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The transformation of modern society under the creative forces of science has often been studied. Until recently the return implications of social changes on science have not been subject to equal scrutiny. Contemporary observers from within as well as from outside the scientific community have noted that the social basis of science is undergoing a rapid and profound transformation.

These writers feel that the attempt to harness the modern scientific *cornucopia* to the requirements of a military-industrial civilization may end by robbing the horn of its magical productivity. Merle Tuve, for example, is alarmed because the professor's life "is becoming a rat race of business and activity," while basic research is being ignored. Scientific activity has increasingly come to be equated with large-scale team projects and technical instrumentation. Science itself has come to be increasingly justified only on the basis of its ultimate utility. In face of this, Tuve makes a strong plea for the substantial support of "academic research, the intensely personal activity of individual professional workers" . . . as an investment of some of our "excess social energy in science and the arts for their own sake" (Tuve, 1959:169-184).

C. Wright Mills makes a similar point from a somewhat broader perspective (Mills, 1956:142-156). In the course of his discussion of the contemporary position of the scientist as well as other types of intellectuals, he points out that whereas in the past the intellectual was the independent critic of his society and its institutions and the creator of higher cultural values and knowledge, he now becomes the servant of institutions as technician and as ideologist. He thus becomes incapable either of criticism or independent creativity.

William H. Whyte, also concerned about the contemporary condition of science, begins his discussion with the general observation that the development of large-scale organizations is the occasion of a profound change in the traditional Euro-American Protestant mentality (Whyte, 1957). He calls this the change from the Protestant Ethic to the Social Ethic. The application of the Social Ethic to science means, 1. that there is an overwhelming concentration of effort in applied research at the expense of basic research, 2. that team work predomi-

* The first hand material on which the present study is based was collected during the winter of 1960. The materials were gathered through personal interview.

nates over individual effort, 3. that organizational loyalty and sociability are considered as valuable as thinking, and 4. that the brilliant man is beginning to be seen as essentially disruptive (*Ibid.*, 225).

American students are not alone in making observations on the impact of society on science. Essentially the same point has been made, with one critical difference, by J. D. Bernal in England. He maintains that in its very structure, "The scientific organization of today is not limited to, and is in fact not mainly concerned with, the internal development of science" (Bernal, 1956:894). The danger to free science is due to its increasing absorption into the laboratories of the practical institutions of government, industry, and medicine. Even the university laboratories are increasingly supported and consequently controlled by government and industry. In his view it is paradoxically true that, although the growth of science measured by the amount of money spent and personnel employed has been phenomenal, it has actually limited the advance of basic or fundamental science, because "it has been at the expense of very serious distortion of aim and method" (Bernal, 1956:896-898). Bernal's analysis goes beyond the other writers cited in that he makes a critical distinction between the process of institutionalization *per se*, and the attachment of science to, or the support of science by, the practical institutions of society. It is the latter to which he attributes central importance in the changing patterns of science and which causes "the distortion of aim and method." This distinction is central to the present argument. The increasing size of the research establishment and conducting research by organized teams alone are not solely responsible for the changes in science seen and feared by many. Although the sheer dimensions of research and the consequent necessity for formal organization certainly must be held as accountable factors, a more fundamental and in the long range more important one is the absorption of science into applied institutions and its application to their particular purposes. In other words, the traditional conception of the nature of science and the role of the scientist are linked as importantly to the value of the pursuit of knowledge for its own sake as they are to research by individuals working independently.

The effort here will be to reduce the general notions of these writers to theoretically precise and measurable dimensions. It is felt that these observations are directed to changes that are actually occurring in three separate, although related ways. First, there is a change from the justification of research by the value of knowledge for its own sake to its justification by the value of utility. Second, in place of the traditional conception of the scientist as an intellectual there is the tendency to assimilate him to the general type of the professional. Third, rather than the conception that research is properly conducted by individuals there is the model of the large scale formally organized research project. The actual occurrence and extent of the changes on these three dimensions will be tested by eight scales developed for this purpose. Before going into this test a few comments on the historical development of science will be useful for supplying a general perspective.

Some Social Factors in the History of Science: Without going into detail it may be said that the modern scientist arose as a dilettantish amateur and only became converted in time into a salaried and institutionally anchored professional. In the 15th and 16th centuries he was either self-supported or was supported by a patron whose fancy he somehow touched. For example, Galileo was first a university professor and later was supported and protected by the Duke of Tuscany; Copernicus was a curate and medical practitioner; Kepler was an astrologist; and Tycho Brahe was given an estate at Uraniborg by Frederick II of Denmark.

In the 17th century, when science underwent a particularly vigorous development in England and France, it was supported by the newly wealthy bourgeoisie, who were in a financial position to indulge their fancy for science. This was true, for example, of Boyle and Huygens.

The academic phase was entered in France in the 18th century, in Germany in the early part of the 19th, and in England and America in the latter part of the 19th century when science became established in the universities.

In the academy the pattern of attitudes, values and activity, described as "natural philosophy" took the stable form that has come to be characteristic of our conception of what science and the scientist are. One central factor behind this complex of ideas is the fact that science was the enterprise of individuals who undertook their scientific activities for their private purposes, whether it be called the satisfaction of curiosity, love of truth, or the attempt to understand the natural world. Related to science as an individual enterprise was the conception that personal freedom was an essential condition for its successful prosecution. Another conception which grew out of the individualistic character of scientific activity was that the source of creativity was the individual personality. This conception was crystalized in the application to science of the 19th century romantic conception of the "genius."

The other central factor in the developing conception of science was that science became heir to the traditional values of the academy. First in importance here is the definition of the new investigations, as "natural philosophy." Hence, science became part of the world of knowledge and of value as an end in itself, and the scientist was a scholar who engaged in the pursuit of knowledge for its own sake. Lastly, there was the conception of knowledge, whether it be called laws, principles, or, later, theory, as the end of intellectual effort, and the method of proof or demonstration as only a means to that end and strictly subordinate to it.

At the end of the 19th century, science became relevant to the larger affairs of life on a large scale, such as industrial, military, and medical technology. Therefore, it began to be pursued explicitly and directly for these purposes under the auspices of the respective institutions. In the 20th century substantial scientific enterprises have been incorporated into, and built or supported by the industrial, governmental, and medical institutions.

The Case of the Medical School, Applied Science in an Academic Institution: The thesis of this paper is that the writers cited above are correct in their perceptions of the changes in contemporary science and the scientific role. These changes are undoubtedly related to large team projects and to extensive technology, and they may well be partly due to the social ethic that accompanies large scale organization or to the tendency of intellectuals to serve and not criticize the institutions that employ them. However, all of these observations are seen here as aspects of the effect of the attachment of scientific research to the practical institutions of society.

Inasmuch as the university contains both basic research, directed to knowledge for its own sake, and applied science, directed to the solution of particular types of practical problems, in a situation in which both are pursued by autonomous scholars working independently, it offers an ideal opportunity to test for a difference in the conception of science and the scientific role in these respective conditions.

For example, in a medical school science remains the enterprise of autonomous scholars working independently with free choice in the research they will or will not do. At the same time its situation is different from that in the College of Science, Literature, and the Arts because it is in an institution explicitly founded for another purpose, the treatment of human ills and the teaching of the healing arts. In short, in a medical school academic conditions prevail for research save that it is applied to other specific human ends.

To test the hypothesis, data, are taken from a study of scientists in the Twin City area. The study includes seventy-one scientists from the University of Minnesota, twenty-six from the College of Science, Literature, and the Arts in the physical and biological sciences, and forty-five from the Medical School. Those in the Medical School are divided into two groups, twenty-five in the basic medical sciences; anatomy, bacteriology, microbiology, physiological chemistry, and physiology, and twenty from all twelve of the clinical departments. Comparisons can therefore be made between three groups; one of basic scientists in the Science, Literature, and Arts College, and two in the Medical School, one of basic and the other of clinical medical scientists.

These scientists were interviewed to obtain information on the origins of their interests in science, on their educational and occupational history and experience, on their attitudes toward science, and on their conception of the scientific role. As far as possible, the individuals were selected on a random basis. The very excellent cooperation, with a few minor exceptions, resulted in a random selection of the individuals within the two sections of the University. The attitudes of the scientists were compared on the basis of their scores on the eight scales listed as follows:

A. On the Conception of Science.
   1. Knowledge-Utility Scale. A measure of the degree to which science is legitimized by appeal to the value of knowledge or to that of utility.

TABLE 1. A Comparison of the Scale Scores of Three Groups of University Scientists

	On the Nature of Science			On the Conception of the Scientific Role			On the Organization of Research		
	Knowledge-Utility	Theory-Method	Personality-Situation	Intellectual-Professional	Priv.-Org'l. Motive, Ab't.	Priv.-Org'l. Motive, Per'l.	Individual-Team	Freedom Bureaucracy	Totals
1. S.L.A.	2.08	2.91	2.49	2.49	2.96	2.32	2.05	2.23	2.44
2. M.B.	2.16	3.43	3.10	2.52	2.40	2.51	2.98	2.53	2.61
3. M.C.	2.65	3.20	2.76	2.74	2.70	2.40	2.87	2.91	2.69
4. M.B.+M.C.	2.42	3.31	2.91	2.64	2.57	2.44	2.92	2.74	2.66
Diff. (4-1)	.34	.40	.42	.15	−.39	.14	.87	.51	.31*
Significance Level	.05τ	.05	.05	.25	−.05	.25	.01	.01	

Abbreviations: S.L.A.—College of Science, Literature, and Arts scientists.
M.B.—Medical School, basic scientists.
M.C.—Medical School, clinical scientists.

*1. Note: This is the average of the differences rather than the average difference.
N.B. The lower the score the closer the group is to the traditional values of science.
τ. By the 't' score test.

2. Theory-Method Scale. A measure of the degree to which essential importance in the research process is attributed to creative thought or to rigorous methodology and advanced technology.
3. Personality-Situation Scale. A measure of whether discovery is attributed to the creative personality or to appropriate research conditions.

B. On the Nature of the Scientific Role:

4. Intellectual-Professional Scale. A measure of whether the scientific role is seen to be essentially that of independent intellectual pursuit or that of a professional employed for his skills and knowledge.
5. Private-Organizational Motive, Abstract Scale. A measure of the degree to which scientific work is seen to be the result of purely private motives (curiosity, etc.) or to be the result of working for satisfactions that are organizationally mediated (salary, prestige, etc.)
6. The Private-Organizational Motive, Personal Scale. A measure of the degree to which the scientist evaluates his job as an opportunity to gain private satisfactions, (learning, freedom, curiosity, etc.), or as an opportunity to gain organizationally mediated satisfactions, (salary. promotion, prestige, etc.)

C. On the Appropriate Organization for Scientific Research:

7. Individual-Team Scale. A measure of the degree to which the most productive unit for the organization of research is considered to be the individual investigator or the organized research team.
8. Freedom-Bureaucracy Scale. A measure of the degree to which the most important quality of the administration of research is considered to be freedom for the individual or efficiency for the organization.

In each case the traditional value is mentioned first and the organizational value second. A low score indicates a position close to the traditional value.

SLA and the Medical School—A Comparison of Scientific Attitudes and Values: The Medical School scientists had higher scale scores, i.e. were further from the traditional attitudes and values of academic science, than the SLA scientists on seven of the eight scales. On five of these seven scales the difference was significant at the .05 confidence level. (See Table 1) On the eighth scale, the Private-Organizational Motive, Abstract, Scale the difference between the two groups was significant but the order was reversed. The medical scientists place more importance on the general operation of private (intellectual) satisfaction as motives for scientific work than the SLA scientists. It is not known whether the reversal of scores on this scale is due to the items or is touching on an actual difference in the attitudes between the two groups of scientists. Whatever the explanation for the negative evidence of the P-O, Abstract, Scale the stronger evidence of the other seven scales must be taken to support the hypothesis.

The Basic Medical Scientists—Holders of the Middle Ground: The scores of the basic medical scientists show that they did not uniformly hold positions, along with their fellows in clinical medicine, nor did they regularly fall in between them and the SLA scientists. On three key scales they hold the traditional values of science along with the physical and biological scientists. On all three scales the difference between the scores of the basic medical and the clinical medical

scientist is statistically significant at the .01 confidence level. They have low scores on the Knowledge-Utility Scale, meaning they tend to justify science by the value of knowledge rather than by that of utility. They also have low scores on the Intellectual-Professional Scale, meaning they tend to have an intellectual rather than a professional conception of the scientific role. And they have low scores on the Freedom-Bureaucracy Scale, meaning they tend to prefer freedom over efficiency in the organization of research projects. Noting also that the basic medical scientists put the most importance of any group on private intellectual motives for scientists in general, on the Private-Organizational Motive, Abstract, Scale, it appears that they have taken a firm position of the side of traditional scientific values on all the scales that touch most directly on value dimensions.

However, the basic medical scientists have taken positions along with the clinicians, or even beyond them, toward the practicality end of all four of the other scales. While the first three of the scales mentioned above deal with central academic values, the latter scales deal with issues that emerge from everyday decisions of working scientists. Preferring to work alone or with others (Individual-Team Scale) may arise from considerations of the size and complexity of the problems involved. The evaluation of the relative importance of methodology and technique as opposed to theoretical issues (Theory-Method Scale) in the research process may be understood as a matter of opinion based on one's own experience. The complex of private and organizational values measured by the Private-Organizational Motive, Personal, Scale was perhaps of too unclear value significance for a firm position to be taken.

Thus the basic medical scientists are found in a middle ground, possibly in a state of tension. On the one hand they are firmly anchored in academic values, and on the other they are responding to the situation of working within an applied institution, the Medical School, at least partly on applied medical problems.

The S.L.A. and the Medical School Scientists Compared on Specific Issues: Returning to the main theme of this paper, the general differences between the scientists in Science, Literature, and the Arts and those in the Medical School can be supplemented and illustrated with their respective positions on several important specific issues.

One of the most indicative items in the study was the question, "What is a Scientist?" The responses fell readily into five categories, 1. definition by motive, as being curious, love of truth, etc., 2. definitions by the type of activity, as doing research, solving problems, etc., 3. definitions by committment or dedication, 4. definitions by the use of the scientific method, stressing objectivity, systematic investigation, etc., and 5. definitions by training or qualification. With only one exception, the SLA scientists defined the scientist in terms of motive or by type of activity while one-third of those in the Medical School defined the scientist by "commitment," by the use of the scientific method, or by training and qualification. It is argued here that both the conception of the scientist as one who wants to discover

knowledge, and as one who investigates nature are essentially conceptions of the scientist as an intellectual. Definitions by method, commitment, and training, assimilate him to a more general model of the professional. If this argument be granted, the tendency of the Medical School scientists to define the scientist in generalized professional terms rather than strictly intellectual terms also supports the thesis of this paper.

One of the central dilemmas of every successful scientist is the decision to accept or reject a promotion to an administrative position. The acceptance of an administrative position was almost universally acknowledged as meaning the sacrifice, and perhaps the abandonment of research interests. Of those who do not already have administrative positions, over 80% of those both in SLA and the basic sciences in the Medical School would refuse an administrative position. Only a little over 40% of those in clinical medicine would do so. ($X^2 = 7.4$, significant at .01 with 1 d.f.)

Another central factor in the scientific career is the character of long range goals and aspirations. If a scientist is essentially an intellectual his chief goal might well be to solve a given theoretical problem, or to make an important discovery. From another point of view, it might be to gain or to preserve his freedom of opportunity to do research. Non-intellectual aspirations might be to make a practical discovery, to obtain an administrative position, perhaps a department chairmanship, or might even be non-professional altogether, as in the case of retirement. Table 2 shows that 90% of the physical and biological scientists and 84% of the basic medical scientists, but only 50% of the clinical medical scientists have intellectual aspirations. ($X^2 = 4.1$, significant at the .05 confidence level).

TABLE 2. The Chief Professional Aspirations of University Scientists

		Theoretical	Freedom of Research	Non-Intellectual	Total
S.L.A.	%	45	45	9	99
	No.	10	10	2	22
Med. Sch., Basic	%	52	32	16	100
	No.	13	8	4	25
Med. Sch., Clinical	%	25	25	50	100
	No.	5	5	10	20
Total	%	42	34	24	100
	No.	28	23	16	67

In sum, all three of the issues selected for illustration—the tendency to have an intellectual rather than professional conception of the scientific role, the tendency to reject the opportunity for an administrative position, and having specifically intellectual long range aspirations, are less characteristic of the scientists in the Medical School, (particularly of the clinical scientists), than of the physical and biological scientists in SLA.

Summary: A series of writers have seen the changes occurring in the contemporary conceptions of science and have focused on one or

another aspect of this same general process. Merle Tuve presents the change as the replacement of quiet investigation by individual scholars by large scale and highly instrumented research projects. C. Wright Mills sees the free intellectual as critic and creator being replaced by the hired professional as the servant of and apologist for the institution. William H. Whyte feels that as the scientist is drawn into the large scale organization the sterile conformity, already characteristic of the world of big business, will be characteristic of science. J. D. Bernal focused his attention explicitly on the implications of the support of science by the practical institutions of society. He argues that this can only result in the use of science for their own narrow ends, the loss of the concept of knowledge as a value in itself and the consequent loss of the capacity of science for a broad scale and autonomous development.

Historically, the individual scientist, both as amateur and as academic, has conducted his research for his own private satisfactions and has justified it by the value of knowledge for its own sake. However, when the scientist comes into the employ of the practical institutions, his work becomes subject to the requirements of the institution and is limited in some way by its purposes. In this situation the traditional scheme of science must be displaced for another and more compatible one.

This displacement was hypothesized to occur in three ways. 1. The justification of research by the value of knowledge would give way to that of utility. 2. The conception of the scientist as an intellectual would be assimilated to the general model of the professional. 3. The conception of research as being properly conducted by individual investigators would be replaced by the model of the organized research team. Eight scales were developed as measures of the changes on these three major dimensions.

Three groups of university scientists were isolated under the expectation that they would display differential portraits with respect to these changes. It was expected that the SLA scientists would represent the nearest counterpart to the old type amateur. The clinical medical scientists were expected to show the greatest displacement toward institutional conceptions. The basic medical scientists were expected to fall between the other two.

With the exception of one scale the predicted portraits were completely borne out when tested by the three types of scales. The positions taken by the three groups on the specific issues of the definition of the scientist, the acceptance or rejection of an administrative position and the content of their chief professional aspirations were also in congruence with the predicted portraits.

The thesis defended here is that the change to a utilitarian and technological conception of science and the assimilation of the role of the scientist, previously conceived as that of the free intellectual, to the generalized type of the professional employed for his specific abilities and knowledge are related to the attachment of science to practical institutions. When science remains anchored in the academy, unattached to professional training or to other practical ends, the

definition of science as part of the world of knowledge of value in itself and of the scientist as a free intellectual tends to remain in its traditional form.

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