there always be joint credit given and taken for jointly-conceived enterprises. The scientist may have other worries about the effectiveness of his superiors' leadership and his need for helpful "management," but he is only slightly concerned with the particular managerial problems which now seem to engage major attention in the business world.

Thus we are left with a pretty tattered claim to primacy. There exists much expertise in the craft of business management which can profitably be applied to profit-seeking firms large and small who are relevantly concerned. But we are forced to conclude that it has a debatable carry-over into the difficult new world we are examining herein.

The Universities and Foundations as Research Leaders

Ever since the great days of Silliman at Yale, in the middle third of the 19th century, American universities have laid claim to a position of primacy in guiding scientific research. They became strongly conscious of this role after about 1875, when the imitative drive to reproduce Germany's research-oriented staffs began to pick up momentum. Since 1890, aided by the examples of Clark, Hopkins, Harvard, and Chicago, and in later years of leading state universities, the claim has been loud and clear. Since 1941, and the advent of a Nuclear Age, the spotlight has been steadily turned on the creative scientific leadership of university faculties.

There has not been much emphasis in this new role upon the expert management of the skills of scientists, upon the formulation of comprehensive long-range programs, or upon inter-university and inter-disciplinary projects to coordinate efforts and eliminate duplication. Rather the claim to primacy has rested upon a record of accomplishment in theoretical science, and upon some applications thereof. The favorable climate surrounding the typical faculty researcher, the accessory facilities given him (including eager, made-in-his-own-image youngsters as assistants), and the freedom and lack of restraints which each individual enjoys, have all been stressed.

Thus, "outside" governmental contracts have sometimes been downgraded, because they may dilute these advantages. What some analysts would cite as weaknesses of our educational institutions in directing scientific progress along the best lines over the past 75 years have been turned around into vaunted advantages by the educational community. Some apologists would go so far as to claim that our "lone wolf" inventor-type has since 1920 or thereabouts found his proper lair within some faculty roster, where in exchange for a little teaching time he can follow his own individualistic research trails. Society thus need no longer worry about his starving in a garret!

The great burst of national expenditure on scientific and technological tasks after 1940 was strongly felt by the general community of university-attached research men, and even more intensely since 1952. War-oriented efforts were in most cases a kind of hothouse attachment to what were austere laboratories and slender budgets--now long forgotten in all topnotch institutions.

Since 1952 there have been few complaints about penny-pinching and austerity. Indeed, the decade from 1955 through 1964 will go down in educational history as the great "Golden Decade" in the history of American higher education. Not only have huge research grants flowed, but educational salary levels have doubled and the major gains since 1958 have been in real purchasing power for faculty members. Opportunities for promotion in rank, gains in appropriations for new buildings and equipment, addition of thousands of young assistants who are being subsidized in their graduate degree-seeking years (including those supported by Federal grants), and reduction in the required levels of teaching time and effort--all have seen revolutionary improvement in this miraculous decade.

Certainly in terms of spectacular and world-recognized original achievements in research, the American university community must stand at the top among the groups which we are examining herein. Lists of achievements in medicine since 1900, or of Nobel Prize winners in the physical and natural sciences, or of new path-breaking concepts resulting from integrated teamwork achievement in theoretical science which will be recognized by future historians of science: by all these tests, the American university world now stands in a foremost position.

But is this undisputed primacy quite relevant to our inquiry? The boast or claim does not include any but a miniscule element of coordinated, nationwide planning for the future. Little is said about an over-all pattern of ultimate scientific objectives. Nor is there reference to sharing-out responsibilities among peer institutions to avoid competitive effort and duplication. Nor is there within this claim any sub-claim that coalitions or groupings of scientists within the academic world have devoted themselves to filling these obvious gaps in their own institutions' approach. Instead, academic scientists have had primary lateral loyalties to their respective scientific disciplines, to their own specialties. It is in such lateral personal relationships that much of the exchange of views and data essential to real leadership and direction in science has taken place. This very important body of evidence about the behavior of university faculty members points to the conclusion that the institutions as such do not possess the record of primacy to which they lay claim. Their faculty men as individuals are the true claimants.

There have been few attempts to create an organized leadership or directive authority, either by top administrations or by inter-university groups. Two or three have been quite frankly lobbying efforts to assure a "fair share" of the Federal funds to support university research; this has been especially true of regional groupings of publicly-supported institutions. There has been a notable lack of offers, in exchange for more Federal grants, to shoulder some of the national planning burdens. Isolated efforts have been made to economize in the cost of facilities and equipment by earmarking certain sub-areas of scientific inquiry to one or another institution within a loose association. In agricultural research, some regional or "natural" specializations have been encouraged by the Department of Agriculture and by the administrative heads of various land-grant universities.

But all of these joint efforts have been modest, or ephemeral, or extremely limited in scope. The very strengths of the academic world are its clearest weakness. In terms of any promise of integrated social leadership, or custodianship of national purposes in the decades to come, the record so far is weak.

It is equally clear that educational institutions ought to be important participative factors in any integrated national

system of scientific directive guidance. Such a system, however, will in all likelihood be created under wise national leadership somewhere outside the university world. Yet by tradition, and by performance, and because they currently have possession of a major fraction of the pool of science research talent these institutions, even though they remain only passively concerned with social objectives, must be included in any master-plan.

Lack of space prevents us here from carefully distinguishing the active or "working" non-governmental foundations from the institutions which have teaching commitments in the educational system. It must suffice to notice those private and non-profit foundation enterprises which support active research programs, i.e., excluding those which merely support individuals or groups elsewhere, with project grants. From the rather small group of this type in the United States could certainly come some of the leadership and planning talent in which we are interested. There is a special reason: Administrators in these enterprises have had decades of experience in "managing" scientists. They have some acquired skills that the problem demands.

It is still true, however, that the two-score or more units which would meet our criteria have many of the same limitations which affect the usefulness of universities in any guidance-role nationally conceived. The programs of most have not been any broader or deeper than those of many university science departments. The special interests of senior staff have too often determined the nature and scope of projects undertaken; and these often reflect a narrow and even parochial range of interest. Facilities and the nature of the scientific equipment employed have not been as widely diversified as in many first-class universities. Nevertheless, there exist a dozen or more excellent private foundations whose record of specialized attainment in particular fields (in oceanography and in forest products research, for example) would enable them to make a real contribution to an integrated national guidance system.

It should be added that many university staff groups are becoming carbon copies of avowed research units in the foundation mold, shedding their teaching function entirely or shunting it over to journeymen teachers despite the pained outcries of graduate-level students.

Federal Departments and Agencies

If during 1965 we were to poll a sample of younger-than-35 American scientists, or a group of American journalists of the same age group who cover the world of science, we might very well discover a sweeping majority who would declare that it is a core-group of Federal agencies which are already the primary directive force in determining the future pattern of American scientific efforts.

Particularly to be noted is the qualification that this sweeping view would be of the Johnny-come-lately variety. Older scientists, particularly those whose careers have been spent wholly in academic environments, would see the situation quite differently. Their memories are longer. Very recent, relatively, is the advent of massive Federal grant funds. Thousands of individual project-grant allotments are distributed and administered by Federal agencies which are nearly all essentially new since 1950. To such older heads, the Federal position of primacy is more illusory than real. It is to them largely an overlay, a top dressing imposed upon the strong underlying structure of scientists' own efforts, their choices, their proposals, and their forward planning.

We need not resolve this particular issue. But we do need to examine quickly the performance of this core-group of Federal agencies, which include many direct-production units as well as project grants. They must obviously be counted as another important cog in any molded and integrated system of guidance. The Federal agencies which can and will play a role in such a system will have to be carefully appraised in detail, beyond anything we can include here.

In a short two decades, a baker's dozen of key Federal bodies that are leaders in science have established an astonishing record of both planning and doing. They have established goals and formulated projects; they have sought out specific scientific undertakings. They have followed up critically on performance. The American public has witnessed a record of Federal Government action and achievement which would have been unthinkable in 1939 or 1929. Behind the executive and administrative agencies themselves has been a Congress which has confounded its perennial critics by ably and consistently supporting a wide spectrum of research efforts. And this support has extended far

beyond the limits of year-to-year military needs and pressures.

In many important sectors, the record of accomplishment has been as strongly positive and "practical" as that of leading industrial companies. Federal agencies have set research and development goals; they have carried out planning and staffing for them and very often they have designed and directed the erection of facilities; they have carried projects through to completion of an exacting time schedule. Even more important from our point of view here, certain of the leading Federal agencies have duplicated the vaunted private industry pattern by setting up very long-range projects with adequate personnel and resources, without an insistence on an immediate payout. This has been marked in the fields of basic medical research, water resources and hydrology, in the development of specific synthetic materials, and finally in space technology.

In the century since the end of the Civil War, those Federal agencies which have really needed the help of first-class scientists as permanent or temporary staff members have had little difficulty in securing them. Nor has this been true only in war. The Pure Food crusade of 1898-1906 was led by an outstanding group of practicing scientists, many of them in state as well as Federal employment. The Coast and Geodetic Survey, the Department of Agriculture, the Bureau of Standards, the Office of Naval Research, the Weather Bureau, and the Census Bureau--all have had long records of success in attracting able specialists. Since 1945 there has been a finality about the record which has laid to rest the old sneer that Federal agencies could never secure the scientific personnel needed to maintain a position of real national leadership.

The needed integration of policy and guidance between the scientific staffs and the career service men in both Cabinet departments and in the specialized agencies has been dealt with at length by Don Price.[4] Here also we must acknowledge the strongly encouraging record since 1940. Among the top hundred career men in Federal service who

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[4]Don K. Price, Government and Science, Their Dynamic Relation in American Democracy (New York: New York University Press, 1954).

hold key roles in guiding and directing a broad range of scientific projects, the level of education, administrative competence, and sheer intellectual capacity would certainly stand rigid comparison with a similar group of say five hundred men who are in parallel roles in managerial posts in leading industries. This would be man-to-man comparisons of a special managerial group: i.e., those actually performing planning and guidance for scientific projects in close association with highly skilled scientific research staffs. It must be noted that this comparison need extend only to men who lack the special education, training and performance records of other administrative leaders recruited from the ranks of science who may be performing executive and administrative functions not only in government or industry, but also in the universities or foundations.

There is, however, an important area of doubt and questioning. It can be phrased thus: To what extent has the spectacular but short record of this core-group of Federal agencies been peculiarly the product of a special period in American history? There have been fertility and an outburst of productive growth all across the many fronts of science in two decades. These lay ready for tillage with money grants and sympathetic encouragement. More harshly, the query raised is one which stresses the essentially passive nature of the role. Should the well-heeled uncle who "sponsors" the career of a recognizedly brilliant and resourceful nephew get the credit for the latter's triumphs? Mere cooperative association with productive scientists, who provide the ideas and projects and plans, does not constitute a claim to society's confidence. Can we place primary reliance upon a group who have experienced only plenty, and who have had a plethora of opportunities and ready-made projects to sponsor?

It is relevant to stress the absence of adversity as a training device. The bloc of Federal agencies to whom we would look for long-range leadership have known only lush times. The hard choices--the analysis in depth of alternatives, the need to build a strong psychological base among not only the political public but the science community in all its ramifications--are tests which have presented themselves only a very few times since 1950.

Scientists and Technologists as Leaders

Why seek to uncover sources of competent national guidance and pathfinding outside the ranks of science itself? The true source, like Maeterlinck's bluebird of happiness, may lie right at home. It is from the scientists themselves that we should rightly expect to secure the tighter national goal-setting, the more rigorous coordination, the definition of goals over varied time strata, the tougher appraisals of performance and use of resources. Why waste time endeavoring to develop some untried combination? Others add that the whole body of concern about the adequacy of management or leadership is wasted effort; when and if needed, scientists themselves will fill any gaps there may be.

Historically, this is a fairly defensible position. For about 125 years individual scientists have been demonstrating: (a) their willingness to help define and achieve national goals, from steamboat inspection and safety standards through national surveys of geological resources to the establishment of standards of purity and safety in foods and drugs; (b) an effective system of communication within the more important sub-areas of scientific inquiry, so that diverse discoveries such as insulin, transistors, antibiotics and synthetic rubber have not only been quickly harnessed into useful technological applications but the peripheral and lateral "follow-up" inquiries were rapidly initiated and effectively explored; (c) an ability through their professional associations, lateral contacts with fellow-workers, and an amazingly thorough educational network to appraise and select and then support the outstanding new individual performers in each rising generation. There are other plus-marks to be added too. Effective criticism, constructive and destructive, is always provided through professional associations. Some degree of informal control over research outlays has been exercised through respected leaders in the academic, industrial and governmental hierarchies.

This is an impressive record. It creates a strong presumption that our correct answer could be a major reliance upon self-guidance, self-appraisal, and a program of goal-setting by the scientific world itself. Aid from the universities, from the Federal Government, from several hundred industrial giants--all of this could be marginal or incidental, if this is to be our basic conclusion.

But if we can imagine an inquiry into this comfortable view by a group of distinguished physical and natural scientists brought back from Mars to study our Earthian "system," a few soft spots might be exposed. First of all, it would be difficult to explain just how the scientific community as such would actually allocate and divide the tremendous resources which will be thrust upon it in the next few decades. There is now an enormous flow of resources into a bewildering assortment of "fruitful" areas of research with little or no real coordination.[5] Are they truly serving our national interests? It would be very hard to satisfy a polite inquiry on this very simple point of information. How, by whom, and by what tests are new grants, ongoing repeat grants, and follow-up grants actually being proposed and decided upon? Are new entrants to the many sub-worlds of research really welcomed and encouraged?

Second, it might be embarrassing if the Martians inquired just what crosschecks are made on possible marginal errors or even substantial duplications in resource-application, as between finely-divided disciplinary areas and as between competing individuals or groups. Do the top research leaders in discrete sub-fields of science have really effective channels to exchange self-disciplining comments on overlapping goals and demonstrated blind alleys?

Thirdly, what future proportions of total resource application would be given--under a system of complete rule by scientists--to the scores of major and minor sub-areas of scientific inquiry? Would these shares be set by past records, by accomplishment, or by the presence of particular persons in decision-making seats?

On this note of imagined Martian skepticism, we may end our sketchy survey of the major candidates for shares in a

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[5]Professor Barry Commoner, of Washington University, said in 1963 when he was chairman of the AAAS Committee on Science in the Promotion of Human Welfare: "We have been massively intervening in the natural world without being aware of the biological consequences . . . . It will be argued . . . that it is the grand purpose of science to move into unknown territory . . . but the processes we now strive to master are neither local nor brief in their effects." Bulletin of the Atomic Scientists, Vol. 19 (October, 1963), p. 8.

future "system."

POSSIBLE FOCI OF STUDY

We must now quickly examine in turn a series of practicable concepts of organization which might be applied to the future guidance-direction problem.

Intensified Federal Leadership

We have seen how the several scientific agencies of the Federal Government suddenly acquired their prime role in the two decades following 1945. Only minimal attention has so far been given to the long-run implications of that new entry. There has been pressing substantive work to be done, more of it in each year that passes. Leaders of the governmental group charged with guiding the nation's scientific progress across a considerable part of the research spectrum, from mental health to moon-landings, have not had much time to reflect philosophically on the abstractions and nuances of role-playing. The sociological researchers have not as yet made monumental inquiries into conflicting roles, power elites, eminences, and leader-images as they have appeared suddenly in this new environment.

A few thoughtful students have examined the roles of the professional administrators and political appointive leaders,[6] and the scientists who accept permanent or temporary administrative and directive roles. Defining short-run and intermediate goals has been easy. Tasks have thrust themselves upon the administrators. They have not been consciously sought or selected, for the most part. Certainly if we are to place long-run responsibility upon a select group of key Federal agencies, we shall need to probe far more deeply into their sources of knowledge, levels of skill, and the functioning of their active and advisory

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[6]Some of the comments are sharp; one professor of history has remarked: "We have moved from an age of science into an age of scientism . . . . Science has lost its pristine purity . . . we deal with public administrators of huge projects . . . all of them depending upon public opinion for their support . . . . " T. H. Von Laue, in Bulletin of the Atomic Scientists, Vol. 19 (January, 1963), 2.

leadership echelons. We would need much better records of the outcomes which have followed their decisions where alternatives existed.

Federations of Academic Institutions

We have seen that the claim of the academic and foundation community, quite broadly boundaried, is perhaps second to none over an historically longer time span. In a sense it has been a sleeping giant. Passive when it could have been more aggressive, loaning its talent to the citadels of government and industry, it has been inept in mobilizing its strength by coalition and coy in thrusting itself forward as the true champion of the national interest.

There have been growing signs of a group-consciousness and sense of cohesion among the six-score or seven-score institutions who control over 90% of academic research facilities and about the same proportion of established scientific leaders. The recent new grouping of graduate schools and colleges as the first unified lobbying front ever successfully launched, several regional associations of both public and private universities, and the increasingly close ties of many faculty scientists with political leaders--all are straws in the wind.

A powerful claim could thus be put forth that the primary guidance role ought to be settled upon a federation of universities and colleges. It would probably be of the loose federal type in order to accommodate specialized academic organizations of scientists themselves, old-line institutional groups such as the Association of American Medical Colleges, and certain newer groups which are oriented toward grants for facilities and projects. The universities have battened on our gigantic system for subsidizing current graduate students in their initial apprenticeship studies. They have perforce gained some skills in managing grants, among many competing disciplines.

Aggressive motivation has been the missing element here. There might be no more objection in Congress to entrusting both the allocation of funds and the primary responsibility for science leadership to some newly-conceived grouping, encompassing the total academic and foundation community, than there was to making land and money grants to the Western transcontinental railroad lines a century ago. As a

long-qualified candidate for the mantle of national scientific leadership, there is no near competitor in terms of past record, combined talent, and a true sense of long-run responsibility. But is there a <u>will</u> to take the necessary steps to qualify? There must be joint action, joint agreements, joint planning, and a skillfully-wrought plan for sharing-out the flow of grants and subsidies. Yet we shall see below that many academic leaders are much more committed, as scientific persons and even as administrators, to another kind of solution.

The "Family" Approach

Radically different from these rather obvious paths of evolution is one which would rely on a quite different and much less obvious area of current strength in the scientific world. To a limited degree, we are following it now, in advisory boards and panels.

Nurture the major lines of progress and the men who lead therein. Both are easily identifiable. Build assistance to science around these powerful fraternities of originative men. Utilize the guild spirit and the guild solidarity of medical, biological, mathematical, and other front-line workers. Smooth the path of actual work by widespread and generous governmental assistance. Do nothing to harm the free atmosphere and elaborate back-up support provided by the universities, the foundations and outstanding industrial research divisions. But rely fundamentally for leadership on the princely families of scientists, who as individuals and teams have carried America thus far down an amazing road. They have a clear inner strength for the long task ahead, plus a curiously greater-than-the-sum-of-its-parts strength in terms of the national interest, plus total personal commitments. These are precious advantages that some of our major world competitors may lack. Do not squander them; use them. So is threaded together the basic plea for such a "families of scientific power" approach . . . .

Special Bodies Created Only for Long-Range Planning

The foregoing pleas may all have merit. Each may be true in the relative sense. We are proud of our government agencies, our great academic institutions, and of the group-power in our scientific guildsmen. But do they have

any clear view of the longer future? How can we pin the insignia of leadership on any group, if we want for goals to set before them? As a nation we are, understandably, full of immediate plans, immediate projects, immediate needs to achieve clearly-stated goals ("immediate" in this context means five to ten years!). But we are simply too busy to integrate into a meaningful whole the scores and hundreds of scientific trails and paths we know exist. Hence we must, in the clear long-run national interest, provide some positive and far-ranging guidance. The fear here is perhaps that we will dissipate our originality and our intellectual strength by waltzing down attractive garden-paths which happen to attract some particular leader or group at any given time. Behind this view lie prudence, frugality, skepticism, and a long eye ahead to a perhaps less rosy world situation.

This fourth approach is therefore essentially an overlay concept. It says we should aim to establish a super-group of true planning agencies (not "action" groups!) in as many scientific spheres as are needed. These would not be exclusively governmental, nor exclusively the property of ruling scientific groups. They would be representative of all interests, including the military agencies and the most pacifist-minded pure scientists. Their task would be clear: to point out the directions and particular areas where conscious efforts needed to be made to bolster our national welfare. A critical and appraisal function would be added, too. Possessing prestige, this cluster of long-range planning groups would after a few years become equipped to speak out strongly against narrow or repetitive or proprietary or doggedly egocentric expenditures of our science resources.

Specialized Groups as Scientific Pace-Setters

A related but differing approach accepts one premise of the foregoing idea, but rejects another. We do need a longer view ahead. We do need to avoid the twin evils of preoccupation with immediate problems and the selfishness of self-centered specialists. We do need the shaping hand of long-range planners in science. But, it says, the basic procedure of the other solution would be wrong.

Precept and example should be the only weapons employed. No group of planners, however well chosen and well balanced and well backed, can hope to have anything but a deleterious effect on our long-range achievements in the complex and

sensitive world of science and technology. Therefore, let us drop the premise that positive long-range planning can be done in a vacuum. Let us put in its place perhaps six or eight well-financed new agencies, headed by rotating staffs of the top science men of the nation. Their only function would be to work and produce--in their own specialties--and thereby provide all the necessary leadership and guidance by pure example.

These would be highly attractive institutions. To be chosen for their staffs would be a blue-ribbon honor. They would rapidly become "famous." They would have a little trouble in the first tests of their functioning; but under inspired direction they could also quickly set new records of achievement in the eyes of their peers. And they would be conscious of their public role of looking far out on developing frontiers, and of trying to see the long-run comparative importance of different trails. These public and publicized responsibilities would rest lightly on men whose very ability and characteristics would make it natural for them to accept such truly charismatic roles.

A Deliberate "Wild Card" Approach

Scarcely articulated in these recent years of organized and resplendently financed research has been the older free-wheeling view that originally inspired the patent-production laws of the eighteenth and nineteenth centuries. This was the first raw material for a national system that we examined above. Encourage the dreamer, set up goals for the wildly impractical man, back the hit-or-miss experimenter and the methodical lone-wolf. Gamble on the "wild card" in the deck. Neither soft cocoons of well-heeled research laboratories nor the fancy "leadership agencies" just described will nurture true genius. Imaginative conquests of completely new terrain in science do not sprout in the soft environment of university faculties or foundation halls. There the main objective is to flatter the collective vanities of the "in-group" who control the programs of research, the requests for grants, and the paths chosen by well-trained and obedient younger men . . . . So goes this dissident plea.

It can be dubbed naive. Only a bare handful of real dreamers have contributed anything in the past century. Their

day is done. All the wild "cards" prefer comfortable captivity. The established orders laugh and note politely that it might be better to provide financing for the accidental great discoveries (e.g., penicillin) or for the puttering-around types who may stumble on something helpful once in a while, in attic or cellar laboratories.

Nevertheless, there is here an element of penetrating importance. If we are to accept the objective of a really integrated and balanced system of directing all the efforts of scientific investigators over the next several decades, this gambling or "wild card" idea must presumptively be included.

To educational administrators, there will occur an intriguing analogy in the changed admission-selection methods of leading colleges since about 1958. This is the idea that within an entering freshman class, hand-picked by tests and grades, there should be deliberately included a number--perhaps 10%--selected on hunches or guesses that they will develop unusual scholarly qualities, offbeat potentialities, or outstanding personalities. The real results of this deliberate admixture will not be known for thirty years or more. But the concept is even more attractive in terms of backing young but skilled scientists who may not even at the moment have a specific "dream project"; they may still ripen into the productive dreamer-achievers who could be one of our greatest assets, though lacking dossiers today!

A Modified "Invisible Hand"

This sketch would not be complete without a mention of the attitude toward the problem that may conceivably be held (no real survey of scientists' attitudes has ever been made) by a majority of all practitioners and teachers in the natural and physical sciences. This is the view that let-us-alone is the best kind of management. The sum of all free-flying efforts, framed in each man's own image, will be the best for American society.

This is of course an espousal of the Adam Smithian view of the best economic motivation for society, so often praised by physical scientists--especially when they first "discover" it as the central principle of laissez-faire economics. In the context of our survey it is simply an incomplete view

of the situation. In actuality there is a problem of formally allocating resources for the use of scientists: there is no independent marketplace flow of money resources to science. People do not "buy" science. Scientists, in other words, do not directly command any portion of the national income stream. This independent command of marketplace income was an obvious first step in the Adam Smith prescription. In our society--and there is little prospect of any change occurring--there must be institutional arrangements for channeling a slice of total available resources into the work of science and technology, except in the minor case of incorporating such costs in the sale price of commercial products.[7]

RECONCILIATION AND INTEGRATION

Incompatibility is obvious. Not all the worthy approaches to the national problem can be applied equally and simultaneously. Yet there is ample evidence on many sides that some steps toward an integrative solution must soon be taken.[8]

One easy conclusion from the foregoing could be that scientists who are quite competent to lay down plans and far-ranging objectives ought to develop a self-administered "Plans Council." Some such national forum on inclusive lines and organized on a permanent basis is a crying necessity. It would be the democratic path toward true planning and management of our science efforts. Something similar might be done in applied science, separately.

Many variations of this fundamentally necessary first step are possible. All of them must rest, however, on the

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[7]It was of course this practice in the pharmaceutical industry which has led to sharp public controversy: i.e., making today's consumers pay a heavy "loading" in the price of drugs for scientific research by the manufacturers. Cf. three well-known articles by Richard Harris in The New Yorker, March 14, 1964 and two subsequent weekly issues.

[8]For a statement of national urgency from a differing set of premises, cf. Vincent P. Rock, "Science in National Policy, A Preliminary Inquiry," Paper No. 1 in this series (November, 1964).

premise of freedom from control by any one of the groups which we looked at in the earlier portion of this essay.

One model of a possible second step has been prominent in national scientific planning since about 1950. It would build on the present foundation of the group of post-World War II federal institutions, but would move definitely toward more autonomy by power-possessing advisory groups of scientists in the management and funds-allocation process of these units.[9]

These advice-plus-power groups would become more and more independent of the Executive Branch, and of Congressional committees. In part this would be accomplished by close alliances with several score of the major industrial research operations, with about a dozen of the leading non-profit foundations which are leaders in major areas of "pure" scientific research and lastly with certain university groups. The approval, sponsorship or imprimatur of such a powerful coalition, acting through an executive group elected by scientists themselves, would presumptively forge a powerful weapon in moving American research in desired directions.

Gradually there would evolve an integrative process from the vantage point of existent scientific and educational organizations. These have long been the possession of scientists themselves and therefore could be ideal vehicles for high-level guidance. Whether the American Association for the Advancement of Science would need to be directly involved seems to many people irrelevant, since the same AAAS body of controlling societies--and their individual leaders--would be utilized in such a new national guidance body. One presumptive advantage would be that leading

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[9]For an important accomplishment in this direction, cf. the discussion by J. H. Cassedy in Science, Vol. 145 (August, 1964), 897. He gives an informative summary of the work of "study sections" in the Division of Research Grants of the National Institutes of Health. These working scientists, with real advisory power, have two major responsibilities: (a) to survey the status of research in their fields, to determine where activity should be initiated or expanded, and (b) to evaluate the merit of grant applications in the light of their constant review. Many individual members of these working groups have testified to their worth.

scientific administrators in private industry and in the universities could be much more readily recruited for counseling, comparative judgments, and sponsorship of creative new projects. The highly suggestive example of the Engineers Joint Council, representing twenty-nine major engineering and technical societies, is often cited as a model. Another variation on this basic approach would make several hundred universities and colleges of the nation the central structure under which a power-wielding guidance and directive mechanism for future scientific work could be established. This we appraised above.

We must not forget the view that the best approach would still be the "invisible hand." Its attraction to many scientists was noted above. Support by public grants, academic facilities and training in educational environments of diverse kinds need be the only kind of social planning required to reap the maximum social dividend by this concept. This approach will have to be brought into the open, and honestly appraised as a long-run base for providing strong national leadership. The appraising will, obviously, have to be done by those who are not emotionally committed to either side of an argument which has persisted for a century.

THE LONG VIEW AHEAD

We return to our point of launching. A goodly fraction of the denizens of the world of science would say, quite frankly, that any marked preoccupation with guidance and leadership is premature. The institutions concerned, and their administrative heads, are too busy with urgent and fruitful work to be much concerned. There is also an unspoken assumption, pervasive and tenaciously held, that all is well.

We have seen herein that it is still quite logical and understandable to reach such a conclusion. The healthy inner dynamics of our total scientific community as it is now led will continue to carry the nation onward and upward to far greater heights of achievement. But just as logically and clearly we can discern dangers and difficulties. The uprush of activity and expenditure obscures them.

Some questioning voices have been heard, for example:

> . . . some have questioned whether the distribution of funds among investigators of the unknown in nature and society results in an equal opportunity for all excellent scientists to tap these funds . . . . Certain disciplines are far more richly financed than others, which the average citizen, or even the average scientist, might feel were equally worthy . . . .[10]

By what exact process are the changes and shifts in emphasis and direction to be brought about within the established pattern of scientific effort as year follows year? Is that pattern merely a crazy-quilt of combined patches of personal bias and personal interests (however "scientific" the holders thereof may be!) of influential individuals in the universities, the foundations, the learned societies, and key government bodies? Does the pattern within reasonable limits reflect any formulated concept of relative, longer-run social evaluations appropriate to a democratic society which--though wealthy enough--cannot yet afford egregious errors? We cannot now even begin to supply convincing replies to these disturbing questions.

Perhaps the power-base upon which the existent scientific planning and guidance rests--such as it is--is simply much too narrow. Perhaps it is framed on seriously inadequate premises and objectives. We simply do not know.

This is not an alarming charge in itself--a healthy democratic society always needs to ask such disturbing questions about itself! But in the special terms of the most important single factors in our national future--science and technology--we may need to bestir ourselves.

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[10]V. P. Rock, "Science in National Policy, A Preliminary Inquiry," Paper Number 1, Program of Policy Studies in Science and Technology, The George Washington University, 1964, p. 14.

PARADOXES OF SCIENCE ADMINISTRATION

by Thomas A. Cowan

I

In the course of his profound analysis of the nature of the mind, the philosopher Hegel calls attention to a deep paradox which attends all human effort. I might risk putting it into colloquial language somewhat as follows: By dint of superior effort, by a stroke of good fortune, or even by the exercise of chicanery, one man becomes boss over another. From the point of view of the boss this looks like a happy or at any rate a superior position; the "worker" is an inferior. But then a peculiar thing happens. If in point of fact the boss does not work harder than the bossed, he begins to deteriorate and the worker gains in moral stature. What dignifies human effort is the work itself. The loafer, the shirker, the time-server--be he boss or subordinate--pays for his dereliction in moral degeneration.

I should not like anyone to think I am referring here to the so-called Puritan ethic, the doctrine that morality is totally encompassed in cheerless and dogged attention to duty. What our philosopher was examining was not any specific creed dedicated to success or gain. He was investigating the nature of the human mind itself and reporting on a universal phenomenon. Superiority is a concrete, objective state of affairs based on discernible productivity, physical, mental and moral. It may begin in natural endowment but it takes sustained conscious effort to maintain. The boss may quickly become the slave of his own workers, of his own community, even of his own image of himself.

These humble truths are so well-worn that it may be puzzling to imagine what new grist can be extracted from them. For one thing, a question: Is this dialectical process, this paradoxical turn-and-turn-about, applicable to the community of scientific workers? Or, on the contrary, is there something about the nature of scientific activity that exempts it from this human perplexity? Is science so exalted or at

least so self-purifying that it raises its devotees above the arena of common strife? We should hesitate to say that there is enough evidence to persuade us that this is so. Are processes then at work in science, such as the process by which scientists select or elect themselves freely to membership in the scientific community, which guarantee exemption from the common fate? This alternative is very tempting, for it is true that the scientist does elect himself. No press-gangs shanghaii scientists for work in the scientific salt mines. Nor does economic necessity force them to work at science by the sweat of their brows. They join up freely. How then can it be said that they are constrained by the laws that govern the exaction of slave labor? The chapter in Hegel's Phenomenology to which reference has been made is itself entitled "Lordship and Bondage." In science we are not dealing with peonage. True, but I think the old philosopher might have something further to say. He was asking himself how men might feel constrained to work and yet might feel free or, as he put it, come to know themselves, come to an acknowledgment of self--the liberating effects of constraining oneself to work. Surely, this situation is well known to scientists. If the scientist happens to be one who works by himself, on his own, then he knows the joyful agony of freedom through self-imposed constraints. He willingly enters into a situation where freedom and slavery go so intimately together.

Suppose, though, that the scientist has elected to work in an organization, a community. Then, since he has agreed to accept constraints from others, the pattern of freedom and bondage changes, without however giving up any of its paradoxical character. Our scientist enters into a relationship with other scientists--men like himself who will exercise toward him the familiar behavioral patterns of lordship and bondage. Now our individual scientist coerces not only himself but others; now he is coerced not only by himself but by his "superiors" (if I may venture the word) and also by "inferiors." There is a man "over" him in some real sense, and men "under" him. These men are scientists like himself. How can there be any question of a scientist giving himself in bondage to another, of allowing another to direct his work, to administer his work, as it is said? Is not the very conception of "science administration" a contradiction in terms? Of course it is. And if scientific administration were not such a palpable, obvious fact it would be necessary to deny its existence.

Still it does exist. There is no question of that. The real question is: How can it justify its existence?

In examining the remarkable human phenomenon of servitude, of the submission of one person to another, of the idea of dominance and of the ideal of service, Hegel sees in all aspects of the phenomenon a single aim: the struggle of the individual to realize himself, to attain a level of the truly human--in the words of the philosopher, to develop and maintain consciousness of the self as a fact of experience.

When I confront another in the act of service, whether voluntarily undertaken or imposed by force, the immediate fact of experience seems to be the quality of subordination or superordination in the relationship. But since service is a universal human phenomenon, the mere fact that it is a dominance-servience relationship says nothing concerning the actual state of my service with respect to you, or of yours with respect to me. It gives no indication of who benefits more by the relationship, of who is likely to suffer moral injury, of who sacrifices more in the way of human dignity and personal worth, or, indeed, whether everyone may not gain in these respects.

I am not now speaking of the clash of wills, of the power struggles that inevitably ensue whenever one human being engages another. Though this question is closely related to the question of service, I should like to put it aside. Beneath the universal clash of individual wills lies the much more fundamental fact of conflict of service. What I insist upon doing for you, you cannot do for yourself. What I insist that you do for me, I, in turn, cannot do for myself. To work is a deeper need for human beings than to will. Without work we sicken and die. He who works becomes dignified in the work. To prevent him from working, as by doing it oneself, is to deny him a necessary condition for human dignity. Who is master and who is servant when we reach this level of human life? Who is the better man--Marcus Aurelius, the Emperor, or Epictetus, the slave? The Pope calls himself Servus servorum Dei; surely the Servant of the servants of God wants thus to remind himself that it is precisely those in the position of power who are most in danger.

The master confronts the servant with a task. The servant performs it, let us say, and thus is dignified in the

work.[1] What now of the master? Subtly, his position has changed. He is in danger of moral degeneration. If now the master can somehow become a servant (it may be the servant of the servant) and perform his task in turn, he is then rehabilitated. If he cannot, he must destroy the relationship or it will destroy him.

I am describing, I think, the age-old process by which revolt succeeds. Not the strength of the underprivileged, the slave, the minority but the weakness of the masters, the leaders, the superiors accounts for the successful revolt.

So much, then, for this brief excursus into the fundamental dilemma of human superordination and subordination. Coming back to our own particular concern, the problem of science administration, we may now apply the lesson learned from the philosopher's reflections on the nature of the human mind.

The science administrator cannot be--or, if he is, cannot remain--a master. All questions of power struggle aside, the mere fact that he has assigned work rather than done it himself assures him that the relation of dominance and servience will be interchanged. Hence, the administrator must find his salvation in his own work, not in the work assigned to others. Here arises the dilemma that besets all administration. It is vain for the administrator to refuse to recognize any difference between himself and his subordinates. The temptation to try to accomplish this result in the field of science is, for some people, well-nigh irresistible. The temptation must be resisted or the administrator must stand down. Regardless of what his consciousness tells him, the relation he has to his "others" will ultimately be determined by the work, not by his or others' intentions.

Secondly, it is vain for the administrator to attempt to merge administration and purely scientific work. These spheres are and must be kept separate. To be sure, one

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[1] "Thus precisely in labor where there seemed to be merely some outsider's mind and ideas involved, the bondsman becomes aware, through this re-discovery of himself by himself, of having and being a 'mind of his own.'" Hegel, The Phenomenology of Mind (tr. J. B. Baillie), 1931, p. 239.

can be or become a part-time administrator, but a failure to keep the two roles separate results inevitably in confusion. Besides, the work of administration is itself inevitable. Someone must do it, for it consists in nothing less than the inevitable and unavoidable conditions necessary to the doing of any scientific work whatever. It is the humble conditiones sine qua non, the indispensable care necessary to the success of the work that is in question here. Hence, if one man steps down, another must take his place.

We have admitted that "scientific administration" is a contradiction in terms. And a contradiction is indeed a very formidable entity. The only thing that can successfully confront a contradiction is its equally implacable foe, a necessity. Let us in our imagination abolish for the moment all scientific administration. A random assemblage of unrelated single scientists results. What happens is that each becomes his own administrator and creates a monster which allows the individual scientist no freedom whatever. It is precisely this horrendous system of constraints that forces the scientist to associate with his fellows and to try to rationalize the division of labor by means of administration. But the chief concern is and always remains scientific freedom. When and if administration costs too much in terms of such freedom, it becomes not administration but bondage. When administration is too loose it forces the individual scientist to become his own administrator and the unwilling administrator of others.

We are addressing ourselves to the problem of scientific freedom, not, fortunately, freedom from the impositions and interferences of government, but freedom from the untoward constraints of our own activities. We ask how scientists may be able to work most freely at being scientists without undue cramping from the very machinery which was set up to enable them to work in freedom, in peace, in health and in happiness.

To the extent that our work involves scientific administration as a part-time or full-time specialty we have the same question to ask of ourselves (though this question may appear novel, it surely follows inexorably from what was said before): How can the scientific administrator as an individual human being dedicated to the pursuits of science maintain his own freedom to further the ends of science in

his own way? One of the warnings to be gained from the wisdom of pondering the dialectic of power is this: The administrator is in constant danger of losing his own scientific soul. For we may be sure that if he has not been able to maintain his own freedom and faith in the scientific enterprise he is not likely to be of much use in helping others to attain their goals.

Having succeeded all too well in showing us how the ruler becomes the slave, our philosopher Hegel passes on to other concerns. But we would stop him with a question: "Do you mean that I, well-intentioned person that I am, must endure slavery as I try to minister to others?" The response might well be, "Aren't you?" Evidently our philosopher, like all his tribe, is content to raise questions, the more baffling the better. It is no business of his, apparently, to answer them. Still, the very way in which the dilemma of administration is raised is helpful. It seems that what bothers us most is not the specialized problems of <u>administration</u>, but the perfectly general one of <u>ministration</u>.

II

So far we have been talking about the paradox of service--how impossible it is to tell who is servant and who is served. What we have said pertains to a whole spectrum of human relations. In order to examine the specific relation of a scientific worker to the organization in which he works and to his fellow workers, it is necessary to go deeper.

Granted that science administration raises all the problems that administration in general does, and that the work of science is not exempt from the universal paradox, in what way does the paradox get its special coloration so far as science is concerned? Is there anything special about the nature of science that makes this kind of work different from other types of human activity? I think there is.

The scientist is a very special kind of specialist. His product is <u>truth</u>, truth of a very particular sort. The scientist's truth has the following earmarks: (1) <u>It is a general kind of truth</u>. The scientist is a generalizer.

So, however, is the philosopher, the theologian, the historian. Therefore we say (2) the scientist's truth is truth about the nature of the world, the whole universe of animate and inanimate beings, investigated for the purpose of discovering the universal laws that govern it. This eliminates the theologian and the historian, whose concerns are seldom with inanimate nature, though it leaves intact the philosopher. Finally, the scientist investigates the laws of nature under a system of controls that is peculiarly his own. These controls are what is known collectively as "scientific method." They produce statements that are either analytically true or that conform to a more or less rigidly controlled model by which observations on the state of nature are processed. This rules out the philosopher and leaves the scientist as sole practitioner of what has in modern times become a highly complex activity of a self-validating kind. Only the scientist can tell whether a scientist is conforming to the canons of scientific procedure, whether he is or is not being "scientific" at any given moment.

This highly specialized art is jealous of the scientist's life energy, demanding fullest devotion and admitting of few other loves and loyalties. It entrenches on his personal life; it tempts him to neglect all aspects of his work save those that conform to the scientific ideal. These are conditions for extreme dedication, and science in the modern world stands for a way of life that expects such dedication and offers rewards, both psychically and spiritually, commensurate with it.

But this way of life exacts its toll. Collectively, it bears most heavily on the <u>feeling life of the scientist</u>. I believe it is here that the scientist must make his greatest sacrifices. For example, he is told that the power which science creates is impersonal, non-political, amoral. We will not stop to debate this issue. That it can even be raised is the significant point. For another example, the scientist's expertise is the art of generalization. But the habit of generalizing carries over into daily human relations, and this is, to run the risk of killing off the human sentiment that calls for individuation, the making unique of the relatedness that all human beings seek. It is a lawyer who is supposed to have answered the question, "How is your wife?" with the chilling reply, "Compared with whom?" Would a scientist have said, "Under what conditions of temperature and pressure?"

The annals of science do not record that the scientist necessarily wants himself to be treated as a generalized object of scientific scrutiny. Indeed, the practice of science requires that the scientist himself be highly individuated, be treated at certain critical moments as the unique focus of attention in the interests of scientific advancement. He needs his own special equipment. He needs assistants and associates. He needs to be housed and fed. In a word, he needs administration.

I think that much of what an administrator must do for a scientist is treat him as a unique human being in sore need of a multitude of services to enable him to practice his art. I put this need, which I call a need for the proper feeling life, even prior to any function which the administrator may exercise as an adjudicator. Obviously, when human beings come into conflict--whether they are scientists or just citizens--they need law and a judge to settle disputes and apportion scarce goods. But an administrator is not primarily a judge. He is a ministrator, and what he ministers to is the feeling life of the scientists he has undertaken to care for.

Not all men have the psychic equipment necessary for ministering to the feeling needs of others. Those who lack this human endowment should not attempt science administration. Human ambition--the desire to lead others--is laudable, and Heavens knows there is plenty of scope for the exercise of the administrative talents that need an outlet in leadership. But such talents, such ambitions, such desire for personal glory are, I am afraid, out of place in the administration of science. Not triumph over the persons of others, but triumph with others in the conquest of nature is the scientific ideal. If I had to state the science administrator's role in brief, I think I should say: "His role is to create an environment that nourishes scientific creativity," and let it go at that.

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