

FACILITY FORM 802

N70-33934

(ACCESSION NUMBER)

(THRU)

(PAGES)

(CODE)

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

INTERDISCIPLINARY RESEARCH IN
THEORY AND PRACTICE:
A VIEW FROM THE UNIVERSITY
by
William E. Davis
6221-TD-1

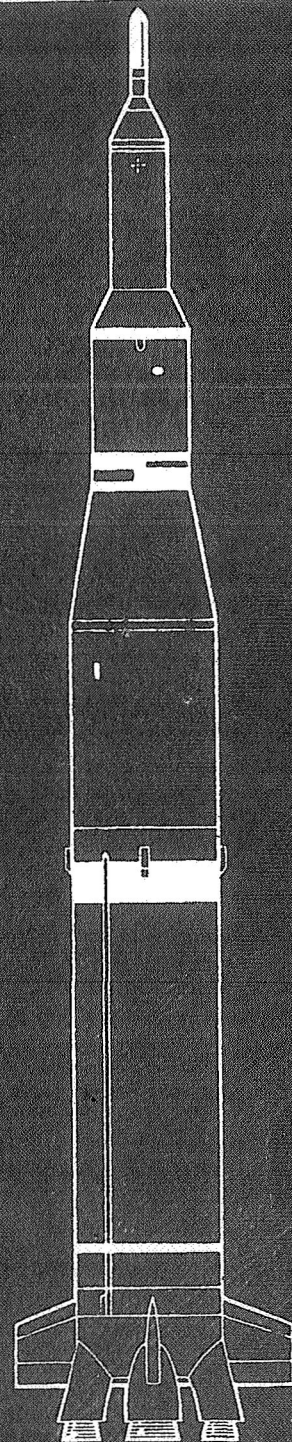
SYRACUSE/NASA PROGRAM



National Aeronautics and
Space Administration



Syracuse University



N70 - 33954

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Thesis

Syracuse/NASA Program

NASA Research Grant No. NGL 33-022-090

Syracuse University

April 1970

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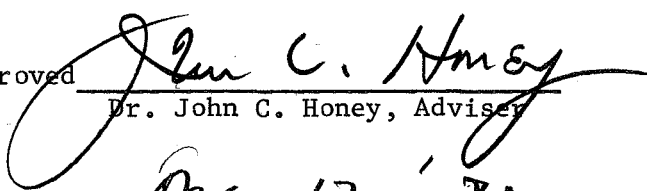
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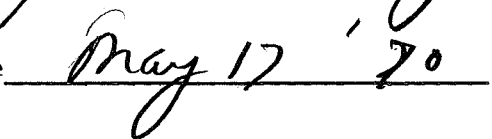
THESIS

Submitted in partial fulfillment of the requirements for
the degree of Master of Arts in Political Science in the
Graduate School of Syracuse University, June, 1970

Approved


Dr. John C. Honey, Adviser

Date


May 17 '70

To: R. S. D.
W. E. D.
A. L. B.

ACKNOWLEDGEMENTS

This study is one of the results of an enjoyable and rewarding two year association with the Syracuse/NASA Program at Syracuse University. Many people at the University, in the Office of University Affairs of the National Aeronautics and Space Administration, and at the universities I visited contributed to the study. To all of them I wish to express my gratitude.

My principal debt is to my chief counsellor and friend, Vice-President John C. Honey of Syracuse University. It was he who initially suggested the study, helped me think through the research design, and then patiently acted as my academic advisor during its execution. The cooperation of NASA's Office of University Affairs was, of course, crucial to the study. I am particularly appreciative of the assistance given me by Herbert Quinn--for his kind answers to my sometimes naive questions and his helpful information on the research element of the Sustaining University Program.

Most importantly, however, to the persons who kindly granted me interviews at the several universities I visited, I owe a primary debt. Their interest and cooperation gave substance to this paper. For candidly reporting their experiences with interdisciplinary research and thinking through with me some of the problems and prospects associated with such activity, I am most grateful. Finally, for their general support and assistance, my thanks go out to all of

the members of the Syracuse/NASA Program research team. Through the Syracuse/NASA Program, research for this thesis was supported, in part, by NASA Research Grant No. NGL 33-022-090 to Syracuse University for "Multidisciplinary Studies in Management and Development Programs in the Public Sector."

While many people contributed to this study, none save the author should be held accountable for the statements contained herein.

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INTRODUCTION

Goals of the Study

This study is an exploration into both the theory and the actuality of interdisciplinary research activity in contemporary American universities. As such, it sets out first, to understand what interdisciplinary research, in an ideal sense, really is, and how it differs from other kinds of inquiry. Secondly, it is an attempt to understand the theoretical utility and advantages of interdisciplinary research and the limitations on its usefulness. Furthermore, the study seeks to discover why institutions of higher education support or, alternatively, discourage interdisciplinary research activity, and what kinds of environments they provide for such activity. It is also an attempt to understand why individual research personnel either willingly (sometimes enthusiastically) engage in such research, or consciously and concertedly avoid it. The study explores the nature of the relationship between the ongoing scholarly enterprise and interdisciplinary research activity. And finally, it attempts to theorize about the conditions which are necessary for the successful accomplishment of interdisciplinary research in those instances where it is actually attempted.

Taken together, the foregoing goals constitute a formidable research undertaking. Thus, the author feels compelled, again, to caution the reader that the study before him is, in the truest sense of the word, an exploration. While the author might have wished otherwise, this study is in no way a comprehensive investigation

into interdisciplinary research activity in American universities. Nor is it a survey of the totality of interdisciplinary activity engaged in by the individual persons interviewed, or extant at the institutions visited by the author. This study makes no attempt to assess the full breadth and depth of interdisciplinary activity occurring at any particular place, during any particular time period, or by any particular person or group. On the contrary, its scope is necessarily much narrower.

Sustaining University Program Focus

In order to reduce to a manageable size the research problem suggested by the foregoing set of goals, the author focused his attention on a specific university support program of the National Aeronautics and Space Administration--the Sustaining University Program (SUP)--and the research activity which occurred at five universities supported by grants from this program.

NASA's Sustaining University Program, it was thought, provided a particularly useful focus for a study of interdisciplinary research because, first, it has several rather unique characteristics relating to multidisciplinary¹ activity, and secondly, it was considered by many within the government and the universities to be a very "successful" university support program. The basis of its importance and usefulness for the present study lay primarily in its following features:

¹It is intended that the words "multidisciplinary" and "interdisciplinary" be understood as synonymous throughout this and the following two chapters. In Chapter III, the author will introduce an important distinction between them and thereafter differentiate between the words.

1. Under the Sustaining University Program, NASA awarded research and research facility grants to universities with the expressed purpose of encouraging the development and extension of multidisciplinary research effort in the recipient universities.

2. Each of the universities supported had been evaluated by NASA's Office of Grants and Research Contracts (OGRC) and after March, 1967, the Office of University Affairs (OUA) as offering "... the opportunity for multidisciplinary studies within the institution...." (Four of the five universities subsequently visited by the author were, in addition, evaluated by NASA's Office of University Affairs as "having high potential for multidisciplinary research," and the fifth university was rated as a "strong critical performer.")

3. The recipient universities and research personnel made formal and explicit commitments to engage in multidisciplinary research. Those which received research support made the commitment through their research proposals, most of which indicated specific desires and intentions on the part of the universities and their researchers to engage in multidisciplinary work. In addition, the universities which received research facilities grants signed Memoranda of Understanding with the Agency, in which they again articulated their desire and intention to pursue multidisciplinary research.

4. Throughout the period of the research grants, NASA personnel (including Administrator James Webb, and those in the Office of Grants and Research Contracts and the Office of University Affairs) kept pressure on the universities to fulfill their commitments to move in multidisciplinary directions.

Thus, university research supported by this rather unique

program seemed to be a particularly appropriate place to begin the study of interdisciplinary research activity.

Theoretical and Empirical Efforts

As was already indicated, the author's intention was that this study would explore both the theoretical and the practical dimensions of interdisciplinary research in universities. For its theoretical base, the author drew on what limited amount of literature could be found on the subject. As with most aspects of higher education, however, there was very little "literature" found upon which to draw. (A Bibliography of some of the more useful material appears at the end of this study.)

Thus, the major effort was directed at gaining information and insight through the process of interviewing other (hopefully well-informed or experienced) persons. A series of open-ended, in-depth interviews were conducted with fifty-six research personnel, administrators and others at the five universities visited. Numerous extended discussions were held with personnel in NASA's Office of University Affairs. Finally, over the full length of the study, discussions were held with research and administrative personnel at the author's own university.

While a more extensive discussion of the methodology employed in pursuing the research behind this report is contained in Chapter II, the empirical portion of the study was aimed at answering the following specific questions:

1. To what extent did research personnel at the five supported universities actually engage in, increase or expand interdisciplinary research activity as a result of NASA's support?

2. To the extent that research personnel engaged at anytime in their experience in such activity, what are the most important factors which appeared to be associated with the successful accomplishment of interdisciplinary research?

3. To the extent that the university researchers did not engage in interdisciplinary activity (either that supported by NASA or other), what are the most significant forces and factors which appear to account for their unwillingness or inability to do so?

The study rests on several assumptions, the most important of which is that interdisciplinary research activity in American universities is either potentially or actually useful enough to constitute a subject which itself is worthy of extensive study. It is the view of this author that interdisciplinary research is not only particularly useful for certain purposes, and particularly productive under certain conditions, but that universities have a largely unrecognized (and unappreciated) self-interest in promoting such research activity.

The dearth of recent literature (either scholarly or popular) on the theory and practice of interdisciplinary or inter-departmental research in university settings would seem to suggest that there is little academic interest in the subject. However, as anyone who has spent some time at American universities recently knows, the idea of interdisciplinary activity is the subject of some --often heated--debate. While efforts to engage in more interdisciplinary activity have occurred periodically in American universities, recent interest has probably been primarily motivated by the national government's indications that it was prepared to support it through research grants and contracts. Thus, though few academics have taken the time and effort away from their central research concerns to study themselves at work, particularly how and why they behave as they do

when they collaborate, and consequently there has been little writing on the subject of interdisciplinary research activity, it is, nevertheless, a matter of continuing concern and interest.

Utility and Limitations

To the academic community generally, it is hoped that this study might find use in directing our attention to some of the consequences of our present patterns of organization and management in colleges and universities. It is hoped that it may suggest some of the significant contemporary forces at work in these institutions, and make us more self-conscious about the academic enterprise, the process of scholarly inquiry, and the research and service functions of the university.

The study is addressed to the scientists (be they "natural" or "social") and philosophers among us with the intention that it might suggest something of the utility and advantage of interdisciplinary research for the advancement of knowledge and the solution of societal problems. At the same time, it is hoped that the study will point out limitations on the utility of such activity as a means for achieving those ends. To anyone who might be considering engaging in interdisciplinary research, the following chapters will set forth some of the factors which this author considers most relevant to such a decision.

Finally, to those outside the university who would support the interdisciplinary work of universities and their research personnel, this study may suggest some of the problems inherent in such an activity, and something about an external agency's ability to advance interdisciplinary activity in a university setting. For the National Aero-

nautics and Space Administration, particularly, it is hoped that this study might enable them to better evaluate, in retrospect, at least one aspect of the Sustaining University Program.

Before going on to the substance of the study, a note of caution must be sounded. The reader will quickly discover that this study does not exude the self-assurance and confidence characteristic of many entirely empirical (and quantified) research reports. It is cautious, tentative and qualified--with good reason. As was noted the literature is small and not very useful, and as many myths and exaggerated stories as facts exist about interdisciplinary research. The research and administrative personnel interviewed by the author were but a sample of those supported by Sustaining University Program funds. The universities visited were only a sample of all supported universities. The study reflects a heavy dose of the theorizing and speculation of the author, and such was the intention. He has tried to avoid sweeping generalizations about all American universities, all researchers, or even those supported by NASA's Sustaining University Program. On the contrary, he attempts to capture, analyze and understand the ideas and experiences of his respondents, and then begin to suggest to his readers some tentative hypotheses about other populations, other places, other times. And rather than developing a theory or "model" of interdisciplinary research activity, he has attempted to suggest a series of variables which appear to him most closely linked to the success or failure of such an endeavor.

Since NASA's Sustaining University Program research grants constituted a central focus for this study, we will now turn to sketching, in outline, the general form of that program.

CHAPTER I

THE SUSTAINING UNIVERSITY PROGRAM

A Role in the Space Race

On May 25, 1961, President Kennedy announced the national goal of landing an American on the moon and returning him safely to earth. His timetable called for accomplishing this feat within the following decade. The decision immediately prompted top administrators in the National Aeronautics and Space Administration to begin seeking ways to further engage the resources of American universities and intensify their contribution to the space program. The view was held by many of them, including the Agency's new Administrator, James Webb, that NASA-university relationships would have to be improved and expanded if the national goal were to be achieved.

Working with Dr. Homer Newell, Deputy Director of NASA's Space Flight Programs, and Dr. Thomas L. K. Smull, the head of NASA's Office of Grants and Research Contracts, Webb and Dr. Hugh L. Dryden, Deputy Administrator of NASA, began formulating a model for a new set of relationships between the agency and the universities. Seeking assistance outside of his own agency, Webb spoke with University presidents, officials of government laboratories, outstanding scientists, representatives of other government agencies, and various groups of consultants. A series of meetings between NASA personnel and a group of consultants (primarily university people) in August 1961, resulted in a set of specific recommendations for NASA's role in

strengthening the universities' research and training capabilities.² Many of these recommendations were subsequently translated into what came to be known as the Sustaining University Program (SUP).

Agency Policies and Program Goals

Early in the process, a decision was made "...to work within the structure of the universities in a way that... would strengthen the university and at the same time make it possible for NASA to accomplish its mission."³

NASA's fundamental decision was two fold. First, it would choose to rely on the university community as its primary scientific resource and it would do so in a way which permitted these skills to remain on the campus. No effort would be made to bring all needed scientific talent into NASA field centers. The second aspect of NASA's fundamental policy for university relationships was . . . means were to be found to aid and strengthen universities through their participation in space-related activities. It was the intention of Webb, Dryden, and Seamans to build up university research, teaching, and the quality and quantity of both graduate and post-graduate education and to deal with each university as an institution rather than solely through individual faculty members.⁴

Articulating a position that, when written in 1965, had become fundamental to the idea of the NASA university program, Smull emphasized:

²See W. Henry Lambright, Launching NASA's Sustaining University Program, (Syracuse, New York: The Inter-University Case Program, Inc., November 1967), Chapters V and VI. (Mimeographed)

³U. S., National Aeronautics and Space Administration, "NASA-University Relationships" in NASA and the Universities, Principal Addresses at the General Sessions, NASA-University Conference on the Science and Technology of Space Exploration, November 1, 1962, by T. L. K. Smull, Publication No. EP-5 (Washington, D. C.: Government Printing Office, 1963), p. 52.

⁴U. S., National Aeronautics and Space Administration, "Organization and Management" in Preliminary History of NASA, 1963-1969, by Charles F. Bingman, Manuscript: Final Edition (Washington, D. C.: Government Printing Office, January 15, 1969) pp. VI-30, VI-31.

. . . we want to support research in the traditional atmosphere of instruction and learning from research that results from keeping the research activity surrounded by students. For example, we are not interested in the creation of institutes that tend to draw university faculties away from the educational aspects of their research. . . . NASA hopes to conduct its joint activities in a manner that will preserve and strengthen the universities' educational role.⁵

As the Sustaining University Program was finally established, it had these broadly articulated goals:

1. An increase in the production rate of highly trained people;
2. More adequate laboratory space in which to conduct research in support of the NASA mission;
3. Removal of the interdisciplinary barriers in research and fostering of genuine cooperation between workers in collateral fields;
4. An increased awareness by universities of their national responsibilities in the attainment of national goals;
5. Application by universities of their unique and extensive talents to an understanding of the interrelationship of space research and technology, academic processes, industry, commerce, and society in general.⁶

Responsibility for accomplishing these goals was vested in NASA's Office of Grants and Research Contracts (OGRC), the formal link between the agency and the non-profit scientific and educational institutions with whom it did business. To achieve these broad goals, three new programs were devised and assigned to OGRC:

1. Training grants for the three year support of doctoral students in science and engineering;

⁵Smull, "NASA-University Relationships," pp. 52-53

⁶U. S., National Aeronautics and Space Administration, The Nature and Scope of the NASA University Program, by T. L. K. Smull, Publication No. SP-73 (Washington, D. C.: Government Printing Office, 1965), pp. 21-22.

2. Facilities grants for the construction of urgently needed research facilities on university campuses engaged in a substantial amount of space research;

3. Research grants for the support of multidisciplinary non-project research at universities, particularly where the opportunity and potential for multidisciplinary activity existed.⁷

This aid differed in several significant respects from that previously given by NASA or other national government agencies. All support was provided in the form of "institutional grants"--that is, awards to the university rather than to a specific faculty member or student. The universities, themselves, selected the research programs (both topics and personnel) to be supported. Likewise, they selected traineeship recipients, and once selected, the recipient could not take the award with him to another university. Research support was to be "step-funded", or forward-funded, for a three-year period to create stable long-term support and to relieve the potential impact of a severe cut in funding in future years. Facilities grants were to be awarded in such a way that buildings were designed, constructed and owned by the grant-receiving university. Trainees were not expected to indicate an intention to work for NASA after their university studies were completed. As we shall see, one of the results of this unique package of university support was that, on the whole, NASA had surprisingly little guarantee of specific kinds of mission-related output for their investment.

⁷Ibid., pp. 22-23

The Emphasis on Interdisciplinarity

As NASA's new university program took shape, it became clear that James Webb intended to emphasize and encourage an interdisciplinary approach in the university work that was to be supported.⁸ "It has become increasingly clear," he stated in a letter to Bureau of the Budget Director David Bell, "because of the complex interrelationships between the various lines of investigation in space and space-related research, that the interdisciplinary approach is essential to achieving a correct understanding of space phenomena."⁹ Referring to the evolution of the Sustaining University Program, one commentator stated: "NASA felt it essential for scientific and technological progress that the universities move beyond existing subject-matter barriers and arrange new patterns of cooperation. For this reason, NASA's institutional grants would primarily take the form of research grants to universities for the support of interdisciplinary investigations."¹⁰

As described recently by one close observer:

The SUP . . . had, at its heart, the concept that the academic disciplines within the university could be brought together to work in a multidisciplinary team to attack research problems which were themselves multifaceted in character and would not yield to narrow, single discipline research. This approach was counter to the traditional concept of increasing scholarly specialization within a discipline, but it seemed more truly representative of "real world" situations at a time when universities were being increasingly challenged to come to grips with the society which surrounds them.¹¹

⁸See the discussion of letters from James Webb to Dr. Samuel Silver, University of California, Berkeley, and Arthur Weimer, Indiana University in Lambright, Launching, pp. 53, 104, 109.

⁹Ibid., p. 67.

¹⁰Ibid., p. 6.

¹¹Bingman, "Organization and Management," p. VI-33.

At a NASA-University Conference in 1962, Dr. Hugh L. Dryden, Deputy Administrator of NASA, spoke of NASA's attempts to encourage interdisciplinary research groups through the SUP research grants.

The broad grants are intended to encourage the establishment of creative multidisciplinary investigations, the development of new capabilities, and the consolidation of closely related activities. . . . multidisciplinary is here intended to include not only cooperative effort among branches of the physical sciences but also between the physical and biological sciences and with some participation from the social sciences, all as appropriate to the selected broad areas in which a given university possesses high competence.¹²

Referring to the promotion of technology transfer at another point, Dryden added:

In the past the transfer process proceeded in a laissez-faire manner at a relatively slow pace. We believe that it is incumbent on all of us to try to accelerate this process. We have suggested that universities participate in promoting wider use of the information obtained by associating members of the faculties in economics, business administration, and political science in the activities of the interdisciplinary groups.¹³

Dr. Robert Jastrow, Director of the Institute for Space Studies at NASA's Goddard Space Flight Center, argued at the same conference that,

In the physical sciences the problems of space science include a broad area cutting across the traditional boundaries of physics, astronomy, and the earth sciences. The deeper significance of the space program may lie in its unifying effect, in its tendency to bring together areas of astronomy, physics, and the earth sciences which were split apart several hundred years ago in the first

¹²Hugh L. Dryden, "The Role of the University in Meeting National Goals in Space Exploration" in NASA and the Universities, pp. 90-91.

¹³Ibid.

flourishing of modern science. The reunification of these fields marks a renaissance of natural philosophy--a return to the earlier tradition of science as a general inquiry into the nature of the external physical world. The developments, at least in this area, may mark a turning away from the increasing degree of specialization which has characterized science in the last decades. The success of the NASA science program now depends on its ability to arouse the interest of the general university community in these problems and on its ability to draw the rich concentration of university scientific talent into its activities.¹⁴

While not recommending the creation of new "space science" departments to replace the existing departments, Jastrow argued that

Interdepartmental committees, without admissions responsibility, are very useful, because they provide a focus for faculty interests in space physics and a source of advice for students in the choice of their courses and research projects. With some degree of accommodation on the part of the departments involved, such a committee should be able to develop a sequence of courses, for the student seeking the Ph.D. degree under its guidance, which stresses physics but also covers sufficient material in other fields to satisfy the course requirements for the Ph.D. degree in the department in which he is registered.¹⁵

This can be done . . . and, if it is done, it will produce a scientifically better educated person, not lacking in the essential disciplines, but having a broad point of view; therefore, he will be better able to understand the meaning of science in the deepest cultural sense and to appreciate that the physical sciences are the codification of a rich variety of human experiences regarding the external physical world--not opposed to the humanities but a part of them.¹⁶

¹⁴Robert Jastrow, "Developing Special Skills for Research in the Space Sciences" in NASA and the Universities, pp. 42-43.

¹⁵Ibid., p. 44.

¹⁶Ibid., p. 45.

Levers for Twisting University Arms

In connection with two of the three kinds of Sustaining University Program grants NASA had a lever (weak though it may have been) for the encouragement of interdisciplinary activity. It was with the SUP's "multidisciplinary" research grants that the first lever was provided. These research grants were designed to serve three primary purposes:

1. The support of broad multidisciplinary investigations;
2. The development of new and promising research capabilities through the support of research (usually in science or technology) to establish new groups where latent competence was apparent and where the research itself was of interest to the space program, but where not having had a grant in the past made it difficult to get external funding;
3. The support for tying together or coordinating separate but related research projects (usually "project-type" research grants) funded by one of the other NASA program offices or one of the Field Centers.

Thus, it was intended that awards would be made for the support of one or another of these kinds of research. While each grant may have been motivated by the desire to further any one or several of the purposes, NASA expected that, in every case, the universities' proposals should "all offer the opportunity for multi-disciplinary studies within the institution."¹⁷

In addition to the encouragement of multidisciplinary activity through its research grants, NASA's facilities grants pro-

¹⁷Smull, Nature and Scope, pp. 30-31. See also T. L. K. Smull, "The NASA University Program" (speech presented at the NASA Western University Conference, Jet Propulsion Laboratory, Pasadena, California, November 8-9, 1965), pp. 8-10. (Mimeographed)

vided another lever for similar efforts. In connection with these grants, NASA required the chief executive officer of each recipient university to sign a Memorandum of Understanding with NASA's Administrator. Each of these Memoranda stated, in part:

The National Aeronautics and Space Administration is particularly desirous that the environment in which space research is conducted will be characterized by a multidisciplinary effort which draws upon creative minds from various branches of the sciences, technology, commerce and the arts.¹⁸

During the 1963 and 1964 years, this statement was usually followed by a more explicit commitment from the recipient university:

The desires of /the university/ are in conformity with this policy, and the University intends to foster and conduct research in the space-related sciences, /and/ to bring to bear on this research the multidisciplinary efforts characteristic of a major university. . .¹⁹

In each of the Memoranda, a statement similar to that in the Arizona agreement was made:

It is further understood that /the university/ will, in the expansion of its research program, continue to make every reasonable effort to bring all its various applicable scientific and engineering disciplines to bear on the problems of space research.²⁰

In the Memoranda signed by the University of Wisconsin and twelve other universities, it was further stated:

¹⁸U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and The Regents of the University of California" (August 2, 1962), p. 1. (Typewritten).

¹⁹U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and Washington University" (February 28, 1964), p. 1.

²⁰U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and the University of Arizona" (June 10, 1964), p. 4.

The University recognizes its commitment to do all in its power, to continue and expand its space-related programs, and to encourage its faculties in cooperative participation in multidisciplinary space research ²¹

The justification for a facilities grant to the university concerned was typically couched in "multidisciplinary" terms.

It will make possible closer coordination of and cooperation between research groups working in related areas. It will permit the use of facilities held in common between them. . . . the University will continue to encourage the participation and cooperation of all its faculties. . . . to assure a truly multidisciplinary approach to the complex problems engendered by our nation's commitment to the exploration of space.²²

The facilities proposed herein will provide for much needed research and effective ways of bringing together the diverse disciplines necessary for a coordinated and comprehensive attack on problems of the national space effort.²³

The multidisciplinary nature of the space sciences requires consolidation of the University's existing efforts.²⁴

The physical limitations of presently available space at the University. . . are seriously hindering the expansion of many research activities, as well as the establishment of new interdisciplinary efforts.²⁵

²¹U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and the University of Wisconsin" (April 24, 1963), p. 4.

²²U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and Purdue University" (April 30, 1964), p. 3.

²³U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and Massachusetts Institute of Technology" (May 29, 1963), p. 2.

²⁴U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space Administration and the University of Maryland" (February 7, 1964), p. 2.

²⁵U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between National Aeronautics and Space

Likewise, in referring to the proximity of a proposed building to other campus science, engineering, professional and social science facilities, many of the Memoranda alluded to advantages for multidisciplinary activity:

The location of these facilities . . . will measurably extend the areas of interdisciplinary cooperation and thus contribute to the cross-fertilization of ideas, thereby enhancing the research potential of the entire program.²⁶

As the facilities grants program progressed, the agency became more explicit and forceful in articulating, within the Memorandum of Understanding, its views on the importance of multidisciplinary activity. Thus, in 1965 the agreement with the University of Minnesota said in part:

Research activities in space science . . . are at present housed with the departments in which the principal investigator holds his appointment. Although this makes it possible to maintain effective interaction between the research activity and the teaching responsibility of the university, it has forced a duplication of many facilities and it has not permitted a multidisciplinary approach to the solution of space problems. The interplay of personnel from the biological sciences, the physical sciences, the engineering sciences and the social sciences will make a major contribution to research and education in the Upper Midwest region.²⁷

administration and University of Denver" (August 20, 1965), p. 2.

²⁶U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between the National Aeronautics and Space Administration and The Trustees of the University of Pittsburgh" (May 6, 1963), p. 2.

²⁷U. S., National Aeronautics and Space Administration, "Memorandum of Understanding Between the National Aeronautics and Space Administration and University of Minnesota" (June 9, 1965), p. 2.

The Sustaining University Program Scope

By April 1962, the Sustaining University Program had officially been launched with the awarding of \$2 million in training grants to ten universities. The program initially supported 100 predoctoral students each for a period of three years. The following month, the Office of Grants and Research Contracts made research awards to 9 universities amounting to \$3.5 million. In September, facilities grants for the construction of buildings on the campuses of the first 5 universities were made.²⁸

Between 1959 and the end of the 1968 fiscal year, NASA's total obligations to universities were \$683.8 million. Of this, \$479.9 million was obligated for "project" research and \$203.9 million for Sustaining University Program research, training and facilities.²⁹ NASA's obligations to universities through the Sustaining University Program grants, as of the end of the 1967 calendar year, are shown in Table 1.

The training portion of the program has supported approximately 5,400 graduate students from 152 universities, approximately 1,700 of whom had received their doctorates by February 1969.³⁰ Before the facilities element of the program was terminated in 1969,

²⁸Lambright, Launching, pp. 81, 111.

²⁹Statement of Francis B. Smith, Assistant Administrator for University Affairs, National Aeronautics and Space Administration, before the Sub-Committee on Space Science and Applications, Committee on Science and Astronautics, House of Representatives, U. S. Congress, (n.d.), Chart Y68-1284. (Mimeographed)

³⁰Ibid., p. 4. See also, U. S., National Aeronautics and Space Administration, A Study of NASA University Programs, by Task Force to Assess NASA University Programs, Publication No. SP-185, (1968), p. 49.

37 awards were made for new facilities on 34 university campuses.³¹ And research programs at approximately 58 universities have been supported by the research portion of the Sustaining University Program since its inception.

TABLE 1

NASA-SUP OBLIGATIONS TO UNIVERSITIES
(July 1, 1958 through December 31, 1967)

Training Grants	\$ 101,905,135
Facilities Grants	42,633,992
Research Grants	<u>49,621,329</u>
Total SUP Grants	\$ 194,160,456

Source: U. S., National Aeronautics and Space Administration, A Study of NASA University Programs, by Task Force to Assess NASA University Programs, Publication No. SP-185 (1968), p. 12.

The Institutional Response: University Programs

While there were undoubtedly many variations in the responses of individual universities to NASA's SUP research support, this author's investigations revealed a fairly common pattern of development in university research programs, in terms of both procedure and substance. The following paragraphs provide a description, based on the author's interviews, of what might be described as a modal university response.

Bringing the availability of NASA SUP research funds to the attention of the university community, seeking out potential faculty

³¹Statement of Francis B. Smith, p. 4.

participants, and generating the interest (and the work) necessary to design a research proposal was typically the work of one man--a university "research entrepreneur"--sometimes a faculty member, but in many instances a College or School Dean, or a member of the university's central administration. This entrepreneur, assisted by the university's Office of Sponsored Research Programs, assembled the initial research group (at least on paper), and then wrote the formal proposal for submission to NASA.

After the proposal was accepted by the agency and support was granted to the university, the "research entrepreneur" was designated by the agency as Principal Investigator. Responsibility for bringing together the necessary university resources to create an active ongoing research program was given to him. Once the research was in progress, the Principal Investigator continued as the formal administrator, or Director, of the research program and attendant activities. Acting as the primary connecting link with the university's central administration, and often as the program's chief spokesman on the campus, the Principal Investigator took responsibility for facilitating intra-university business--which included negotiating everything from library resources to salary rates for the program research personnel.

Many of the problems which arose, concerning the allocation of research funds, the acquisition and use of facilities and equipment, and the assignment of support personnel, came to the Principal Investigator for a decision. Typically, he was assigned responsibility for preparing the research budget, and preparing and submitting records and reports required by the university and by the agency. The recruit-

ment of additional research or support personnel, or replacement of these personnel became his responsibility. As the chief link with NASA Headquarters and the Office of University Affairs (or earlier, OGRC), the Principal Investigator was the primary conduit of information, "feedback" and contacts between the research group and the agency. He was not, typically, actually engaged in the ongoing substantive research as a working member of the supported "team", but it was clear that in some instances, he acted as a "broker" between members of a research group--resolving conflicts and negotiating compromises--concerning both procedural and substantive matters.

At NASA's suggestion, a university-wide Space Sciences Advisory Committee was established on each campus at the time of the grant to act as the overall policy-making body with regard to the allocation of funds among faculty and projects, and the administration of all NASA SUP-supported activity on the campus. The membership of the committee consisted of "representatives" from appropriate Colleges, Schools and Departments--those whose personnel were receiving support from NASA SUP funds. (In some instances, the committee membership included personnel at the level of College Deans, but it appeared that the higher the rank of personnel on the committee, the more seldom the committee met and the less action it took.) However, with few exceptions, once the research program was in progress, the university-wide Advisory Committee was reduced to little more than a formality--accepting the recommendations and ratifying the decisions of the Principal Investigator when it rarely (if ever) met. For all practical purposes, and in most cases, the original functions of the committee

had, with time, accrued to the Principal Investigator, and the committee itself was dormant.

Typically, over the period of the grant, many projects were supported by SUP research funds, most of them in the physical science and engineering areas, with some support going, in the more recent past, to the natural and social sciences and to some of the professional schools. At any one time, it was likely that a number of different projects would be in progress, some of them essentially one or two person investigations (usually a faculty member and a graduate student), with a few others each involving three or four researchers. Project support took the form of salaries for graduate students and supporting personnel, supplies and equipment, facility rental and university overhead, travel expenses, and to a lesser extent the salaries of university faculty researchers.

(On university campuses where a SUP facilities grant-financed laboratory building had been constructed, a number of multidisciplinary research grant-supported personnel might be located together in the building. Preference was typically given, however, to providing space for more closely mission-related project-type research, such as was usually carried out on contract for one of NASA's field installations.)

Evaluations of University Performance

To what extent the efforts of the Sustaining University Program, in promoting multidisciplinary activity, actually had an effect on the universities it supported has been, and is still, a matter of debate both within NASA and within the universities. By the summer of 1968, the time at which the research for this study was

begun, disappointment in university performance was being expressed in many quarters of the agency. A conclusion seems to have been reached that universities whose faculty were supported under research grants from the Sustaining University Program had failed to keep their commitments, either because they were unable or unwilling, to engage in more multidisciplinary activity.

As early as August, 1966, in what came to be known as the "Hagerty Report," a Special Committee asked to evaluate the responses of five academic institutions to the Memorandum of Understanding reported:

Even among outstanding universities such as the ones visited, true multidisciplinary programs are extremely rare. Almost overwhelming difficulties are involved in encouraging one faculty member to move away from his central interest in one discipline in order to join with faculty members from other disciplines for the purpose of working in some aspect of a much broader problem. The Committee believes that until the social scientists join with physical scientists, there can be no true multidisciplinary research teamwork.³²

In March, 1968, several persons associated with the in-house Task Force to Assess NASA University Programs, including Task Force Chairman Homer G. Morgan, indicated their preliminary impressions, from conversations with university personnel at five universities, that nowhere was real interdisciplinary research occurring as a result of NASA support. Indeed, when their final report was published in October 1968, it said:

³²Special Committee, W. W. Hagerty (Chairman), A Summary Report on Site Visits to University of Wisconsin, University of Maryland, University of Michigan, Washington University, University of Minnesota, Drexel Institute of Technology, August 30, 1966, p. 4. (Mimeographed)

. . . the long-range goals that require innovation and change by universities--/including/ capability for multidisciplinary research, . . . --have not been successfully attained. The multidisciplinary aspect of Sustaining University Program research grants has generally not been taken seriously by universities. A small amount of multidisciplinary research that involves physical and life scientists and engineers is supported, but little of it was initiated under the grants. Research involving individuals from multiple disciplines, including social sciences, jointly attacking a multidisciplinary problem is nonexistent.³³

To date, there has been no total evaluation of the multidisciplinary activity engaged in by NASA-supported universities, and no evaluation of NASA's efforts to get universities to engage in such activity. There have been few close examinations of the results obtained at individual universities. Furthermore, there has been only very limited examination and assessment of the reasons--the crucial variables--which might account for varying patterns of success and failure in a university's willingness and ability to carry out the kind of multidisciplinary research activity desired by NASA.

While the present study did not attempt any of these first three efforts, subsequent chapters will seek to shed some light on those factors which might determine, at least in part, the success or failure of interdisciplinary research activity in university settings. Before turning to these chapters, however, a short discussion of the methodology employed in this study can no longer be delayed. It is presented together with a summary report of some of the findings obtained. Again, the reader should note that only a small sample of

³³Task Force to Assess NASA University Programs, A Study of NASA University Programs, pp. 4-5.

Sustaining University Program-supported university research personnel were interviewed. Thus, the conclusions presented here should be read as tentative hypotheses, and what we might properly call "informed speculation."

CHAPTER II

RESEARCH METHODOLOGY AND FINDINGS

Methodology

The empirical portion of this study was executed during the spring and summer of 1969. Early in the study, it was determined that information would be acquired from essentially three sources: the literature on interdisciplinary research, university organization and the sociology of science; first-hand reports of the experiences of NASA Office of University Affairs personnel in supporting interdisciplinary research; and first-hand reports of university personnel who had been involved in such research. Several visits were made to NASA Headquarters in Washington where personnel in the Office of University Affairs were interviewed at length, and an intensive review of the files on university research was made. A survey of the approximately fifty universities supported through the research component of the SUP was made for purposes of selecting a sample of universities for which extensive data on interdisciplinary experience would be sought. The evaluations of Office of University Affairs personnel were solicited concerning the extent to which interdisciplinary activity was taking place in supported universities. Persons at The Brookings Institution and the American Society for Public Administration were interviewed, as well as several NASA consultants.

It was expected, however, that the most valuable substantive information would be acquired from university personnel themselves,

by questioning them on their experiences with interdisciplinary research and their ideas about such activity. Preliminary work was done on the development of a set of questions to be used in the form of a mail questionnaire. This was abandoned however, in favor of the development of a set of questions to be employed in personal interviews. The interview schedule that was subsequently employed is included as Appendix "A" at the end of this paper.

Fifty-five questions were included in the schedule, covering the following areas: Identification and Background of Respondent; Origin and History of the NASA/University Relationship; Organization and Administration of the Grant Supported Research Program; Output: Measuring the Multidisciplinarity of Research Activity; Characteristics of the Environment Surrounding Research Activity; The Intra-Project Decision Making Process; Inputs: Identifying the Relevant Personal, Professional, Institutional and Situational Variables; and Personal Evaluation of the Process and Outputs of Multidisciplinary Research. While each question could not be put to every person interviewed--clearly, some questions would have been neither relevant nor answerable--an attempt was made to gather the information required by each question from one or another person, and as many persons as possible, on each campus visited.

Financial constraints dictated that four or five visits could be made to university campuses to interview research faculty and administrators. Of the approximately fifty universities supported by the research component of NASA's Sustaining University Program, those universities which had been supported for less than two years, had received less than \$1 million in Sustaining University Program Research

(SUP/R) grants, or had been visited by the 1968 Task Force to Assess University Programs were eliminated from the population. Only those universities which had been evaluated (in 1968 for purposes of 1969 funding) as either having "High Potential for Multidisciplinary Research" or being "Strong Critical Performers" were considered.³⁴ The five universities subsequently visited were then chosen to reflect as broad a range as possible of the following characteristics:

1. Size of student body;
2. Control or affiliation (public or private);
3. Emphasis on graduate/undergraduate education;
4. Academic specialties;
5. Location;
6. Size of research commitment;
7. Quality of graduate faculty and program;
8. Cumulative SUP/R grants (over \$1 million);
9. SUP facilities grant;
10. Date of initial SUP/R grant.

At the five universities visited, the author accomplished a total of fifty-six individual interviews with research faculty and administrators, and one group interview with the university's Space Science Advisory Committee. At each university, interviews were obtained with several faculty (who either were or had been) supported by SUP multidisciplinary research grant funds, the Principal Investigator, representatives of the Space Science Advisory Committee (where appropriate), appropriate College and School Deans, and one or more

³⁴This eliminated a number of universities which had been categorized as "NASA Field Center Related," "Seed Grant Oriented," or "Special Problems." The author was repeatedly told by NASA OUA personnel that the "real hope for accomplishing interdisciplinary research" hinged on the "High Potential" and "Strong Critical Performer" universities.

persons in the university's central administration office (usually a Vice-President) most concerned with university-wide research activity. At one university the Chancellor was also interviewed.

Interviewees were asked to draw on all of their research experiences (not only those related to NASA-supported activity) in responding to the author's open-ended questions. Many of the interviews were recorded on tape with the explicit agreement that interviewees would neither be identified by name or institution in any paper that might subsequently result from the research. The author made clear, in each case, that his purpose was not to report on specific institutions or personnel, but to identify attitudes, and gather information and ideas from the experience of the persons interviewed.

Criterion of Interdisciplinarity

In pursuing this study, the author assumed that NASA Administrator James Webb, desired and intended that NASA's Sustaining University Program would produce a quality of interaction between university research personnel as well as a quantity and quality of research product. While the Office of University Affairs referred alternatively to "multidisciplinary" and "interdisciplinary" research, this author understood the essential meaning of the terms, as applied by NASA personnel, to be a relatively continuous, coordinated and cooperative face-to-face interaction of university research personnel working on the same problem.³⁵ Thus, in attempting to assess the

³⁵The distinction between "multidisciplinary" and "interdisciplinary" research, and a discussion of the process of interdisciplinary research is contained in Chapter III. See infra., pp. 41-47.

extent to which research personnel at the visited universities had engaged in (or were engaging in) interdisciplinary research activity as a result of NASA's efforts, a quality of interaction was considered the chief criterion of interdisciplinarity. While evaluating the quality of interaction between members of a research effort is extremely difficult, the author considered it unavoidable. And while such quantifiable data as the co-authoring of publications, attendance at meetings and conferences, team teaching, and other items could be useful as indicators, it was felt that they represented only a quantity (rather than a quality) of interaction, and in fact, did not represent the quantity of interaction very effectively or accurately.

Interdisciplinarity of Supported Research

Interviews at the five campuses visited by the author indicated that at these universities, most of the research supported by NASA's Sustaining University Program research grants has been essentially disciplinary research activity. Some mutual consulting has occurred among university personnel whose work was supported by the grant, but it appears that this interaction has seldom become sustained or very intensive. While a large number of supported research personnel have carried out their research activity as members of formally organized "multidisciplinary groups," it is this author's considered opinion that such groups have been, in most cases, little more than administrative umbrellas, and not real loci of substantive intellectual interaction. Furthermore, at more than one university, it appeared that a "token integration" of the disciplines had occurred in the process of assembling the original (and subsequent) multidisciplinary research

groups. In such cases, there seems to have been a purposeful inclusion of "extra" (i.e., not essential to one of the central research problems) personnel from outside the primary disciplines to make the group "look" multidisciplinary.

On at least two of the campuses visited, there appeared to be rather extensive, and apparently continuing, amount of interdisciplinary research activity occurring throughout the university community. However, little, if any, of this interdisciplinary research was in any way related to, or connected with NASA support. Furthermore, it was apparent that efforts to encourage even more interdisciplinary research with NASA support, in situations where there was already a high level of ongoing interdisciplinary activity, met with little apparent success.

There were, of course, at least some instances on most of the campuses visited where it appeared that real interdisciplinary research activity had, indeed been supported by NASA's Sustaining University Program research grant. While it is difficult to determine whether NASA's support was really indispensable to the accomplishment of these efforts, it is reasonable to expect that some of the supported research projects would not have occurred had it not been for NASA SUP/R funds. It appears likely, however, that at least some of the supported interdisciplinary work would have occurred with or without NASA's support. For example, several projects were discussed in the course of interviews, about which faculty interest and planning for interdisciplinary activity had already occurred at the time NASA support appeared on the scene. While NASA funds allowed the projects to begin immediately, alternative sources of support were such that

participating faculty felt it likely that the research would ultimately have been carried out even if NASA's funds had not been forthcoming. In other cases, ongoing interdisciplinary research activity, which had been supported from other sources prior to the NASA multidisciplinary grant, was brought under the NASA umbrella. Clearly such interdisciplinary activity did not occur as a result of NASA's efforts.

When taken together, these findings--based primarily on the interviews conducted at the five university campuses visited--force the author to conclude that little interdisciplinary research activity occurred at those universities as a direct consequence of NASA's SUP research support.

The Use of SUP/R Funds

While differences did exist between universities, the use of NASA SUP/R grant funds tended to follow a general pattern. Support was in most cases relatively short-term. At one university, a maximum of three years of support for any one research project was the limit, and everyone supported under the grant was advised to look for other funds after the first year. With few exceptions, money was allocated in many small amounts to a relatively large number of research personnel. At several of the universities, it was used as seed-grant money--that is, primarily to fund small projects of younger faculty members who were not able to attract extensive research funds for themselves.

Funds tended to be expended for research that, for one reason or another, could not easily be financed through other, more typical, kinds of governmental or foundation grants. In many instances, NASA SUP/R support was used to finance rather speculative or feasibility-

study work. In other cases, it was used to "carry over" a researcher who was between grants or contracts. In still other instances, it was used to purchase rather exotic equipment (for example, aerial survey equipment for the university's airplane).

As was mentioned in the previous chapter, most of the funds went to the physical science and engineering divisions of recipient universities to support several one or two person investigations. Depending on the particular situation of the science and engineering segments of the recipient university--their strengths and weaknesses--at the time of the grant, it was used with the intention either of building a basic competence where little strength had previously existed, or alternatively to fill in some of the gaps in the research activities of an otherwise strong department or division. In more than one case, the building of a basic competence in a particular discipline was considered necessary before interdisciplinary activity involving that discipline could even be considered. Yet where excellence had already been attained in the department or division, "filling in gaps" often had nothing to do with encouraging interdisciplinary interaction.

Research Program Administration

Sustaining University Program research activity occurred within one of two organizational contexts at the universities visited by the author. At two of the campuses, research took place within what were essentially "independent research facilities." That is, research was carried out through multidisciplinary organizational units whose primary mission was to support research activity rather than instruction,

whose facilities and staff were not considered an integral part of one of the academic departments, whose administrator (or Director) did not report to a department head but to a division head or a university Vice-President, and whose funding did not come through any of the academic departments but was independently budgeted.³⁶ Thus, the "research center" or "laboratory" provided facilities, equipment, staff assistance and a mechanism of financial support for faculty research projects.

At one of these universities, all professional faculty had appointments with one or another of the university's academic departments; at the other university, there were professional research personnel whose appointment was to the "laboratory" rather than one of the departments. In the latter case, the "laboratory" had become more than a service agency for research support, but had attained the position of a strong, broadly staffed, independent research organization whose identity was in no way tied to the university's academic programs or departments, and many of whose personnel identified themselves first with the "laboratory" rather than with the university.

The second organizational context through which SUP-supported research activity occurred was that of the traditional academic department. At three of the universities visited by the author, emphasis was placed on carrying out all university research within the organizational framework provided by the university's departmental structure. Typically, in these cases, "independent research facilities" were a rare occurrence on the campus. NASA funds were budgeted through the

³⁶For a further discussion of "independent research facilities," see Chapter IV, Infra., pp. 83-86.

academic departments and research administration was typically accomplished by department heads, who reported, in turn, to Deans and university Vice-Presidents.

In the final analysis, it appeared to have made little difference in the quality of interaction among members of the supported research "group" (that is, in the interdisciplinarity of their research) whether research funds were allocated and the program administered by a university Vice-President, a college Dean, a faculty member or a committee. Regardless of the level at which the research program was administered, little interdisciplinary activity resulted. Likewise, because so little NASA-related interdisciplinary research activity had apparently taken place, it was difficult to determine whether any more interdisciplinary activity had occurred when research was carried out through the "independent research facilities" than when it had been confined to the departmental framework.

Disposition of the Academic Community

At only one university visited did there appear to be a visible institutional interest in, and a commitment to, the idea and utility of interdisciplinarity. On this campus, the "idea of interdisciplinarity" seemed to pervade the professional (including engineering) schools particularly. At the other universities, however, the only office with a campus-wide perspective on research activity --typically that of a university Vice-President for Research--appeared to do little to effectively "encourage," or help facilitate, interdisciplinary research activity. In some instances, this appeared to be the result of a simple lack of interest in, and understanding of,

the kind of interaction required for real interdisciplinary collaboration. In other cases, the office appeared unable to encourage such activity (although it was convinced of its utility) because of other duties, a lack of personnel, a restricted "mission," or a general lack of contact with, and influence among, the essentially "hostile" faculties of the university.

At the one university where the Space Science Advisory Committee was more than a formality, it too failed to effectively generate intensive, sustained and cooperative collaboration among the faculty. While the committee appeared, indeed, to be a vigorous and concerned force on the campus, and did make decisions on the allocation of NASA SUP/R funds, it seemed unable to translate the idea of interdisciplinarity into functioning interdisciplinary projects. Again, as with the university administrations, the committee members were apparently unable to motivate their essentially discipline-oriented faculty colleagues toward such collaborative work.

Where effective decision-making on the use of SUP/R funds had moved from the Advisory Committee to the Principal Investigator, the author found no more interdisciplinary work than where effective power was still held by the committee. Thus, Principal Investigators (including several College-level Deans) were themselves generally unable or unwilling to really advance interdisciplinary activity on their own campuses. Indeed, in more than one case, Principal Investigators appeared to have distributed support funds among faculty whose projects they considered "needy," regardless of the potential of that project for interdisciplinary interaction. At one university, funds were apparently allocated to Department Heads by a College Dean-Principal

Investigator according to a politically acceptable mathematical formula. Department Heads then allocated their portion of the funds to those faculty who were in need of research support.

Hurdles to Interdisciplinarity

It is this author's conclusion that four sets of problems are immediately involved in any attempt to generate or execute interdisciplinary research activity in contemporary American universities. The first problem is one of purpose. Probably few academics have really thought through the theoretical foundations underlying interdisciplinary activity, the links between a cross-disciplinary collaborative enterprise and the primary functions of the university, and the potential such a method might have for the advancement of their own research interests. Since the force of recent academic history and tradition directs the university man's activity down closely defined (and ever narrowing) disciplinary paths, he is likely to perceive little purpose or advantage in doing collaborative research across disciplinary boundaries. Moreover, among many university faculty, there is a distinct impression that such work runs counter to their own personal goals and those of their institutions.

The second set of problems concerns institutional environment. The modern American university does not usually provide a setting which is very conducive to the conduct of interdisciplinary research activity. It is typically not well organized for such work; it does not reward interdisciplinary research activity as it does disciplinary research (in fact, it tends to penalize the former); its internal leadership is weak; and it is essentially a very tradition-bound conservative insti-

tution. Interdisciplinary interaction, almost by definition, requires relationships and internal decision-making patterns which run perpendicular to those presently existing within the university. And attempts to structure new relationships and new decision-making patterns often cause the kind of intra-institutional strains which in turn are steadfastly resisted.

The attitudes of university personnel, concerning the nature of the research process--particularly as it applies to their own substantive interests and as it relates to their own roles in that process--the state of the theory among disciplines, and the relative competence of their academic colleagues, provide a third source of problems. Most university faculty (and students) seem to find interdisciplinary research activity slow, difficult, distracting, fraught with high personal and professional risks, and relatively unrewarding. Scholars tend to be suspicious, and often disdainful, of the work of other academics and work in other fields. And they tend to perceive their own roles, and those of their institutions, in various ways --some of which will necessarily preclude the possibility of interdisciplinary interaction with their colleagues. The consequences of these, and other attitudes, is that it is initially difficult to interest researchers in interdisciplinary activity, and once engaged in that work, it is difficult to maintain a cooperative and productive association.

The fourth set of problems confronting any attempt to generate or to execute interdisciplinary research activity is that of the organization and management of the research effort at the working project level. Thus, questions of problem definition, research

design, recruitment of participants, the programming of tasks, management of resources, and decision-making on both substantive and procedural matters, must be answered in relation to the particular existing situation. In the final analysis, this may be the point at which the "interdisciplinarity" of the research effort will either succeed or fail.

The following chapters are, in one way or another, addressed to these four sets of problems. Chapter III further examines the matter of theory and purpose in interdisciplinary research. The university as an institutional environment for the conduct of such activity is addressed in Chapter IV, Chapter V concerns those attitudes, perceptions and predispositions of university personnel which are related to collaboration across disciplinary boundaries. Finally, the Conclusion suggests some implications of the author's findings and sets out a series of prescriptions (some of them concerning project-level organization and management) which might be useful when we engage in the pursuit of interdisciplinary research.

CHAPTER III

THE THEORETICAL FOUNDATION OF
INTERDISCIPLINARY RESEARCH

This chapter will explore the theoretical foundations underlying interdisciplinary research activity and the rationale for its pursuit in the modern American university. Necessarily, several terms will first be defined. Then, the author will attempt to set forth the idea and ideals of interdisciplinary research, explaining how it differs from other kinds of research. The links between interdisciplinary activity and the several primary functions of the university will be traced, and finally, pressures to engage in such research activity will be dissected.

Thus far in this study, the terms "multidisciplinary" and "interdisciplinary" have been used interchangeably. However, a more careful examination of these words, as well as others which we will use repeatedly, can be postponed no longer. Let us begin, then, with some definitions.

Interdisciplinary v. Multidisciplinary Research

The temptation to define research as "any activity--other than teaching--in which an insecure scholar is engaged" will be resisted. In its most general meaning, the word "research" refers to the process of scholarly inquiry. It is a process by which one attains knowledge about a phenomenon. That process is usually assumed to consist of an intensive, systematic study of some phenomenon, under-

taken for the purpose of describing it, understanding it and sometimes controlling it. The reader will note that such a definition says nothing about the nature or characteristics of the knowledge (findings) produced, the utility of that knowledge, the procedures used in generating the knowledge, or the motivations of the person pursuing it.

Any of several kinds of processes, "research" can include the reading of a novel as well as the conduct of a laboratory experiment. Findings so produced may be general or very specific, and they may vary widely in their subsequent utility. The methodology employed may be empirical or theoretical, and any kind or form of phenomenon may be the subject of study. Finally, a researcher may engage in this activity because he is simply curious, or because he is employed to do so.

A more difficult word to define (but one whose definition is most essential for our purposes) is the word discipline. In academic circles, the term is commonly used to refer to a multitude of elements which when taken together constitute both a particular body of knowledge and an identifiable process of inquiry.³⁷ The components of a discipline may, depending on who is using the term and for what purposes, include any combination of the following items:

1. an identifiable body of extant knowledge;

³⁷Reporting on the definitions adopted by participants of the National Institute of Mental Health - National Training Laboratory conferences on interdisciplinary research in mental health, Margaret Luszki notes: "Discipline was defined as 'different bodies of knowledge and different backgrounds of training.'" See Margaret B. Luszki Interdisciplinary Team Research: Methods and Problems (Washington, D. C.: National Training Laboratories, National Education Association, 1958), p. 9.

2. a set of communicative and analytical instruments (including an identifiable language, techniques and methodologies);
3. one or more distinctive patterns of interaction which are typically employed in research activity (that is, a typical research process);
4. an identifiable written history of successes and failures in research activity, and an agenda for subsequent inquiry (including both a set of questions and an identifiable direction);
5. a set of theories and/or propositions about the nature of reality;
6. an identifiable media through which to communicate;
7. the subject of the professional identification of a group of scholars;
8. an identifiable focus, perspective or approach to the study of any phenomenon;
9. a limited identifiable category, or area, of phenomenon considered "legitimate" as the subject of scholarly inquiry.

Thus, in short, we can define a "discipline" as a group of men, a body of knowledge, a pattern of inquiry, and a series of speculations about the nature of man and/or his environment.

Disciplines are typically characterized by the existence of journals devoted to their designated concerns, and professional associations identified by their name. Academic departments in universities are organized according to them and identified by their names. In the final analysis of course, they are arbitrary administrative categories. Most importantly, however, they are categories which help us to focus our attention on something less (and more manageable) than the entire universe of man's knowledge and technique. Thus, they are particularly useful to those engaged in the process of

scholarly inquiry. By putting boundaries on knowledge and inquiry, they make its manipulation and handling more than manageable; they make it possible.

Making use of these definitions of "research" and "discipline," let us now return to the question of "multidisciplinary" and "interdisciplinary" research. The author would like to suggest that these terms be defined and employed as follows:

Multidisciplinary: containing two or more disciplines.

An adjective describing the composition of a research (or teaching) group. A multidisciplinary research group is one which has representatives, or members, from two or more academic disciplines (e.g., a research team consisting of a physicist, a chemist, a biologist and an anthropologist).

Interdisciplinary: cooperative, coordinated and sustained interaction between disciplines or members of disciplines. An adverb describing the quality of interaction between members of a multidisciplinary research group. A term referring to one characteristic of a process. Interdisciplinary research activity is that in which there is continuous (or regular), close, cooperative interaction between the representatives of two or more disciplines wherein each person brings the particular perspectives and body of knowledge of his discipline to bear on the common phenomenon under study.

Thus, the test for the multidisciplinaryity of a research effort involves the question, "What are the disciplinary identifications of research group participants?" While we must keep in mind that there are several possible means of classifying individuals by discipline (e.g., training, degrees held, departmental appointment, past research field, teaching area, etc.), determining the multidisciplinaryity of a research group is a relatively simple task. However, testing the interdisciplinaryity of a research effort involves a much more difficult question: "What is the nature of the interaction

between research group participants from different disciplines?"

What is the nature of interdisciplinary interaction? The author would suggest that research, to be unquestionably designated as "interdisciplinary," must be characterized by the following conditions:

1. There must be a face-to-face interaction among the participants from various disciplines.

2. Interaction must be relatively continuous over the period of the study. It cannot be intermittent with extended periods of isolated research activity between periods of face-to-face activity. Occasional cross-consulting is not interdisciplinary research.

3. Interaction must be relatively cooperative. This does not imply that participants agree in their descriptions of, or conclusions about, the phenomenon under study, or even the best perspective from which to view it. It does imply that they agree upon a particular identifiable phenomenon as the subject for study, and that they will all work toward a common purpose or goal in their research (i.e., a description, a theory, a solution to a problem, etc.).

4. The perspective and knowledge of each discipline must be articulated by its spokesman to the participants from other disciplines. That is, there must be an input of knowledge, ideas, information, theory, method, etc. from each of the disciplines.

5. All participants must consider the knowledge generated within disciplines other than their own. Thus, research personnel cannot ignore the contributions presented by participants from other disciplines. They must take those contributions into account in their own thinking and work. This does not mean that they may not judge those contributions irrelevant or invalid. It does imply that they give them critical consideration.

6. The research activity of all participants must be coordinated in some fashion so that a set of integrated results are obtainable at the conclusion of the research effort, so that efforts are not duplicated, so that tasks are clearly assigned and responsibilities shared, so that the research effort progresses along

agreed-upon paths, and so that information generated is cumulative, combined and integrated.³⁸

Proceeding on the basis of our previous definitions and conditions, we can see that group research can be either "disciplinary" or "interdisciplinary," depending on the nature of the interaction among group members and the quality of their participation, one with another.

A multidisciplinary research team is doing essentially disciplinary research when individual team members are assigned research tasks and each person works independently; bringing to bear the perspective and expertise of his own discipline only; arriving at conclusions, descriptions, statements of probability, etc., relatively uninfluenced by the perspectives or knowledge of his fellow research team members. In such a situation, no integration of separate bodies of knowledge occurs. No cross-pollination of ideas is accomplished.

In contrast, a multidisciplinary research group is doing interdisciplinary research when team members work cooperatively, continuously and intensely together on the same tasks (even though ultimate responsibility for specific portions of the work may be divided among the team members and assigned to individuals) toward the same purpose or goal. In such a situation, each researcher brings to

³⁸The definition of an "interdisciplinary team" which was employed by the NIMH-NTL Conference participants contained some similar elements: "an interdisciplinary team is a group of persons who are trained in the use of different tools and concepts, among whom there is an organized division of labor around a common problem, with each member using his own tools, with continuous intercommunication and re-examination of postulates in terms of the limitations provided by the work of the other members, and often with group responsibility for the final product." See Luszki, Interdisciplinary Team Research, p. 10.

bear the knowledge, theory, instruments, perspective and expertise of his own discipline into open, explicit, articulated confrontation with those of the team members of other disciplines. Ideas, information and theories are freely, regularly and continuously exchanged, and subsequently internalized by all participants of the group. Through this process, the integration of separate bodies of knowledge occurs; and an integrated set of findings--theories, descriptions, statements of probability, etc.--is the product of the research group's efforts.

(A middle ground, somewhere between disciplinary and interdisciplinary research activity, is probably represented by the process of mutual consulting. Mutual consulting is practiced when one researcher contributes relatively small portions of the knowledge, theory, instruments or perspective of his discipline to a researcher of another discipline on a periodic, short-term basis with the understanding that the researcher whom he assists will, in the future, provide a quid pro quo. The process is almost always an informal transaction between only two researchers, and for obvious reasons is not considered at length in this paper.)

University Functions

An essay directed at the exploration of interdisciplinary research unavoidably moves us, sooner or later, to a discussion of the social functions of the contemporary American university. The importance of such a discussion lies first in the fact that interdisciplinary research activity depends for its theoretical foundation, on the acceptance of certain functions as "legitimate" for the university to perform. (At the same time, of course, it depends upon the proposition that interdisciplinary research activity will aid the

university in the performance of one or more of these functions.) Thus, establishing the legitimacy of those functions must precede any argument that seeks to provide a rationale for interdisciplinary activity in terms of institutional purpose.

A second reason for our discussion of the functions of universities is that the persistence, continuity and productivity of interdisciplinary research activity--in short, its success--depends, in part, on at least the partial sharing of ideal images (i.e., visions) of university function or purpose by the research participants, university administrations and agency sponsors. The general lack of agreement which persists on the goals or purposes of the academic enterprise makes cooperative research activity difficult. And, a conflict on institutional goals and purposes may, in addition to its other obvious deleterious effects, completely preclude cooperative activity.

One of the reasons that the conceptions of proper university functions held by members of the academic community are particularly important lies in a unique characteristic of universities. Participants in the life of the university are, to an extent much greater than that in other institutions which deal in "knowledge," crucially important in determining institutional goals and purposes. In government research agencies or industrial research laboratories, for example, institutional goals are not determined by the participating research scientists. In these cases, the purposes, functions and roles of the organization are determined by administrative elite groups and others outside the institution.

In universities, however, both administrators and students, but primarily faculty, are the principal goal setters. W. Allen

Wallis observes, "Traditionally, the university itself, not any outsider, sets its own goals, establishes its own standards, charts its own paths; and it does this most effectively by delegation to the professors--not even to the faculty as a group, but to the professors individually."³⁹ Thus in universities more than in other similar institutions, the opinions which research personnel, students and administrators hold about what their institutions should be, and what they should be doing, are crucial to what the institution does.

A list of primary functions with which this author feels most comfortable would include:

1. the communication or transmission of knowledge from the older generation to the younger one (i.e., teaching);
2. the organization, systematization, integration and storage of knowledge (i.e., knowledge custodianship);
3. the generation, or production, of new knowledge about man and his environment (i.e., research);
4. the application of knowledge to the solution of societal problems, that is, problems posed by a person or group outside the university (i.e., client problem solving).

Such a list is, of course, not complete. Some academics would argue that a primary function of the university is the socialization of the young into adult roles. Others would argue that the university should transmit social and cultural patterns and norms to the next generation. Still others argue that the transmission of knowledge from one sector of the society to another within the same

³⁹W. Allen Wallis, "Centripetal and Centrifugal Forces in University Organization," in The Contemporary University: USA, ed. by Robert S. Morison (Boston: Houghton Mifflin Co., 1966), p. 41.

generation (adult education) is a proper function of institutions of higher education. And there are, of course, many who would take exception to one or more of the purposes enumerated above. The fourth item, "client problem solving," is particularly criticized by many academics as an inappropriate university purpose. The author will expand on this point at greater length below.

Without a detailed explication of individual purposes, any list tends to obscure some very critical questions about the functions of a modern American university: What kinds of knowledge do we consider as appropriate subject matter for university concern? What means and methods of generating new knowledge are considered legitimate? At what point does the "solution of societal problems" cease to be a legitimate function of the university and a function more appropriate to other types of social institutions? To what degree should research and problem solving direction be determined or influenced by external (societal) need or the demands of those outside the university?

Clearly, the most important thing that we can know, at this point, about the social "functions" of contemporary American universities is that there is no agreement among university personnel, much less those outside the university, on what those functions are or what they should be. Almost every scholar of higher education has developed, at some point in his writing, a list of the most important social functions which universities perform or should perform. And to this author, at least, the only common denominator which can be extracted from this endless supply of enumerated functions is their (sometimes tenuous) focus on "knowledge." Indeed, a careful and honest examin-

ation of many late 20th century American universities would reveal the existence of numerous functions quite unrelated to "knowledge."⁴⁰

The consequence of this situation should be obvious. If we cannot agree upon what it is that we are doing, it seems likely that we can "cooperate" in doing it only with the most difficulty. As Clark Kerr has observed, "The university is so many things to so many different people that it must, of necessity, be partially at war with itself."⁴¹ Let us now examine more closely several of the "primary functions" enumerated above, considering more carefully their relationship to interdisciplinary research--particularly their importance as theoretical foundation for interdisciplinary research activity.

Knowledge Custodianship

As suggested above, one of the functions of the modern American university is something approaching an intellectual custodianship--the organization, systematization, integration and storage of knowledge. In the words of Paul Weiss, it is, "The preservation, critical interpretation, and synthesis of existing knowledge."⁴² More than any other social institution, the university is expected, both by the public and those within it, to be the guardian and interpreter of

⁴⁰Not the least important of these "unrelated" functions are the housing and feeding of the student population, providing entertainment for the surrounding community and particularly university alumni, protecting the virginity of its female students, and extricating its students, faculty and employees from punishment by the state for "illegal" activities.

⁴¹Clark Kerr, The Uses of the University, (New York: Harper and Row, 1963), p. 9.

⁴²Paul Weiss, "Science in the University," in The Contemporary University: USA, ed. by Robert S. Morison, (Boston: Houghton Mifflin Co., 1966), p. 172.

specialized and esoteric, academic-type knowledge. And yet, a significant tension is introduced with the acceptance of this function.

In carrying out the custodianship function, universities have been forced, by the sheer bulk of the knowledge to be managed and the complexity of the task of managing it, to organize this knowledge (that is, to categorize and systematize it) according to some principle. The organization pattern employed is that of disciplines and sub-disciplines. Essentially arbitrary administrative categories, they provide the organizational framework for the storage of knowledge just as they do for its transmission and for the organization of inquiry. As mentioned previously, they make the manipulation and handling of knowledge and inquiry possible.

Yet, while the disciplines assist us in handling and storing knowledge, they inhibit us in our attempts at integrating it. The disciplines tend to constitute insulated, self-sealing and sometimes petrified bodies of knowledge and inquiry. The author found it significant that in his interviews with university personnel, most of the really important advances in knowledge today were viewed by most of the respondents interviewed as occurring as the result of a halting, incremental and cumulative process of inquiry within their disciplines. Thus, the tendency toward constantly narrowing research activity is compounded by a tendency toward more and more isolation and division between areas of inquiry. And the integration of knowledge becomes more and more difficult.

Interdisciplinary activity, as David Riesman points out,

constitutes a countervailing force to this process.⁴³ It has the effect of promoting the integration of existent knowledge. And as we, in the university, attempt to move toward more general theory, we might consider that the integration of existent knowledge, which interdisciplinary research activity promotes, clearly advances us toward that goal. Such research allows us to puncture, at least occasionally, those self-sealing bodies of knowledge and inquiry, exposing them to the criticisms of equally acute, but differently trained minds.

Writing about the social sciences in particular, Muzafer and Carolyn Sherif argue,

The best means available for checking the validity of findings and generalizations, ... before application is attempted, is to measure them against the findings and generalizations established on the same or related problems by another . . . discipline. If a generalization reached at one level of analysis is valid, it is not contradicted by valid generalizations reached at another level of analysis.⁴⁴

Thus, interdisciplinary research provides us with a validity check on our conclusions, theories and descriptions, our statements of probability, and even our perspectives and approaches.

It serves an equally important purpose in facilitating the transmission of specific bits of knowledge and theory, and specific analytical instruments (tools, techniques and methodologies) from one discipline, where they may have first been discovered or employed, to

⁴³David Riesman, Constraint and Variety in American Education, (Garden City, New York: Doubleday and Co., Inc., 1958), pp. 83-109.

⁴⁴Muzafer Sherif and Carolyn W. Sherif, "Interdisciplinary Coordination as a Validity Check: Retrospect and Prospects," in Interdisciplinary Relationships in the Social Sciences, ed. by Muzafer Sherif and Carolyn W. Sherif, (Chicago: Aldine Publishing Company, 1969), pp. 7, 13.

another discipline which can make use of them but where they were theretofor unknown. In doing so, interdisciplinary activity serves the whole process of scholarly inquiry. Calling it "one of the major hang-ups of the scientific field today," a respondent at one of the universities visited by this author illustrated the consequences of disciplinary isolation thus:

In 1924, a man in physics came up with an idea, a concept, which we call the crystal field theory. It did not catch on in chemistry until the late 1950's--a thirty-five year lag. And when it did hit chemistry, it revolutionized one segment of the field. There was a thirty-five year lag because the physicist was so close in upon the discipline . . . there was no communication.

In his own work, this same respondent seemed to feel it particularly important that the new methodology (a technique for investigating the fundamental properties of matter) be shared with researchers outside of his own discipline.

Writing about the consequences of isolation among the social sciences, Muzafer and Carolyn Sherif point out that, "insulated from related disciplines and lacking firm bearings relative to them, intensive study within a discipline sooner or later starts to produce floundering expeditions into territories already explored by other disciplines. . . ." However, interchange with other disciplines provides insight into the selection of variables that might be useful to one's research as well as "a basis for hypotheses that are both testable and fruitful for the disciplines in question."⁴⁵

In connection with the organizational patterns employed in

⁴⁵Ibid., pp. 8, 19.

handing knowledge and inquiry, interdisciplinary activity provides us with a constant option to reorganize and recategorize knowledge where it seems most appropriate. Writing about the growth and fluidity of scientific concepts and techniques in the post-World War II era, Harvey Brooks illustrates this process thus:

The growth of science . . . has been characterized most by the spectacular growth of hybrid disciplines such as geophysics, geochemistry, biochemistry, chemical physics, computer science, systems analysis. Techniques such as radiocarbon dating, radioactive traces, paper and gas chromatography, microwave and nuclear resonance spectroscopy, and X-ray diffraction have spread rapidly into all fields of science. Interdisciplinary subjects such as oceanography, atmospheric sciences, and space science draw on all the more classical disciplines, and it is difficult to tell at what point they do or should become disciplines in their own right. Whole areas of research often move from one field to another. For example, atomic spectroscopy, which used to be a major branch of physics, has now moved almost entirely into astronomy. Similarly, molecular spectroscopy has largely moved from physics into a branch of space science. The theory of low-energy nuclear reactions has become an important branch of astrophysics.⁴⁶

In what Riesman calls the "continuous process of fission and reunion," interdisciplinary activity is a mechanism through which new groupings of thought and activity, which prove particularly productive, may gel to become new specialties, new fields, new sub-disciplines, new disciplines.⁴⁷

Thus, in moving us toward more "general" theory; in allowing

⁴⁶Harvey Brooks, "The Future Growth of Academic Research: Criteria and Needs," in Science Policy and the University, ed. by Harold Orlans (Washington, D. C.: The Brookings Institution, 1968), p. 57.

⁴⁷Riesman, Constraint, p. 98.

us to shuffle our facts, our theories and our tools; in facilitating the criticism of our scholarship; in opening the disciplinary structure to new entries and exits; and in assisting the transmission of theory and methodology among the disciplines, interdisciplinary research serves the university's knowledge custodianship function.

Research

In much the same way, another university function, that of research, can also be served by interdisciplinary activity. Earlier, we defined "research" as that process of scholarly inquiry aimed at the generation of new knowledge about man and his environment. And we will remember that the word "research" does not imply the use of any particular procedures in generating that knowledge. The university's purpose, here, is to take institutional responsibility for the discovery of that which was heretofore unknown, and the variety of method which those in the university employ to make such discoveries is theoretically unlimited.

As with many of its other activities, however, most university research is organized by discipline. There are good reasons for this. The disciplinary organization of scholarly inquiry helps us to focus our attention on a manageable portion of the world's phenomena, and employ a single perspective, use a manageable number of analytical techniques and a limited set of theories and propositions to study that phenomena. Referring to this organization, David Riesman writes that a discipline ". . . embraces a series of intellectual tracks down which we run, protected by our lines from having to

look in too many directions at once, and able to hand on the torch to another runner on the same task."⁴⁸

Clearly, some method of organizing scholarly inquiry is necessary because first, knowledge is collectively held, and second, inquiry is a social activity. In that the disciplinary organization of inquiry makes research a rational social process, it is probably as useful a principle for organizing activity as any other which we might employ. As Jencks and Riesman say elsewhere:

At any given moment there would be some advantage to regrouping the various subdisciplines into new combinations, simply because the new units would be less hallowed by tradition and more subject to criticism and ad hoc modifications. But over the long haul there is no reason to think new combinations would have any significant advantage over the old ones; all are somewhat arbitrary, and all tend to become houses of worship as well as of work.⁴⁹

Why then are we interested in interdisciplinary research? There are several reasons. In general, however, we are interested because interdisciplinary research sometimes gives us new knowledge that appeared unobtainable by strictly disciplinary research. Thus, we are interested in engaging in, or supporting, interdisciplinary research activity when we have reason to anticipate results different than (and perhaps more useful than, or superior to) those which we could expect to emerge from disciplinary research. This is a rather complicated way of saying that we do interdisciplinary research when we anticipate that it is the most useful way to get the results we want.

⁴⁸Ibid., p. 110.

⁴⁹Christopher Jencks and David Riesman, The Academic Revolution, (New York: Doubleday and Co., 1968), p. 525.

Interdisciplinary research activity may be suggested as a potentially useful mechanism because of the characteristics of the phenomena under study, the research personnel engaged in the study, or the nature of the findings which they seek. It can be a particularly useful type of research under any of the following conditions:

First, it can be useful when the phenomenon under study does not lend itself to illumination by the efforts of a single traditional discipline. An example of such a phenomenon is the moon. Another is the concept of "ideology." Phenomena such as these tend to be viewed as "complex" because in some cases, they are relatively new subjects for scholarly inquiry, and thus we have very little knowledge about them to begin with. In other cases, we have much useful knowledge about the phenomena under study, but that knowledge consists primarily of singular or unique bits that are as yet relatively unintegrated and unsynthesized. Such phenomena also tend to be subjects which, because of their physical or conceptual inaccessability, must be studied indirectly. Such is the case with both the moon and ideology.

Second, interdisciplinary research is suggested when research personnel in any one of the traditional academic disciplines lack a theoretical framework or technical competence necessary to accomplish the research problem undertaken. In one discipline, for example, few testable propositions or hypotheses concerning the phenomenon under study may exist. While at the same time, many testable propositions and hypotheses may be suggested by a researcher from another discipline. Similarly, the previous work of a scientist from yet another discipline may suggest an agenda for research on the phenomenon. A

particularly useful set of analytical instruments may be contributed by a researcher from still another discipline.

As Joseph Ben-David and Awraham Zloczower point out,

Today . . . research in every field has become a co-operative enterprise where the lone worker becomes an increasingly rare phenomenon; specialization is so complex that most of the disciplines which about a hundred years ago still seemed narrow specialization are nowadays considered too broad fields for any one person to comprehend.⁵⁰

Third, when the questions asked and the level of results sought in the study are such that less specific, more general, and more comprehensive statements, descriptions, theories, and models are desired, the utility of interdisciplinary research is obvious. More "synthesis-oriented" research tends to fall in this category. As we move toward the formulation of more "general theory"--that is, theory which explains the way some class of phenomena work--we are more likely to benefit from interdisciplinary endeavors. Indeed, the tremendous interest in the "systems approach" in both the physical and social sciences reflects the concern of researchers with making increasingly comprehensive attacks on the phenomena which they study. The problems which give rise to such research tend to emerge out of conflicts between disciplines--that is, between the theories of two disciplines, or between the theory of one discipline and the findings of another. And, while it is often difficult to distinguish between the categories, interdisciplinary activity tends to be more useful in applied research than in basic research.

⁵⁰Joseph Ben-David and Awraham Zloczower, "Universities and Academic Systems in Modern Societies," in Science and Society, ed. by Norman Kaplan, (Chicago: Rand McNally & Co., 1965), p. 83.

Client Problem Solving

The utility of interdisciplinary activity in applied research areas suggests the final university function which we will discuss.⁵¹ In recent years, a change has occurred in the functions performed by the university vis-a-vis the larger society. We are only beginning to recognize the significance and implications of this new emphasis in university function, and are doing so only because of the reaction against it mounted by contemporary university students.

What are these new directions? Forces both within and outside the university have joined to change that institution in three ways: to expand and change its traditional "service" role; to emphasize its applied research role; and to broaden and expand the university professor's individual "consulting" role. The end product of the conjoining of these movements within the contemporary American university has been the emergence of a new (and as yet largely unrecognized) institutional function--that of client problem solving. As we characterized it earlier, this is the application of knowledge to the solution of societal (or individual) problems posed by a person or group outside the university. This newly evolved function is probably the most important of those discussed in this paper in providing a justification and rationale for interdisciplinary research activity.

The notion of service as an appropriate function of universities in the United States began with, and gained a tremendous

⁵¹The relevance of interdisciplinary activity for the advancement of the teaching function of universities, while clearly very important, is beyond the scope of this paper, and thus, will not be discussed.

initial momentum from, the land-grant movement which followed the passing of the Morrill Act of 1862. With government support, universities began emphasizing agriculture and mechanic arts (engineering) in their teaching, extended the use of their facilities to their local communities, developed adult education (university extension) programs, and engaged in research and direct advising to the nation's agricultural and industrial sectors. During the first two decades of the 20th century, the University of Wisconsin, a model for other universities, served its government to the extent of writing state legislation.⁵²

Building on this foundation of association with segments of the wider society, and in response to the requests of government during the World War II period, universities moved to engage in applied research activity--chiefly, in the early stages, that of weapons design.⁵³ The cold war of the 1950's and the space race of the 1960's further solidified and expanded the involvement of universities in government supported applied research. Beginning with the physical sciences, moving through some of the professional schools, and finally involving the social sciences, the university has gradually, but firmly, accepted the function of performing applied research for all who could pay. In discussing the obligations and responsibilities of the faculties of modern universities, Stephen Orgel and Alex Zwerdling comment:

⁵²See Kerr, The Uses of the University, pp. 15-16. See also, Frederic Heimberger, "The State Universities," in The Contemporary University: USA, ed. by Robert S. Morison, (Boston: Houghton Mifflin Company, 1966), p. 58.

⁵³Clarence H. Danhof, Government Contracting and Technological Change, (Washington, D. C.: The Brookings Institution, 1968), pp. 283-88.

A major problem in university administration, especially in state-supported institutions, is how to fulfill the university's civic responsibilities without giving in to the concept of the university as a research institute whose time may simply be bought by outside organizations with projects.⁵⁴

A third movement underway during the last 25 years in American universities has been the increasingly heavy personal commitment of individual faculty member's time to consulting activities outside the university.

. . . today individual professors themselves participate in a wide variety of activities outside the university. Much of a modern professor's time is spent with people in business, professional associations, foundations, publishing houses, and 'projects' of all kinds--not to mention public affairs and just plain politics.⁵⁵

Of concern here, particularly is the practice of "consulting" with industry and government. Acting as individuals (independent of their educational institutions), but with the approval and encouragement of their universities, faculty have spent an increasing portion of their time and effort in the service of business and government clients. As consultants, they have served essentially non-education-related institutions in a wide variety of capacities; from inventing bigger mousetraps (and humantraps) to helping sell deodorant, from testifying in legal proceedings to predicting the effect of certain anticipated government social policies.

University professors have been called upon to give technical advice and policy council, to inform their clients of essentially

⁵⁴Stephen Orgel and Alex Zwerdling, "On Judging Faculty," in The Contemporary University: USA, ed. by Robert S. Morison, (Boston: Houghton Mifflin Company, 1966), p. 220.

⁵⁵W. Allen Wallis, "Centripetal," p. 44.

extant knowledge as well as generate new knowledge, to develop pieces of equipment as well as discover new principles, all within the context of consulting to business and government clients. And in doing so, they have helped define a new social function for "higher education." As W. Allen Wallis puts it:

Today, universities, besides trying to preserve their traditional role, have become important wheelers and dealers in affairs large and small. They accept, indeed seek, assignments (if accompanied by funds) from businesses, governments, foundations, or individuals to carry out specified missions on stated schedules. At times, they even agree to keep the results secret, for the exclusive benefit of the client.⁵⁶

Thus, in expanding their traditional "service" role, in seeking and accepting (as institutions) applied research contracts from government, and in encouraging their individual faculty to provide services to both government and industry, the universities have developed a relatively new method for fulfilling their essential obligations to society. As they have always done, the universities still educate and train society's young for the tasks which they will have to perform and responsibilities which they will have to assume after they leave the university. Now, however, the university is attempting to serve society more immediately by addressing its social, economic, technological, political, environmental, and philosophic problems and attempting to solve them directly. As John Corson has pointed out, there are excellent reasons why society turns to the university to meet and respond to social problems. The university possesses unique qualities which qualify it to help actively shape

⁵⁶Ibid., p. 41.

society, and which make it ". . . inevitable that society will turn to the university with increasing frequency."⁵⁷ The university has become more than the generator, integrator, and disseminator of knowledge. It is increasingly a vehicle for social action. And it is in attempting to solve the "real-world" problems of its clients that American universities have increasingly turned toward interdisciplinary activity.

Referring to the kind of research which we are here calling "problem-solving," L. Kowarski argues, "It is . . . research for a practical purpose which tends to be done by teams . . . ~~[T]~~o achieve something which requires methods or techniques that are still only partly known: for instance to produce a very hard alloy or launch a missile that will go into orbit," research which "aims at achieving a well-defined practical result rather than revealing a new aspect of nature," requires interdisciplinary team work.⁵⁸

But, why interdisciplinary activity? By their very nature, and by their statement, most of the "real-world" problems presented to the university by its new clients require that the efforts of several of the traditional disciplines be directed to their solution. Consider, for example, any of the following "real-world" problems which the university has been asked to solve: developing artificial human organs; supporting life in outer space; depolluting our environment; reforming criminals; preventing tooth decay; designing a "safe" government infor-

⁵⁷John J. Corson, "Public Service and Higher Education: Compatibility or Conflict," in Whose Goals for American Higher Education?, ed. by Charles G. Dobbins and Calvin B. T. Lee, (Washington, D.C.: American Council on Education, 1968), pp. 83-87.

⁵⁸L. Kowarski, "Team Work and Individual Work in Research," in Science and Society, ed. by Norman Kaplan, (Chicago: Rand McNally & Co., 1965), pp. 247-48.

mation system; developing new building materials and construction techniques; preventing automobile accident deaths; educating deprived children.

Such problems are complex and tend to be defined and articulated in "general" terms. Typically, the research necessary to solve them requires not only the collection of information, its analysis and evaluation, but also the prescription of a "solution" (either a physical or social invention). That data collection, analysis, evaluation and prescription requires, in most cases, that research personnel attend to a vast array of relevant information, viewing it from several perspectives, and employing various analytical instruments on it. Seldom do we find a person trained in only one discipline competent to accomplish such a broad task. Thus, we turn to a team of experts, each of whom possesses a different body of relevant knowledge, a different perspective, and skills in the use of different analytical instruments. And it is through their interaction, each with the others, that we expect to solve our real-world problems.

Pressures for Interdisciplinarity

Both from within and outside the university, pressures to break out of the disciplinary framework and engage in research activity across the disciplines has long existed. But with the advent of direct, non-teaching, problem-solving public service as an important university function, these pressures have increased.

To many university researchers, aware of the limits of their competence, the need for more than occasional "consulting" among themselves has become obvious. As knowledge has expanded, so has special-

ization within and among the disciplines. The Renaissance man is no longer a possibility: inquiry is, more than ever before, a social activity; and comprehensive or "general" knowledge is only collectively held. Thus, specialization implies interdependence, interdependence demands cooperation, and the more university researchers have narrowed the scope of their inquiry, the more they have needed to cooperate in order to say anything important.

Related to the interdisciplinary impulse that results from the growth of knowledge and specialization, is the impulse that comes from the spread of powerful analytical tools. More than any other, the "systems approach" to problem solving has, itself, strained the boundaries between disciplines. Comprehensive and indepth analysis of complex phenomena typically requires that the expertise and perspectives of differently educated men be trained on that phenomena. And the use of a common analytical framework is a powerful device in enabling those differently trained men to combine their resources in a particularly cooperative and productive way.

The pressure for interdisciplinarity in research activity has been even greater from outside the university. Business and industry, foundation and government clients have increasingly argued that solving their problems requires interdisciplinary efforts. Whether the problems have been public ones like placing a man on the moon, cutting highway deaths, or slowing the population explosion, or essentially private ones like developing a permanent contact lens, reorganizing an industrial production line, inventing non-breakable glass, or expanding the circulation of a periodical, extra-university

clients have turned to interdisciplinary team research in the belief that this is the best way to get complete, dependable, and immediately implementable answers to their problems.

Government agencies which support university research, such as NASA, DOD, HEW and others, have deviated measurably in recent years from their historically typical practice of supporting the research of individual scholars (and the production of individual, specific and unrelated "bits" of knowledge such as normally results from discipline-restricted research). They, and to a lesser extent the university's business, industrial and foundation clients, have embraced the "interdisciplinary ethos". And the universities have, of course, not resisted the tide.

Because of these pressures and others, the university has in fact put a new emphasis on "problem studies". Like the "area studies" movement which occurred in American universities at an earlier time, each of these "problems" tends to be a subject of mutual interest for both the client and the university. Thus, we have research and teaching activity concentrated on such topics as "pollution", "environmental health," "space sciences," "population control," "urban studies," "communications technology," and "natural resource conservation."

Each of these problem areas is a subject of public concern and governmental interest. Each is a subject about which students want to concentrate their studies and faculty members want to pursue research. Each is an area where the larger society can benefit from the problem's solution. Each is an area in which external supporting agencies are willing to fund research, And most importantly, for our

purpose, each is a "natural" for interdisciplinary research.

Yet, in the final analysis, we find that American universities have engaged in a relatively limited amount of real interdisciplinary research activity. While such activity seems to have been increasing in recent years, it has not proceeded at the pace which we might otherwise have expected. When it would seem to be in their individual best interests, the best interests of science, the best interests of their universities, and the best interests of their society to do so, why have university faculty and administrators been slow in generating and engaging in interdisciplinary research activity? In the following three chapters, we will examine more closely some of the forces and factors which help account for their reluctance, their difficulties, and their failure.

CHAPTER IV

THE UNIVERSITY AS ENVIRONMENT FOR
INTERDISCIPLINARY RESEARCH

If faculty and administration attitudes at the universities visited by this author are characteristic of those at other American universities (and he would suggest that they probably are), we find a great ambivalence about interdisciplinary research activity on contemporary American campuses. On the one hand, we find faculty and administrators expounding its virtues, while on the other, resisting the efforts of their colleagues, and particularly interested parties outside the university, to encourage it.

Scholars speak convincingly about the utility of interdisciplinary research activity for the pursuit of knowledge and the solution of problems, but when requested to join such an endeavor, are extremely reluctant to do so. If they do become engaged in interdisciplinary research activity, they are likely to continue active research efforts within their own disciplines, giving the group only a portion of their research time, and leaving themselves a disciplinary "out" upon which they can fall back if the need should arise. Referring to the complexion of external research support coming to their universities, research administrators will argue that interdisciplinary research is the wave of the future--one that only some of them welcome--and then admit that, for practical reasons, they do little to encourage interdisciplinary growth, and when it does occur on their campuses, do

little to help their institutions accommodate to such activity.

We find many people in the university who question the benefits--scholarly or practical--to be derived from interdisciplinary research. Typically, they regard such activity as detrimental to the advancement of the disciplines, a diversion from "central questions," and counter-productive to scholarly pursuit. They argue that the most significant advances in man's knowledge have come through a continually narrowing focus on a specialized category of phenomena, and that disciplinary inquiry is simply the recognition and formalization of this process.

Even among proponents of the idea of interdisciplinary research activity, there is reluctance to involve themselves in it, reluctance to support it, and among many, an apparent lack of success when attempting to engage in it. Why is this so? In this and the following chapters, we will explore some of the factors which appear to this author to account for our present state of affairs. In this chapter, we will examine the university setting and evaluate it as a "research environment" for interdisciplinary research.

Organizational Fragmentation and

How We Got There⁵⁹

Let us begin by examining the patterns of organization and decision-making which characterize most of our institutions of higher

⁵⁹The following discussion of organizational patterns in modern American universities--in fact the general description of the social system of these universities--derives from too many sources to cite conveniently. In addition to the specific sources cited below, the author learned much from the analysis of Theodore Caplow and Reece J. McGee in The Academic Marketplace (Garden City, New York: Anchor

learning. Typically, American universities are (or are quickly becoming) large complex organizations, their complexity deriving in part from the multiplicity and diversity of social functions which they perform and goals which they pursue. The several social functions which these institutions seek to serve accrued to the university serially, over a long history. As they did, structural adaptations (largely informal) were made on an ad hoc basis to accommodate to these new functions, but the basic organizational form remained intact.

The basic organizational form which evolved from the university's original teaching function is characterized by a division of labor and specialization between and among the disciplines, with little differentiation in the kinds of activities required of personnel. Everyone executes essentially the same tasks. Activity is divided and assigned among university personnel in such a way that the department (each corresponding to a separate discipline) became the primary or basic organizational element. Thus, in virtually all contemporary American universities, we have the typical arrangement of schools, colleges, and departments--each unit being responsible for the education and training of either a portion of each student or a portion of the student body. The basic element, the department, has primary responsibility for the determination of curricula, the design of courses, the establishment of achievement standards, and the hiring,

Books, Doubleday & Co., 1958); Neal Gross in "Organizational Lag in American Universities," Harvard Educational Review, XXXIII (1963) pp. 58-73; John J. Corson in Governance of Colleges and Universities, (New York: McGraw Hill Book Co., 1960); and Herbert Stroup in Bureaucracy in Higher Education, (New York: The Free Press, 1966).

promotion and firing of its faculty. The work of the department tends to be relatively independent and autonomous.

Carrying out the most essential (and again, original) social function of the university--instruction--is the responsibility of individual faculty members, and the task is accomplished with a minimal integration or coordination of activity among them. Teaching is, for the most part, an individual, independent and unsupervised activity. Authority and responsibility for making and executing decisions are divided and assigned in a widely dispersed pattern. And within the scope assigned to each man or each departmental unit, authority and responsibility tend to be unrestricted and unqualified, unreviewed and self-controlling. When collective or community decisions are required, they tend to be achieved through a collegial decision-making process. Thus, to serve the university's teaching function, a relatively decentralized and fragmented pattern of organization emerged.

As new social functions accrued to the university, the same organizational pattern persisted, relatively unchanged. This was possible because, a division of labor and specialization did not occur on the basis of university's output functions. On the contrary, the teaching faculty became the research faculty, and the public service-performing faculty. Perhaps because the research and service activities of university scholars tended to be relatively independent, small scale and inexpensive, there was no reason to organize activity any differently than it had been organized for teaching. It was assumed that these new functions could be pursued with just as little cooperation, coordination, integration and control as was necessary for the university's other

functions. And thus, the same decentralized pattern of responsibility and authority assignment persisted.

Furthermore, as the university became larger, multi-functional and more complex, its internal guidance or "system maintenance" became more difficult to manage. Governing the university became more complex and required more effort. And it was here that we saw a differentiation in the kinds of activities engaged in by university personnel. A separate administrative structure emerged--its responsibilities being related to the internal guidance and governance of the institution. But with regard to the internal maintenance functions of the university, authority and responsibility patterns were not clearly divided, differentiated and assigned. Spheres of activity and decision-making were not clearly delineated and lines of jurisdiction were not clearly drawn except in the coarsest sense (e.g., as between trustees, administration, faculty and students). Even where authority-responsibility spheres were made clear, university personnel--individually and collectively--failed in many instances to exercise their rights and execute their obligations. Thus, informal patterns of action and decision-making emerged, and power no longer remained consonant with formal authority and responsibility.

For the most part, universities really didn't have "research policies" until recently; many still have no discernable policy regarding research activity. The decisions relevant to their research activity were largely made by the individual professors involved. While the university took on research as an institutional function, it was assumed that this required little, if anything, from

the institution itself--perhaps some record keeping, if even that. Research activity (both in its substance and in the managing of activity) was considered to be the personal concern of each professor doing it, and no one else. (As we see, in retrospect, some of our professorial entrepreneurs created small academic empires involving many projects, large amounts of money and numbers of faculty and graduate students.)

However, as "little science" became "big science," as university research began to involve many people and expensive equipment, require large amounts of specially designed space in campus buildings, and extensive funds for travel and fieldwork away from the campus, as "public service" took on the complexion of big-time consulting, extended leaves from the campus, and real-world problem solving, the adequacy of some of the traditional organizational arrangements came into question. It became clear that the independent, relatively uncoordinated, unintegrated and uncontrolled decision-making and action of individual professors concerning the increasingly important functions of research and public service had important effects on the institution as a whole.

Cohesion and Community

And yet, little has been done to rationalize the performance of the university's several functions. Organizational laissez-faire still pervades the campus. Decrying the lack of institutional cohesiveness in modern American universities, the Chancellor of the University of Pittsburgh wrote:

In my experience there are few universities whose members generally regard the organization as a total

institution. It is more accurate to say that the university is usually treated as a miscellaneous collection of faculties, research institutes, museums, hospitals, laboratories, and clinics. It has become a commonplace to observe that most of our large university organizations are held together by little more than a name, a lay board of trustees, an academically remote figure called a president, and--in his more despairing moments, one might facetiously add--a common concern for the power plant. On most of our large university campuses our individual faculties tend to live in isolated proximity.⁶⁰

A community "can hardly be said to exist," he continues, "unless there is a constant interaction among its elements."⁶¹

Denying that the modern American university--the multiversity--is in any sense a "community" any longer, Clark Kerr, the past-President of the largest and most complex of all American universities, has characterized the modern American university as " . . . a mechanism--a series of processes producing a series of results--a mechanism held together by administrative roles and powered by money."⁶² Recalling the words of other university presidents, he wrote:

Flexner thought of a university as an "organism." In an organism, the parts and the whole are inextricably bound together. Not so the multiversity--many parts can be added and subtracted with little effect on the whole or even little notice taken or any blood spilled.

Hutchins once described the modern university as a series of separate schools and departments held together by a central heating system. . . . I have sometimes thought of it as a series of individual faculty entrepreneurs held together by a common grievance over parking.⁶³

⁶⁰Edward H. Litchfield, "Organization in Large American Universities: the Faculties," Journal of Higher Education, XXX (October, 1959), p. 354.

⁶¹Ibid., p. 355.

⁶²Clark Kerr, The Uses of the University, p. 20.

⁶³Ibid.

Developing the theme that the modern multiversity president is primarily a mediator or broker of conflicting interests and values, Kerr portrayed the multiversity as almost out of control--goal-less because of its multiplicity of goals, almost leaderless because of the inability of any one person to "lead," and virtually lawless because of the "many separate sources of initiative and power."⁶⁴

Kerr quotes Robert Hutchins as having said that the faculty really "prefer anarchy to any form of government"--particularly the presidential form.⁶⁵ It may be that a social system without government is not inappropriate for the university. If there is any institution in our contemporary society that would seem to benefit most from an anarchic social system, and benefit least from a narrowly bureaucratic one, at least from the point of view of many scholars and students, it is probably the modern university. This is not, however, the place to pursue this argument.

But we see, in the modern American university, an overly fragmented, decentralized and rigid collection of relatively undifferentiated and independently operating subunits (i.e., professors, administrators, departments, advisory committees, research groups) many of which are pursuing multiple functions and emphasizing essentially different operating goals. These individual units exercise relatively uninhibited and unsupervised control over their own activities. Their work is only minimally coordinated and integrated. "Community" decisions, made by accretion or, when necessity demands, by faculty

⁶⁴Ibid., pp. 29-41.

⁶⁵Ibid., p. 31.

senates or university administration, are often unimplementable in the essentially hostile atmosphere. "Community power" is dispersed and elusive. There is little sense of institutional cohesion or "community," except in the face of attack from outside the campus. There is virtually no sense of university direction, and a very real lack of institutional leadership.

Consequences of Organizational

Fragmentation

Let us now consider some of the consequences of this organizational fragmentation and power dispersion for the pursuit of interdisciplinary research. While it should be quite clear that the total effect of existing organizational patterns is to inhibit the development of interdisciplinary efforts, this occurs in several ways.

First, the faculties of our universities tend to be so physically and socially isolated from each other (even in closely related fields) that the opportunity to discover mutual interests seldom arises.⁶⁶ While this is probably primarily the result of the identification of scholars with their disciplines rather than their institutions (and the general level of disinterest in what each other are doing exhibited by most faculty), it is surely reinforced by, and thus in part, a consequence of organizational fragmentation. The division of the university into rigidly separated and independent

⁶⁶At one university with which this author is familiar--one with extensive athletic facilities in various locations on the campus--this "splendid isolation" has developed to the point that, informally and probably without anyone realizing it, the tennis courts have been divided up according to colleges and schools.

departments (each corresponding to a "discipline"), the assignment of faculty and students--their work time and workspace--to departmental units, the low level of ongoing coordinated and integrated activity among those units, the failure to encourage joint teaching and research efforts, the relative lack of review, supervision or control of faculty activity by other faculty, and the facts that competition among faculty for promotion is seen to occur primarily within the department, and competition for professional recognition and prestige is seen to occur within the discipline, all of these characteristics tend to create a general environment of social isolation--one in which "mutual interests" remain undiscovered much less unpursued.

The effects of these organizational patterns has the greatest impact on young faculty, both because they tend to be more insecure with their new institutions, and because they are in the process of "making it" in their professions. On the campuses with which this author is most familiar, there is far less interaction across disciplinary boundaries among young, "upward bound" Assistant Professors than there is among the older, tenured and professionally secure "full" Professors. While there are other reasons for this as well (and they will be discussed below), the barriers created by organizational fragmentation are important explanatory factors.

The second major way that organizational arrangements inhibit interdisciplinary efforts arises out of the identification of people, space and equipment with a discipline, their "assignment" to an academic department, and the competition which ensues among departments and colleges for portions of the university's people, space and equipment resources. This identification, assignment and competition for

resources causes many faculty to encounter difficulty in moving away from strictly disciplinary (or departmental) activity, and it is the source of strong reluctance on the part of departmental, college and university administrators to see them do so.

Adjustments in the authority and responsibility patterns which derive from this identification, necessary for effective decision-making within and over an interdisciplinary research project, are particularly troublesome. Faculty are typically responsible (at least in an accounting and record keeping sense) to an academic department for their work time. For practical purposes, this means less that their activities are subject to the "supervision" of members of that department, than it means that their time is "assigned" to a particular discipline. Negotiating the release of a portion of the professors time for interdisciplinary (often perceived by both other faculty and administrators as "other-disciplinary") research is often difficult. Department chairmen, and others responsible for curricular and other decisions at the departmental level, tend to be apprehensive about the "loss" of one of "their" faculty to interdisciplinary (read "other-disciplinary") endeavors.

In the teaching area alone, an indicator of the jealousy with which departments hold their colleagues to disciplinary chores is the general scarcity of joint appointment systems, releases to teach courses in departments other than the one in which an appointment is held, multidisciplinary team teaching, interdisciplinary teaching and degree programs and the cross-disciplinary advising of graduate students. As Edward Litchfield has pointed out, the identification of a scholar as one thing--a physicist, mathematician or clinical psychologist--

permeates our thinking, not only about teaching, but also about our research activities.⁶⁷

While the academic departments tend to have some jurisdiction over, responsibility for, and decision-making authority over the instructional activities of their faculty and to a somewhat lesser extent over their research activities, jurisdiction, responsibility and authority always end at the disciplinary boundary. Interdisciplinary research activity tends to be very effective in removing the researchers from the jurisdiction and control of their own departments. And though faculty so engaged may identify, and be identified, with an academic discipline and department, when such identification is unaccompanied by formal responsibilities to that department and the lack of departmental control over the activities of those faculty, it is likely to give departmental chairmen and university administrators an uneasy feeling of powerlessness or administrative impotence. Thus, the release of a professors time away from teaching, difficult for any research purpose even when it is accompanied by its own funds, is particularly difficult when the research activity does not fall within traditional disciplinary categories.

While faculty work time is, in one sense, a budgeting problem (although it should be clear by this point that it is more importantly a problem of "identity") questions of assignment, allocation and distribution are more clearly visible when we consider the physical accouterments of university research activity. Not only is the work effort of professors and students typically assigned to a department and disci-

⁶⁷Litchfield, "Organization: the Faculties," p. 357.

pline, but their physical accommodations and equipment are likewise. In most universities, the use of buildings (including research space) and equipment (including that used for research purposes) tends to be allocated by the college or department to which it is nominally "assigned." This is particularly true of space and equipment used for research purposes. While all teaching facilities tend to be alike, research facilities are likely to be specially designed for specific purposes.

Except in extremely small schools, laboratories are seldom general purpose and open for general use. Rather, they are likely to be the special purpose, specially equipped facilities suggested by the titles: Nuclear Physics Laboratory, Language Laboratory, Hydraulic Engineering Laboratory, Microbiology Laboratory, or Poultry Science Laboratory. Such facilities tend to be the "property" of their corresponding academic departments, and their use subject to the approval of that department.

Understandably, research space and facilities of this kind tend to be allocated for research work that falls within the scope of the "home" discipline before they are made available to "outsiders" from across the campus. Department chairmen, college deans and individual professors are all likely to be extremely jealous of "their" facilities and equipment and quite reluctant to allow research personnel from other departments and disciplines to use them. The zealousness with which they protect their facilities sometimes results in the refusal to admit researchers from other departments even when such facilities are being underused by the members of departments to which the laboratories are assigned. It appears that the politics of

facilities assignment, like the politics of departmental budgeting, demands that "you had better make one-hundred percent use of what you receive, or you're likely to get less in the following year."

It must be said here that while the problem of having oneself identified with only one particular discipline is probably the same for young Assistant Professors as it is for their tenured colleagues of Professorial rank, the former are much less able to resist conforming to the expectations of their senior colleagues and the demands of their department chairmen. Thus, they are likely to be more inhibited in their ability to engage in interdisciplinary activity by their "assignment" to the discipline and department.

Additionally, there is the effect that this "identification" and "assignment" has on certain departments vis-a-vis others within the university. Jealousy and apprehension over the potential loss of any of their resources--be they faculty work time, space or equipment--is exacerbated in the case of departments weak in relation to others on the campus. This is particularly true of those departments that must continually fight for recognition (those considered "service" departments, for example--such as the humanities and social sciences in an engineering and applied science-oriented university), those that are small and need all of their "full-time" faculty effort just to cover the department's teaching responsibilities, and most importantly, those "on the make" either in the university or in the discipline.

Pursuing interdisciplinary research requires the cooperation of the academic departments, both in terms of faculty time, and space and equipment. When the environment is characterized by competition among those departments for resources which are, once assigned,

then owned by the departments--when the free and easy transfer of men, space and equipment is prevented or inhibited by essentially organizational obstructions--interdisciplinary research efforts are likely to be slow, difficult, and personally frustrating for the research personnel involved.

An Experiment in Organizational Adaptation

It would seem that a way to circumvent these organizational obstructions might be to acquire the necessary work time, space and equipment from sources other than those of the academic departments. And while this does not always solve the problem, in most cases it has been the direction in which those interested in interdisciplinary activity have moved.⁶⁸ A major attempt to avoid some of these organizational pitfalls (as well as problems related to prevailing conceptions of university purpose), was made by universities in the post-World War II establishment of research facilities (i.e., laboratories, bureaus, centers and institutes) as independent entities. Peter Rossi has pointed out that:

Research centers arose when research activities demanded collaboration among colleagues that went beyond the traditional organizational pattern of scholarship as presently exemplified in the humanities.⁶⁹

⁶⁸Sometimes, of course, this does not even work. One respondent whom this author interviewed reported that the "identification" of people, space and equipment with specific disciplines in a university with which he was familiar, was so strong that the funding of interdisciplinary activity through an independent research organization simply resulted in the transfer of squabbling from the departmental and college arena to the interdisciplinary group itself.

⁶⁹Peter H. Rossi, "Researchers, Scholars and Policy Makers: The Politics of Large Scale Research," in The Contemporary University: USA, ed. by Robert S. Morison, (Boston: Houghton Mifflin Company, 1966), p. 115.

The demands of truly interdisciplinary research activity, as we have described it in the previous chapter, not only stretch the traditional organizational arrangements of universities, they may well suggest the appropriateness of whole new organizational forms.⁷⁰

The independent research facilities which have appeared on campuses in recent years have developed different organizational patterns depending on the university to which they are attached. But many have certain characteristics in common. They tend to have faculty "directors" (between half-time and full-time) who are responsible to an administrative officer with university-wide jurisdiction (such as a Vice-President or Graduate Division Head). Typically, they are funded independently of the academic departments and schools by grants and/or contracts from the national government or foundations. They are likely to have their own staff of professors, student assistants and technicians (sometimes on loan or part time from the departments), their own facilities and equipment and be located somewhere along the perimeter of the campus. Research activity tends to be rather carefully programmed and closely supervised by the director or project heads.

These research units were, in many cases, designed to support research, the subject matter of which could not comfortably be accom-

⁷⁰Some indication of the shape of possible organizational forms can be gained by an examination of the literature on scientific research organizations in industry. See, for example, Norman Kaplan, "The Role of the Research Administrator," in Science and Society, ed. by Norman Kaplan (Chicago: Rand McNally, 1965) pp. 211-228; Donald C. Pelz and Frank M. Andrews, Scientists in Organizations: Productive Climates for Research and Development, (New York: John Wiley and Sons, 1966); and Herbert A. Shepard, "Nine Dilemmas in Industrial

modated within the scope of one or another academic department. Their work tends to be oriented toward broad subject areas rather than single disciplines. Thus, we have such organizations as the Institute for Human Development, the Latin American Studies Center, the Cancer Research Laboratory, the Ecology Studies Center, the Institute for Governmental Research, the Operations Research Center, the Space Sciences Laboratory, and the Institute for Urban and Regional Studies.

The research group or groups in many of these units are multidisciplinary, some of the units support interdisciplinary research activity, a large number of them are real-world problem oriented, a lesser number are oriented toward the work of a particular profession, and a few of them provide specific services to the populace or government of their state. They tend to involve faculty from primarily the social and applied sciences--seldom faculty in the pure sciences and humanities. Leading examples of the proliferation of these independent research units are provided by the University of Michigan and the Berkeley campus of the University of California.

Notwithstanding their own internal problems--some of them major--and the organizational strain they have caused in the rest of the university by their mere existence, these research units seem to have been beneficial in the work they have supported, and probably critical in the development of a first-class research capability at a number of universities. With regard to NASA-related research at the universities visited by the author, it will be remembered that he

Research," in The Sociology of Science, ed. by Bernard Barber and Walter Hirsch (New York: The Free Press, 1962), pp. 344-355.

reported the discovery of so little interdisciplinary activity that he was unable to determine whether the work pursued through independent research facilities was more interdisciplinary than that carried out through the multiple support of several of the academic departments. However, if we consider the full range of research activity on American university campuses, regardless of their source of financial support, and the independent research facility as a generic organizational type, a clearer and more conclusive statement can be made. Unquestionably, efforts at producing real interdisciplinary research activity through the use of independent research facilities have been appreciably more successful than have similar efforts attempting to work through academic departmental structures.

The Academic Reward Structure

We have seen some of the difficulties involved in pursuing a collaborative enterprise produced by the typical organizational patterns of the contemporary American university. Let us now consider another characteristic of the research environment which also bears heavily on the pursuit of interdisciplinary research in the university: the system of academic rewards and penalties.

While the discussion below will, for the most part, deal with academic "rewards" rather than "penalties", the withholding of rewards, can, in a very real sense, constitute the imposition of a penalty. The primary reason, however, for the emphasis on rewards rather than penalties in this paper is the simple fact that by their very nature, universities and professions tend to induce conformity to their expectations, contributions by their members and the implementation of organi-

zational decisions through the use of incentives rather than commands and rewards rather than penalties.

Academic rewards and penalties come in many different forms, both physical and psychological. Some of them are bestowed on a faculty member by his university; some by other institutions such as government, foundations, or industry; and still others by his disciplinary colleagues (his profession) or the scientific community as a whole. All of these rewards tend to flow, however, either through the university, or through the faculty member's professional association. As used here, "professional association," refers not only to the formally organized disciplinary associations to which a faculty member may belong, but more importantly, to the informal network of associations and contacts which exist among persons of his own discipline regardless of their institutional affiliation or location.⁷¹

Physical rewards are meant to include the payment of money (in the form of salary, travel funds, etc.), payments in kind (such as space and equipment, computer time, graduate student assistants, secretarial and technical assistants), and payments in time (meaning "release time" from teaching or other responsibilities to pursue other essential activities, sabattical and other leaves-of-absence). They are usually channelled through, and thus under the control of, the

⁷¹One of the most penetrating analyses of the influence and reward system which operates on academic scientists is to be found in Warren O. Hagstrom's The Scientific Community (New York: Basic Books, 1965). In his theory of social control, "colleague recognition" appears as the primary ingredient. See also, Robert K. Merton; "Priorities in Scientific Discovery: A Chapter in the Sociology of Science" in The Sociology of Science ed. by Bernard Barber and Walter Hirsch (New York: The Free Press, 1962), pp. 458-63.

faculty member's university, even in cases where the rewards originate outside the university--for example, research funds provided to the professor by a foundation, industry or government. Where such rewards are provided by institutions outside the university, the faculty member typically has to satisfy two masters, both his university and the agency providing the funds. Difficulty arises, of course, when the demands of each master are contradictory or when the contributions expected of the faculty member are unrelated or conflicting.

Psychological rewards include a sense of worth (meaning prestige, honor, and respect--as manifested in academic rank, professional recognition, gaining a place in history or having prizes, awards, titles and other distinctions bestowed upon one), a sense of security (including tenure at one's university, being in demand, and a good reputation in one's field of study), and an expanded set of professional employment options (such choices as the opportunity to consult with, advise or even join government, industry, business, foundations or professional associations; or move easily to another university). Psychological rewards tend to accrue to an academic by action of his professional colleagues--particularly those in his discipline--although academic rank, tenure and titles are bestowed by his own university.

It has been suggested by many observers of modern university life that in contradistinction to other professions, these psychological rewards are much more important to the academic man than are physical rewards.⁷² If this is true, it seems likely that it is not because the

⁷²Hagstrom argues this position; see Ibid., p. 19.

academic man has had a long history characterized by the receipt of few economic rewards, nor because the academic man is any more selfless, nonmaterialistic, humble or committed to the significance of his work than the average businessman or other professional. Rather, it is because the first and most essential reward of all--professional recognition--is the one from which all others eventually derive.⁷³ And it is typically the case that receiving psychological rewards (particularly those bestowed by one's professional colleagues) precedes the acquisition of physical rewards (particularly those bestowed by one's university) for most university professors.

If we analyze the process by which reward-decisions are made in academia, we find it to be singular in both its complexity and eccentricity. Regardless of where they originate or who actually bestows them, most of the rewards available to the academic man are bestowed on the basis of one criteria: contribution to the body of knowledge in his discipline. Given the actual duties and activities of the typical university professor, it is probably true that in no other field of endeavor is the criteria for evaluating performance so narrowly conceived.

While such a practice may be justified by a belief that the distinguishing and most important task of the modern university professor is that of advancing knowledge, it is also probably true that the preponderant use of this criteria is, in many cases, completely unintended. For the most part it results from the practice of most academic reward givers of deferring to the judgments of others for an evaluation of the worth of the professor in question.

⁷³Ibid., p. 39.

Let us examine the process by which this occurs. Rather than attempting to evaluate the past performance or capability of the faculty member directly, reward-givers whether they be industry, government, foundations or universities, (for reasons which are not at all clear) tend to defer to the "expert" judgments of an academic man's professional colleagues, that is, those in his discipline.⁷⁴ Necessarily operating on the assumption that his scholarly contributions are a better indicator of his worth than are his teaching capabilities, the counsel of those persons who are in the best possible position to judge such achievement--those who can best understand his work--is sought.⁷⁵ Thus an evaluation of a political scientist is sought from other political scientists, and the work of a biologist is judged by other biologists.

Seeking the public acknowledgement by a man's scientific peers that he has made a valid and significant contribution to their body of knowledge, reward-givers attempt to evaluate the degree of "professional recognition" which he has received.⁷⁶ Thus, the outward manifestations of this professional recognition become key indicators of the worth of the professor under consideration: articles and books

⁷⁴The practice of deferring to the judgments of an academic man's colleagues may well be a sign of the growing recognition among non-university people of the professionalization of all of higher education. For a discussion of this professionalization, particularly among the "non-professional" graduate schools of Arts and Sciences, see Christopher Jencks and David Riesman, The Academic Revolution, (Garden City, New York: Doubleday & Co., Inc., 1968), pp. 199-207, 236-50.

⁷⁵If reward-givers felt that teaching capabilities were a better measure of worth, they would, of course, seek the counsel of the faculty member's fellow instructors, and most importantly, his students.

⁷⁶For a short discussion of the literature on "professional recognition," see Norman W. Storer, The Social System of Science, (New York: Holt, Rinehart and Winston, 1966), pp. 19-26.

accepted by publishers, papers read at professional meetings, invited lectures at other universities.⁷⁷ Particularly with regard to the rewards conferred upon faculty members by their own institutions, the statement of Caplow and McGee made over twelve years ago, still seems to have currency:

It is neither an overgeneralization nor an oversimplification to state that in the faculties of major universities in the United States today, the evaluation of performance is based almost exclusively on publication of scholarly books or articles in professional journals as evidence of research activity.⁷⁸

Discipline-Oriented Rewards and Interdisciplinary Research

The implications of the academic reward system for interdisciplinary research activity are profound. The most obvious consequence arises from the use of "contribution to one's discipline" as a criteria for the bestowal of rewards. It makes it very likely that in the long run, under normal circumstances, interdisciplinary research activity will not be rewarded. While those who engage in such activity may receive some short-term physical rewards in connection with this work, they are most unlikely to receive many of the more sustaining, and in the final analysis all-important, psychological rewards available to their discipline-bound colleagues.

When a faculty member engages in interdisciplinary research activity, the disciplinary-oriented rewards that might have accrued to

⁷⁷For a discussion of the recognition of status among academics, see Stroup, Bureaucracy, pp. 61-66.

⁷⁸Caplow and McGee, Academic Marketplace, p. 69.

him from, or through, his professional association are largely eliminated for obvious reasons. In his professional association, there is not likely to be anyone or any group either interested or competent to judge the quality of his work. Thus "professional recognition," the most valued of all rewards to the academic man, both for itself and the other rewards which depend on it, will not easily come to the researcher engaged in such activity.

Likewise, at his own university, while the legitimacy of interdisciplinary research activity may be clearly recognized and unchallenged, such activity is also likely to go relatively unrewarded. Unlike the professional association of a scholar, the university should have an interest in developing its own competence to judge the performance of those of its faculty who are engaged in interdisciplinary activity. But not only have they not yet developed criteria for doing so, they do not appear to be in the process of developing any.

The lack of rewards for interdisciplinary research activity means that, for individual faculty considering the opportunity to engage in such collaborative efforts, few incentives are provided. Given the other research options open to a scholar--essentially disciplinary research options which carry with them the possibilities of academic rewards--the reward system as a whole constitutes a clear disincentive for the university professor. But the way it is perceived by many faculty members, more than a concern for foregone opportunities characterizes their views on the subject. Unquestionable penalties tend to be associated with interdisciplinary research.

An example was provided by one interview respondent at a university visited by this author. The professor had been involved in

interdisciplinary research for a period of three years. He suggested that while his own promotion in academic rank had not been delayed by his having engaged in interdisciplinary research activity, the promotion of his closest collaborator--a man from a different academic department--was most evidently delayed at least a full year, if not two years, by the inability of his departmental colleagues to evaluate his research effort to their own satisfaction.

A general inability to gain the psychological rewards of the academic life--the lack of professional recognition, a general lack of interest and support by one's departmental colleagues, difficulty in establishing an academic reputation both in one's institution and in the professions--as well as rewards that have both psychological and physical dimensions--delays in gaining academic rank, the inability to gain tenure at one's institution--and the consequent denial of the physical rewards that derive from them--including salary increments, student assistants, release time, space and equipment--all of these penalties are often associated with interdisciplinary research in the university.

Yet the impact of this system does not bear on the perceptions and attitudes of faculty members alone. University administrators, including many department chairmen and deans, aware of the reward difficulties inherent in interdisciplinary activity, apprehensive about their inability to evaluate the faculty members' performance, and concerned with the building of departmental, college and institutional reputations in the disciplines, tend to discourage faculty members from "getting too far out of their field."

The effects of the academic reward system vis-a-vis interdisciplinary research are, of course, distributed unevenly. This occurs first because of a difference in the relative importance of rewards at different points in an academic career. The system tends to deter the young, less secure Assistant Professor much more than it does the older, ranking and tenured Professor who has already established his reputation in academia and has received the laurels of his profession. Graduate students are almost universally dissuaded from involvement with interdisciplinary research for the obvious reason that their ticket of admission to the charmed circles of academia is contingent upon their demonstrating an understanding of the knowledge (i.e., literature) in their primary area of study (i.e., discipline).

Secondly, its effects are unevenly distributed because, while adherence to the criteria of "contribution to one's discipline" is relatively strict and unvarying everywhere, the meaning of "discipline" varies greatly in its restrictiveness. Thus, the system has a greater inhibiting effect on the members of more traditional, narrowly self-defining, discipline-oriented departments in the university than on the members of more problem- and more service-oriented, widely self-defining professional schools and departments. Thus, the system of rewards would, for example, tend to discourage a chemist or a biologist more than an engineer or a medical doctor from engaging in interdisciplinary research.

Third, the system's effects on interdisciplinary activity vary according to the directness with which faculty are able to receive those rewards which are made on the basis of criteria other than "disciplinary contribution." Here we refer to rewards which almost neces-

sarily originate outside the university. Those faculty members whose rewards tend to be tightly channelled through their university or their profession are usually less willing to engage in interdisciplinary research activity than are their colleagues who receive rewards directly from non-university sources (such as industry, foundations and government.) Therefore, faculty in the pure sciences and the humanities (e.g., mathematics and language) tend to be more dissuaded from collaboration across disciplinary boundaries than are their colleagues in the applied sciences, engineering, and to a greater extent recently, the social sciences.

Power and Leadership in the University

Before leaving the discussion of the university as an environment for interdisciplinary research, a final characteristic of some significance should be mentioned. While related to the organizational fragmentation and dispersion of authority that is characteristic of contemporary American universities, the author has chosen to consider it separately. He refers to the rather conspicuous absence of the exercise of power within the university, and the generally low level of leadership that we find in it.

Reflecting on a previous portion of this chapter, the reader will remember that both the individual faculty member in his role as teacher (and to a lesser extent his role as researcher), and the departmental and research groups in their roles as organizers, procurers and standard bearers, in making decisions and executing tasks, tend to carry out their activities alone, in a relatively unsupervised, uncoordinated and uninhibited manner. The extent to which this general

pattern of decentralization and dispersion of responsibility and authority has permeated the university and affected the exercise of power and leadership in the institution is significant.

Many different kinds of decisions are constantly required for the continuing operation of an institution as large and complex as a modern college or university. In an earlier age, some community-wide policies related to general academic matters concerned with the pursuit of institutional goals were made by the assembled faculty, but usually by university presidents. In fact, the contours of higher education in the United States today were largely determined by the work of a number of strong and determined university presidents. Today, in so far as issues of general academic policy (especially those important in their community-wide effects and closely tied to the output objectives of the university) are even addressed, decision-making or the reaffirmation of previous decisions on these issues tends to involve a slow incremental process including many persons within the institution. Unfortunately, in many cases issues are never addressed, decisions are simply not made and the university operates on the basis of inertia alone.

While central university administrations often have the symbols of authority and power, they often have difficulty making "authoritative community decisions" on matters of academic policy. For the most part, administrations simply ratify the decisions of others and then plead, prod and hope that those decisions will be implemented or those tasks carried out. With very little formal (or positional) authority concerning academic matters--much of it having been delegated to other parts of the university--and almost no infor-

mal authority based on competence or expertise, the university's central administration is relatively powerless to advance the university's institutional objectives.

For the most part, the administration's effective authority and power extends little further than to questions of physical plant, business policy, student guardianship, parental relations, and the acquisition of sorely needed money.⁷⁹ Perceived as "the enemy" by many students and faculty, it operates in an essentially hostile immediate environment. Perceived as having neither expertise nor skills, it has not convinced either students or faculty that it has any particular competence, especially competence concerning questions of academic significance. Were it, in fact, competent to deal with critical academic problems (which is often questionable), its general lack of credibility would keep it from exerting strong institutional leadership on such questions.

While faculties, on the other hand, exercise--individually and in small research and departmental groups--extensive authority and power, it is generally over their own activities rather than those of their colleagues across the campus. Thus, they like university administrations do not really make many "authoritative community decisions". However, unlike the central university administrations, they hold--collectively--much of the formal policy-making authority over academic matters related to the pursuit of the institution's output objectives.

⁷⁹While the power exercised by university administrations over the institution's budget is a notable and important exception to this limited scope, the politics of university budget-making is a subject too broad to be considered in this study.

They are the university's most important potential powerholders. Yet for one reason or another, they are either unable or do not choose to exercise their collective potential power to advance the university's institutional goals. Similarly, they seldom exercise that collective power to influence the internal guidance and maintenance of the university.

A partial explanation is provided by some of what has been described above concerning the physical, psychological, and social atomization of the university faculty and their orientation toward their disciplines rather than their institutions. In addition to the lack of unity already discussed, however, issues are seldom addressed and policies seldom made on general academic questions because of what David Fellman describes as a lack of information and a lack of interest among contemporary university faculties. Fellman argues that where university presidents (and presumably university administrations) are able to make policy on important educational matters, "the power of the president persists because of the inability of the faculty to exert its own influence efficiently, effectively, and consistently. Presidents are strong because faculties fail, . . . to exercise the authority that is within their grasp if they wish to take it. When a faculty is uninformed or indifferent or divided, the president has added scope within which to operate."⁸⁰

⁸⁰David Fellman, "The Academic Community: Who Decides What," in Whose Goals for American Higher Education?, ed. by Charles G. Dobbins and Calvin B. T. Lee, (Washington, D. C.: American Council on Education, 1968), p. 112.

However, regardless of its causes, a general abdication of the exercise of leadership and power has gripped the contemporary American university. Administrations don't have much authority and are relatively incapable of providing leadership. Faculties have the authority and potential power, but are unwilling or unable to exercise it, and thus do not themselves provide institutional leadership. In short, no one person or group of persons appears to be "in control" of the university and increasingly it appears to be uncontrollable, or at minimum, presently out of control. And the lack of leadership and the exercise of power leaves one with the insecure feeling that the contemporary American university has no institutional movement or direction other than that produced by inertia and the random forces of the environment.

What are the implications of this power and leadership "vacuum" for interdisciplinary research activity in the contemporary American university? Fearful of the loss of control over their faculty, yet seemingly unable to discharge existing organizational barriers to interdisciplinary interaction or to develop new organizational arrangements that will facilitate such interaction, and helpless to affect the reward system which operates across the nation-wide community of higher education and science, the university administrations seem caught in a state of inaction, with few ideas about how to solve their dilemma. Thus, even if convinced of the desirability and utility of interdisciplinary research activity within their institutions, and the necessity of doing something to encourage its development, university administrators--with few exceptions--fail to demonstrate initiative and leadership in that direction.

When the failures of university administration are coupled with the lack of initiative and leadership in the faculties, we can understand that little effort is being made by anyone in the universities to even address the problems posed by interdisciplinary research activity, much less suggest solutions. The result of a pervading feeling of helplessness and general state of inaction within the university is a widespread pessimism as to whether interdisciplinary research activity can, in fact, work and a widespread lack of interest in making it work.

CHAPTER V
INTERPROFESSIONAL ATTITUDES AND
INTERDISCIPLINARY ACTIVITY

The next set of factors to which we will turn our attention are the attitudes of university personnel, and how they affect the pursuit of interdisciplinary research activity in the contemporary American university. Whether they be participants in such research activity or not, the attitudes of professors, students and administrators affect both their own behavior and that of their colleagues concerning this subject. In this chapter, we are particularly interested in examining the perceptions and attitudes, biases and predispositions held by university personnel about the nature of the research process, the state of the theory among disciplines, and the relative competence and imagination of their university colleagues.

It is the view of this author that the sets of attitudes held on these subjects, by participants, potential participants and those around them, can and does greatly influence both the ability of the university to generate a truly interdisciplinary research endeavor, and the quality of the work subsequently generated by the group, once formed. It will be the task of this chapter to identify some of the most important of these attitudes and show how they affect interdisciplinary research.

Let us begin, then, by examining some typical sets of attitudes held by scientific and other university people concerning

the nature of the research process and their desired role in that process.

Attitudes on the Research Process

The attitudes of university research personnel vary widely concerning their aims or expectations vis-a-vis the applicability of the findings generated by their research activity. For some, the research process is envisioned as one of "pure discovery," in which one becomes engaged for the sake of intellectual curiosity alone, without regard for the possible application of one's findings or the direction in which one's research leads him. For others it is a process in which one engages to find answers to specific questions or solutions to specific problems. For still others, the research process is associated with what is essentially development; products, instruments, techniques, policies and other artifacts are "invented" for the use of someone other than the researcher.

Thus, for example, we expect researchers in the fields of engineering and many of the professions (including social work, law, architecture, medicine and business) to be more interested in the applied areas of research (in some cases including physical and social invention). However, their colleagues in chemistry, mathematics, economics and astronomy, for example, are likely to be decidedly prone to more "pure" research--that is, the discovery of physical and social "truth." This is not to say, of course, that the disciplines are themselves either "applied" or "pure". But, while medicine and mathematics, for example, have both applied and pure areas of research, differences in the central tendency of research in the disciplines do appear to exist.

The attitudes of researchers concerning the centrality of a disciplinary perspective in defining their research problems also differ greatly within the university. Some scholars conceive of "legitimate research activity" as limited to something which grows out of the conflicts, inconsistencies and gaps in the theory and findings of their discipline--what Scott Greer refers to as "generic scientific problems."⁸¹ Thus, questions are structured according to the analytical and conceptual framework of their discipline only. For others--perhaps those who are more broadly trained or experienced--the research process is conceived of as wider than the constructs of their own discipline and central questions can be formulated in a more general nondisciplinary (adisciplinary) or multidisciplinary manner. The pursuit of policy problems by some of the social sciences is an example of the latter direction in research. The essential difference here is a matter of the disciplinary specificity with which central questions are formulated, and thus, differences in opinion among research personnel do not necessarily derive from differences in their disciplines. However, we do find among some of the pure science disciplines, such as physics, more of a predisposition to define problems in a narrow disciplinary way than we find among the engineering or social science disciplines.

Again, depending on the phenomena under study and the state of our disciplines, the attitudes of researchers and other university personnel may differ widely on the research aim or purpose appropriate

⁸¹Scott Greer, The Logic of Social Inquiry, (Chicago: Aldine Publishing Co., 1969), pp. 12-14.

to the study under consideration. For some, like the biologist, an essentially descriptive goal might be assumed, because of the tendency for research in his field to be descriptive in nature. Others would more likely have a predisposition toward the task of explanation. Another group of researchers might envision the appropriate goal as the development of a set of theories or testable hypotheses. For still others, including for example a large segment of sociology, the building of conceptual or physical models is the preferred research aim.

In addition, we find the attitudes of research personnel divided sharply on the type of research work, that is, general research orientation (theoretical or empirical) that should be employed in studying a particular phenomenon. Some will emphasize the need for gathering evidence, collecting data and testing hypotheses, while others will argue the necessity of elaborating explanatory structures, formulating hypotheses and developing general principles. The former --empirical--orientation might be typical of a botanist or many physical anthropologists, while the latter--theoretical--orientation would be expected of physicists, mathematicians and economists. The contribution to knowledge which research people expect to make is, in most cases, directly related to this general orientation. Thus, empirically-oriented scholars expect to generate essentially small and very specialized "bits" of hard information, while their more theoretically oriented colleagues typically envision their contribution to be one of integrating or synthesizing many of these separate "bits" of information into a larger body of knowledge.

Attitudes about both the research aim--description, explanation, theory or model building--and the essential research orientation

--empirical or theoretical--will be a reflection in large part, of both the state of the theory and the nature of the research agenda which exists in the various disciplines at any point in time. If it is true, as Gordon Tullock has suggested, that the social sciences suffer from a general lack of elaborate and testable theory compared with the physical sciences, and thus have few real hypotheses to test, we can understand that different emphases and priorities will obtain in the research agendas of these various disciplines, and furthermore that the attitudes of research personnel concerning both research aim and orientation will be greatly affected.⁸²

Another subject about which significant divergences in attitude and opinion often occur among research personnel is the use of specific analytical instruments. All scholars are prone to the use of certain methods, tools and techniques, either because the scholars are competent to use only them, or because the tools have proven powerful in past research. While the use of certain analytical instruments is becoming increasingly widespread across the campus, their number is still very limited. And several of the instruments which are held in common are employed in different ways in different disciplines. There is yet no extensive and commonly held inventory of methods, tools and techniques which scholars from different fields are sufficiently knowledgeable about or competent to use (and therefore prone to use) together. Indeed, one of the ways that we differentiate among the disciplines is by reference to the tools used by different groups.

⁸²Gordon Tullock, The Organization of Inquiry, (Durham, N.C.: Duke University Press, 1966), pp. 60, 173.

Thus, we find social scientists using opinion survey techniques to gather their data; while anthropologists use participant observation; geologists use areal photography; chemists, physicists and psychologists use controlled experiment; astronomers use telescopes; and historians use library collections. Similarly, in how they manipulate their data once obtained, there are significant differences among the disciplines. Examples include the social science dependence upon automatic data processing; the physical science dependence upon complex measuring devices and mathematical calculations; and the differential use of inductive and deductive reasoning among the various disciplines. Clearly, the differences which exist among analytical tools themselves are not what is important here. Tools developed in one area can well be put to excellent use in another area of inquiry. However, differences in attitude about the relative utility of these tools, and predispositions toward the use of "familiar" ones over others, can be crucially complicating factors in the pursuit of cooperative activity.

The attitudes of research personnel and others within the university may also differ on the mode of operation employed in research activity--that is, the degree to which the process of inquiry must be "structured" or "organized." Some research personnel consider the best process of inquiry to be one in which research proceeds in a relatively undirected, free-moving evolving manner. The theoretical sciences and humanities probably typify this style. Researchers in the experimental sciences, on the other hand, tend to prefer a more carefully calculated and "designed" mode of operating, wherein activities and tasks are planned and programmed in both a temporal and

logical order. All across the campus, of course, we find individual researchers, regardless of discipline, who differ greatly in the degree to which their personal "style" is free-wheeling and unconstrained, or inhibited and compulsive.

A final difference between research personnel derives from the history and traditions underlying and supporting their scholarly activity. Some scientists, by virtue of the history of their discipline and their socialization into it, are more predisposed to cooperative or team activity than others. To them, research is seen as a social process. We find this to be a characteristic of the natural sciences as compared with the social sciences. The patterns of inquiry typical of the latter disciplines, despite their name, are much more those of independent, individual and relatively isolated activity. For them, research activity--and the making of a contribution to man's knowledge--tends to be an individual and personal rather than social process.

The "State" of the Theory and the "Competence"
of One's Colleagues

A second category of attitudes which cannot fail to affect the pursuit of interdisciplinary research in the universities is that concerned with the "state of development" of the various disciplines and the competence of one's colleagues in those disciplines. In the minds of most academic men, there lie a set of notions or preconceptions about the relative status of their own discipline in a hierarchy (or continuum) of academic disciplines.⁸³ Where any discipline appears

⁸³Hagstrom, The Scientific Community, pp. 148, 167, 175; and Margaret B. Luszki, Interdisciplinary Team Research: Methods and

on this status hierarchy depends on how "old" or "new" it is, how methodologically "rigorous" or "sloppy" it is, how esoteric its terminology is, and other characteristics. Most importantly, however, its place vis-a-vis other disciplines depends on the evaluation which is made of the complexity, elaborateness, sophistication and particularly the generality of its theories and those of the other disciplines. The status of one's discipline in academia depends most heavily on one's determination of the point at which it is in development toward "general theory."

Whether all academic men evaluate the disciplines, and arrive at the same positioning of each in the total continuum is, for our purposes, irrelevant. (There seem to be similarities in the general positions of at least some of the disciplines.) More important is the fact that each researcher tends to have a set of attitudes and opinions concerning the utility, the value or the potential contribution of other disciplines (at least some of them) relative to his own. And these attitudes, more than suggesting patterns of group leadership and initiative, and creating expectations of deference and respect, problems of primacy in group endeavors, and feelings of inferiority and superiority among group members, will affect their willingness to collaborate and their ability to interact productively with colleagues in other disciplines.

We see these attitudes manifest in the general level of distrust of, and lack of respect for, the work done in "other" fields

which characterizes many academics. They tend to be skeptical (sometimes overtly disdainful) of both the research process and the findings generated in a field of inquiry which they perceive to be at a lesser stage of development toward general theory than their own. For example, many academics (both physical scientists and others) would argue that the field of physics is more highly developed toward general theory than either zoology or political science. And while a zoologist and a political scientist might consider it useful to engage a physicist in a cooperative effort directed at the control of lower atmospheric pollution, it would not really surprise many academics if the physicist declined the invitation for reasons which derived from differences in the status-positions of the disciplines concerned. Though they might otherwise be attracted to such research, many physicists, including some whom the author interviewed, might feel unwilling to gamble (with good reason) on the possibility of losing the confidence and respect of their own disciplinary colleagues by spending their time on cooperative research with members of the "lesser" disciplines.

Attitudes such as these carry over to the evaluation of the intellectual capabilities, technical competence and creative imagination of individual faculty members as well as their disciplines. And the relative status of a researcher's discipline tends to be a determining factor in his own personal status relative to that of other personnel working on the research effort. Thus, all other things being equal, university researchers tend to have less confidence in, and respect for, the competence and imagination of their colleagues in the "lesser developed" disciplines than their own.

Attitudes as Sources of Weakness and
Strength in Collaborative Activity

What are the implications of differences in the perceptions and attitudes, biases and predispositions, of university personnel for interdisciplinary research in the university? First, it appears clear that those concerning the nature of the research process, because they are typically unexplored during the development of the research project, are more likely to undermine the work of an already functioning interdisciplinary group rather than prevent the group's formation. However, the degree to which differences in these attitudes and preconceptions are the source of weakness in interdisciplinary research varies widely depending on the nature of the attitude set itself.

Clearly such differences can be irrelevant in given cases, as they can be extremely important in others. Differences in attitude and opinion concerning the definition of the problem to be studied or the phenomena to be examined can make effective collaboration purposeless. Similarly, disagreements on the research orientation (theoretical or empirical) and the general aim (description, explanation, etc.) of the research can constitute serious barriers to cooperation. Disagreements on lesser important matters, such as that of the general mode of operation employed in the research, can cause bickering while not subverting essential cooperation. If they are immediately perceived by the potential members of a multidisciplinary group, differences on some of these matters may prevent such a group from ever attempting real interdisciplinary activity. If they are not perceived until after work is in progress, they can effectively undermine what

cooperative effort might have been occurring, and even cause the group's dissolution. The latter is unfortunately the more typical situation.

Secondly, differences in attitude, such as those identified above, do not necessarily derive from differences in the disciplines of researchers holding them. There are both "purists" and applications-oriented researchers, empiricists and theoreticians, model-builders and describers, in almost every discipline. And the particular attitude or orientation held by each individual researcher relative to others within his discipline may be more important to the success and productivity of a particular interdisciplinary group than those differences which exist between the disciplines. However, it does appear that some of these opinions, predispositions and attitude sets tend to be much more characteristic of scientists and scholars in certain disciplines than is the case in others. And thus, a realistic assessment of the "fit of the disciplines" during the process of recruiting team members and the construction of the research design would seem to be particularly useful as a means of avoiding potential problems and insuring the conceptual compatability of the overall research effort.

Third, unlike those concerning the research process itself, attitudes on the relative status of disciplines and the competence of one's fellow researchers tend to inhibit research personnel from initially becoming involved with the work of an interdisciplinary research group. For the most part, they simply restrict the supply of available faculty from which one can draw in forming a multidisciplinary group for interdisciplinary research purposes. The highest status disciplines (like physics, chemistry, mathematics and to a

lesser extent economics) are, in this sense, less likely to become involved in any interdisciplinary work except that with each other. Indeed, it appears that the most productive and enduringly cooperative groups are likely to be those made up of researchers whose disciplines all tend to be perceived as having about the same relative status and prestige.

Thus, in the attitudes, opinions and predispositions of university faculty concerning the nature of the research process, the state of the theory in various disciplines and the relative status of research personnel, we find potential barriers to effective cooperative research. Clearly, some of these attitudes are grounded in the nature of the academic disciplines and the differences which, in reality, exist between them. Some of these attitudes derive from an identification with, and tendency to be proud of, the contributions to knowledge made by those in one's own field. In addition, these attitudes probably have some of their origins in the haunting (and sometimes quite accurate) feelings of academic men that the subtleties and varieties of their own disciplines are lost or diminished by the process of transmission across disciplinary boundaries and mixing with other disciplines. Yet, in the final analysis, some of these attitudes boil down to little more than disciplinary parochialism, ethnocentrism, and an overabundance of academic snobbery. And while the previous reasons for a professor's reluctance to engage in interdisciplinary research are understandable (if not completely explainable), parochialism, ethnocentrism and snobbery are so antithetical to productive scholarly inquiry and the ideals of the academic community that they are indefensible as motivating factors in the conduct of university research activity.

In this chapter, certain kinds of attitudes, typically held by university research personnel, have been portrayed as potential sources of weakness for interdisciplinary research activity. Yet a variety and specialization in many of these attitudes and opinions, biases and predispositions, is the very basis of the strength of a multidisciplinary group, and one of the reasons for our encouragement of interdisciplinary activity. To quote R. Richard Wohl, "the occasion for interdisciplinary collaboration arises from the very fact of specialization and would be inconceivable without specialization."⁸⁴ Clearly, we want the individual participants in interdisciplinary research to offer to the common purpose a variety of approaches, perspectives, analytical instruments, theories, hypotheses and research experiences. Thus, paradoxically, the source of a multidisciplinary group's strength and utility can also be the source of its weaknesses and inability to work successfully.

⁸⁴R. Richard Wohl, "Some Observations on the Social Organization of Interdisciplinary Social Science Research," Social Forces, XXXIII (May, 1955), p. 376.

CONCLUSION

Among the findings reported in Chapter II, the author concluded that NASA SUP/R supported university research at the universities visited had been essentially disciplinary in nature. Of the supported research that was found to be interdisciplinary, there was little that the author could conclude would not have occurred had NASA SUP/R funds not been available. Thus, at least one of the goals of the Sustaining University Program, "removal of the interdisciplinary barriers in research and fostering of genuine cooperation between workers in collateral fields," was not accomplished.⁸⁵ Furthermore, the intention of the agency "to encourage the establishment of creative multidisciplinary investigations" through Sustaining University Program research grants was in most cases not realized.⁸⁶

University Failure to Respond to NASA's Expectations

Thus, using the criteria previously set forth, the author must conclude that the fostering of "interdisciplinarity" at the five universities visited, largely failed. Why did NASA's attempt to advance interdisciplinarity encounter difficulty? Our examination of some of the forces and factors at work in the modern American university--the organizational fragmentation, the disciplinary-oriented reward structure, the failure of leadership, and the prevalence of disintegrative interprofessional attitudes--begin to suggest that at least some of the difficulty can be attributed to the university itself.

⁸⁵See Supra, pp. 10, 31-32.

⁸⁶Supra, p. 13.

First, it seems clear that in any university community we find many people (including faculty members, research entrepreneurs, and university administrators) who do not understand the theoretical foundation underlying interdisciplinary research, and who do not perceive the potential utility or value of such activity. Thus, such people are likely to be relatively uninterested and unreceptive to suggestions that they engage in, or encourage, collaborative work across disciplinary boundaries.

Second, of those who do perceive a potential value to interdisciplinary activity, only some researchers will consider its utility great enough to justify the considerable risks and difficulties with which they associate it. Many potential research group members are reluctant to become involved with interdisciplinary activity because, as the author indicated in an earlier chapter, they anticipate that the university's decentralized pattern of authority and decision-making, its practice of "assigning" men and machines to disciplines, its failure to reward and its tendency to penalize interdisciplinary activity, and the general delay and uncertainty in receiving professional recognition will make their involvement not worth the considerable effort required and the risks entailed.

Third, many research entrepreneurs and university administrators convinced though they are of the value of interdisciplinary activity, will be reluctant to encourage such research because they anticipate, quite correctly in many cases, that they are relatively powerless (devoid of adequate formal authority, perceived as without legitimacy, and lacking in the necessary respect and influence among their academic colleagues) to do so effectively. Indeed, the distribu-

tion of power and loyalty in academia is such that the term "encourage" means little more than arguing for the utility of interdisciplinary research activity and helping to remove the organizational and administrative barriers to it. Clearly, it is difficult to actually "seduce" university faculty into engaging in research activity in which they are not particularly interested.

The fourth reason that NASA's attempt to advance interdisciplinary research failed, derives from the distinction which was made in Chapter III between "multidisciplinary" and "interdisciplinary" research activity and a general lack of understanding and agreement on that distinction between the agency and the supported universities. It will be remembered that while the agency asked that the universities engage in "multidisciplinary" research activity (suggesting only that supported research be done by persons from several disciplines), they quite apparently expected the universities to engage in "interdisciplinary" research (meaning a sustained collaborative enterprise in which several researchers from different disciplines work together on the same problem). Yet, it became clear to the author during his visits to university campuses that most university personnel perceived NASA's interests and intent to be that of encouraging the formation of multidisciplinary research groups, but not necessarily the pursuit of interdisciplinary cooperation within those groups. To most university people (particularly the research entrepreneurs and administrators), it appeared that the university's obligations to the agency would be met by the support of research and researchers from the several disciplines. If the researchers all worked on the same project, it would be nice-- but it certainly wasn't necessary.

Fifth, the universities--convinced that the road to Federal government money was paved with terms like "multidisciplinary" and "interdisciplinary"--moved quickly to fulfill the letter, if not the intent, of agency requirements and expectations that supported research be carried out by a team. And in the process, both they and the agency confused means with ends. At universities visited by this author, research groups appeared to be formed in one of two ways. Essentially separate and theretofore unrelated research proposals (or faculty research interests) which came to the attention of university "research entrepreneurs" were melded together--at least on paper--to form one consolidated proposal and research package. Typically, however, such a proposal allowed each member of the "multidisciplinary research team" to do his own research relatively unobligated in terms of interaction with other team members.

An alternative pattern of group formation occurred when an existing multidisciplinary team (not necessarily engaged in interdisciplinary research), which was involved in research related to NASA's interests, was recruited by the university "research entrepreneur" to submit a proposal for support through the Sustaining University Program research grant. While such research was occasionally interdisciplinary, and was in many instances done by multidisciplinary teams, it was not really "generated" by NASA's SUP/R funds. Rather, it was simply "continued" by them.

A consequence of the emphasis on multidisciplinaryity was that the focus of university research entrepreneurs, and university and agency administrators was more on assembling (and keeping together) a multidisciplinary team than it was on defining good

research problems, articulating appropriate aims and goals, and developing coherent research designs. The question "How will we do it?" was answered before the question "What will we do?" was asked. And at more than one university visited, it appeared that preferred research proposals were not able to be supported with SUP/R funds because it would have resulted in a total SUP-supported research program which did not "appear" multidisciplinary enough. Thus, in the final analysis, the agency's emphasis on the "need to be multidisciplinary," combined with the universities indiscriminating scramble for funds, resulted in confusion among both agency and university personnel of means and ends, and a diversion of attention from central research purpose to method.

The final reason for NASA's failure to advance interdisciplinary research in the universities is implicit in all of the other reasons. It was a common theme which kept repeating itself, in one way or another, in discussions with the persons interviewed at university campuses. The agency's attempt to encourage interdisciplinary research activity failed because few people, both in the agency and in the university, really pursued the task with much conviction, with much initiative and with much design. In short, few people really tried.

As we have seen, NASA's attempts to foster collaborative work across disciplinary barriers failed (at least at the universities visited by this author) for rather substantial reasons. This might tempt us to conclude, as others have, that interdisciplinary research is so difficult as to be a practical impossibility in the typical university setting. Yet, there were some instances of successful interaction across disciplinary boundaries--where the nature of the problem required an interdisciplinary approach, where collaboration was really

cooperative, continuous and sustained, where the findings were cumulative and integrated, and where the results unquestionably justified the effort. Thus, for this author, the question is not whether such research is worth the trouble, but "How can we minimize the difficulties inherent in interdisciplinary research activity and maximize its utility as a means of advancing the personal aims of the research personnel and the social purposes of the modern university?"

Prescriptions for Encouraging Engagement

Let us first examine some considerations relevant to the development of sensible and potentially valuable research problems and the assembling of a group of scholars to address those problems. Unquestionably, the most essential consideration in attempting to minimize our difficulties and maximize our results is to engage in, or encourage others to engage in, interdisciplinary research activity only when the research problem itself demands an interdisciplinary attack. As Margaret Luszki points out, "The kind of operation necessary to handle a particular problem determines both whether the work must be done by a team and whether it must be done by an interdisciplinary team."⁸⁷ Thus, whether the "problem" is one of synthesizing or integrating existing knowledge, generating new knowledge, or applying existing knowledge to practical purposes, the problem itself must be the determinant of whether an interdisciplinary approach is required.

Furthermore, interdisciplinary research activity cannot be its own justification, for in itself there is no value. What is of

⁸⁷Luszki, Interdisciplinary Team Research, p. 11.

value are the results produced by it. Neither multidisciplinary groups nor interdisciplinary activity have any inherent advantage, utility or value aside from that which derives from their capabilities to assist us in intelligently addressing a particular problem, answering a particular question, or profitably investigating a particular phenomenon. Thus, it will serve no one's best interests for individual researchers to engage in, or university administrators and agency personnel to encourage, interdisciplinary research as if it were an end in itself.

A second consideration is essentially a caution directed to both the university and to the external supporting agency. The university must attempt to harness--at least make more purposeful and less frantic--its compulsive search for external research funds. Both faculty researchers and those individuals who represent the institution as a whole must resist compromising their individual and collective integrity. Thus, research projects which have obvious conceptual or other weaknesses should not be promoted. More importantly, projects should not be packaged and sold to the highest bidder (i.e., government agencies, foundations and corporate business) as something other than what they actually are.

Similarly, the external supporting agency should consider the implications of "inducing" desired research activity by offering the too anxious academic researcher short term support for his project expenses. The agency can sometimes temporarily affect the reward structure of the university and thereby produce desired research--particularly in financially weak universities, schools and departments. But it may do so at the risk of only short term involvement of research

personnel, incompetent research, uninterested researchers, and finally, the ever present "snow job" by those whom it would seduce. Thus, in attempting to capture an institution or a researcher, and inducing activity that researchers would not otherwise be interested in pursuing, the agency may be doing itself, the researcher, the university and science a disservice.

Ideally, externally supported university research should arise only out of a mutuality of interests among the parties--that is, when a desire on the part of a faculty to engage in particular research activity is matched by the interest of an external agency to see such research occur.

A third consideration in attempting to maximize our research results is concerned with formation of a research group. Once the initial task of isolating a phenomenon for study and articulating the problems to be addressed (or otherwise setting the purpose of the intended research) has been accomplished, and the need for an interdisciplinary approach has been determined, a team must be assembled. Here, the university central administration can be much more forceful than is usually the case, in putting faculty from various departments who have common interests in communication with each other. Clearly, the university administration is the only group in the contemporary university who has the capability of performing this function. And in doing so, they can help to counter the forces which tend to atomize the university community and strangle the process of knowledge integration and verification.

(It should be pointed out that in terms of protecting its power position within the institution, the university's central

administration has a clear interest in helping to maintain an atomized university community rather than encouraging a potentially very powerful faculty to become unified.)

A fourth consideration is probably most appropriately directed at the efforts of the research entrepreneur. Many personal and professional characteristics must be considered in recruiting potential research personnel to the interdisciplinary project. One element that is not often thought of is the degree of professional security possessed by potential contributors. Young, professionally aggressive university researchers--those who are without recognition and reputation, but who desire it and are actively seeking it--tend to be professionally insecure and thus extremely discipline-oriented. As such, they are likely to be less interested, and less successful, in a sustained collaborative enterprise operating across disciplinary boundaries. On the other hand, older, more established, professionally recognized and academically secure faculty are likely to find working at the boundaries of their discipline (or outside of their discipline) much easier.

The fifth consideration in the development of sensible and potentially valuable research problems is that of involving potential participants in the development of the research design. As soon as the research entrepreneur assembles a group of likely team members, he should turn over to the group the task of determining the research processes, analytic instruments, and the research agenda to be employed on the project. The goals to be pursued, the division of labor and the method to be used should be determined by common agreement of the participants. And planning "what to do" and "how to do it" will not only give potential participants insight into each other's knowledge

base, perspectives and approaches, methodologies, techniques and skills, it is likely to suggest particularly useful avenues for research exploration. Clearly, the only way that a strong personal commitment to the research program will be made by individual researchers is if the research itself makes sense to them, if it interests them, and if it seems to require their participation. Necessarily, this means that they be involved in its design.

The sixth, and last, prescription that the author will offer on the development of the interdisciplinary research project concerns the academic reward system. It seems clear that one of the most sensible directions in which we can move, in attempting to minimize the difficulties and maximize the results of interdisciplinary research, is that of encouraging the bestowal of equal academic rewards on faculty engaged in interdisciplinary research as those engaged in disciplinary work. University faculty can help serve this goal by working to develop and implement in their own institutions new criteria for the granting of physical, institutional rewards--criteria other than that of "contributing to the body of knowledge in one's discipline". The practice of having his own departmental (disciplinary) colleagues judge a faculty member's performance for the bestowal of institutional rewards and penalties is not likely to change. In fact, a change is not suggested here. However, the criteria used in judging one's colleagues can be modified so as to include relevant "contributions" other than that of disciplinary research and publication. Such criteria should recognize the contribution of faculty working on interdisciplinary projects as well as the contributions of non-research activity.

Prescriptions for Maintaining a
Productive Group

There is, of course, a second set of considerations relevant to an attempt to minimize the difficulties and maximize the potential results of interdisciplinary research activity. That set is concerned not with the formation of a group or the delineation of the problem, but with maintaining a productive research group once it has been formed and the research is in progress.

The first of these considerations is that of insuring a flexible and transient organizational structure. There has been much concern, particularly with NASA, with the development of "institutional research capabilities" at supported universities. Clearly, the maintenance of a research capability at a particular university implies the maintenance of a competent resource base--including faculty and students, technical and other support personnel, facilities and equipment. Just as clearly, however, it should not imply the maintenance of a particular structure or organizational form persisting beyond the time period required to complete the research project for which it was designed.

Attempting to maintain an "organized" research capability, which is then available for any of several kinds of research activity, is clearly unworkable in a university setting--a case of confusing means and ends. First, the organizational pattern which is employed by a multidisciplinary research group must be a response to the demands of the problems to be solved, the questions asked, and the phenomena to be studied. Secondly, unlike typical patterns of internal organization employed in industrial research groups, the

university is internally structured in such a way as to make the maintenance of an ongoing research organization very difficult--that is, unless it is spun off as an independent entity. Third, the norms of individualism and independence among university scientists result in a demand by most scholars that they be continually free to select their own problems and methods. Therefore, membership in a continuing "general-purpose", "multi-purpose" or "no-purpose" research team is not likely to be desired.

In addition to the need for structural transience, over the long-run, the maintenance of structural and procedural flexibility should be a concern of the group during the entire period of the research project. Thus, it should be made as administratively easy as possible for researchers to join and leave the research group during the course of the project. Likewise, flexibility in the formal and informal leadership arrangements of the group should be maintained. It may be advantageous, for example, to rotate the position of Principal Investigator. Or, to use another example, it might be useful to recognize the primacy of different "idea men" at different periods during the project, by shifting the informal leadership of the group on matters of research substance.

A second important consideration in maintaining a cooperative and productive group once the research process is ongoing is concerned with the physical support arrangements required by the group. A common work space and shared support personnel and equipment can be important contributing factors to cooperative and productive interaction. NASA's financing of research facilities on university campuses under the Sustaining University Program was, at least in part, presumed to reflect a recognition of this point.

A third consideration is concerned with the work effort contributed by various research personnel on the interdisciplinary project. It appears that, in so far as it is possible, there is some minimal amount of time that must be required of each participant in an interdisciplinary research endeavor if that person is to make a significant contribution to the group's effort. Furthermore, it seems reasonable to suggest that, within certain ranges, approximately equal amounts of time must be contributed by primary contributors if the knowledge, perspective and method of each discipline is to be reflected in the results of the group's activity. No integration of separate bodies of knowledge, cross-pollination of ideas or significant exchange of information and theory is likely to occur when one member of the group is spending full-time on the project and other participants are contributing only 10 percent of their effort.

As important as the actual commitment of research time is also the programming of research activity in a logical time and task sequence. Thus, the division of research effort into specific tasks, and the scheduling of these tasks, must be agreed upon by the research team. University research personnel who are expected to wait idly while other group members do their work are likely to lose interest in, and commitment to, the research project.

A fourth, and related, consideration is that of the nature of decision-making within the interdisciplinary team. Hierarchical administration of an interdisciplinary research project in a university setting is likely to insure a difficult and contentious atmosphere within the group and a less productive association. On the other hand, collegial decision-making on matters of significance to the group

(whether they be procedural or substantive) is more compatible with the norms of individualism and independence in science and the normal distribution of power and responsibility within the typical university community. Thus collegial decision-making is likely to be associated with a minimum of difficulty in group interaction and therefore a more successful collaborative experience.

A fifth consideration is concerned with the requirements demanded and the support given a multidisciplinary group by the university's administration. Department, college and university administrators can advance the cause of interdisciplinary interaction among university personnel by dispensing with outmoded record-keeping, accounting and reporting requirements which throttle productive activity across disciplinary (i.e., departmental) boundaries. The practice of assigning personal effort, facilities and equipment to the academic departments must be made more flexible. Likewise the practice of accounting for faculty time and effort by assigning percentages to certain categories of activity should be recognized for what it is --arbitrary, typically inaccurate, and therefore useless. Finally, some of the formal reporting requirements employed by universities are not only archaic, but unreflective of the real distribution of power and responsibility on the campus.⁸⁸

⁸⁸To some extent, these record-keeping, accounting and reporting requirements are responses by the university to the demands of government auditors concerned with questions of accountability for the expenditure of public funds. Thus, changes in these requirements are likely to require a cooperative effort on the part of both university and government.

The sixth, and final, consideration concerned with maintaining a productive interdisciplinary research team is directed primarily to the role of the Principal Investigator, or chief administrator of the research program. As was pointed out in the first chapter of this report, the Principal Investigator, as chief spokesman for the research group and the primary link between the group and other elements of the university and the supporting agency, was typically responsible for negotiating with these external elements on behalf of the research team. And in connection with those negotiations, he was often a combination business manager and public relations officer.

However, a second role for the Principal Investigator--that of facilitator of intra-group activity, broker of individual interests, and resolver of intra-group conflict--is equally, if not more, important to the productivity and success of an interdisciplinary research effort. As David Hertz succinctly puts it,

. . . the team itself must be actively created and maintained. It is obviously not just a matter of choosing a group of top-notch scientists and putting them in a room somewhere and tossing them a problem and waiting for the answers to be turned out. People have to get to know each other, to be able to communicate with each other, and to be able to work together. This is particularly true where diverse disciplines are necessary to solve particular problems. A common language has to be developed and an atmosphere of intellectual security has to be maintained. Both language and security take time to develop. . . . the team has to work together for a while before we can expect it to produce results.⁸⁹

Thus, it seems clear that a large part of the time and effort of the Principal Investigator must be directed to "maintaining

⁸⁹David B. Hertz, "Human Factors in Research Teamwork," Teamwork in Research. Edited by George P. Bush and Lowell H. Hattery (Washington D.C.: American University Press, 1953), pp. 72-73.

the group as a group"--that is, maintaining a cooperative atmosphere and reinforcing the identity of the research group as a "team." As we have seen, there are many forces militating against the identification of sociologists, physicists, biologists, surgeons and mathematicians with each other as a group. The disciplinary forces at work within the university and their professions will continually draw them in different directions, and the difficulties which they encounter in extended collaboration are likely to discourage them in their efforts, repeatedly tempting them to return to disciplinary concerns. Therefore, the Principal Investigator must indeed be a broker in resolving intra-group conflict and a facilitator in helping the group to adjust its purposes, methodologies, tasks and personnel. In terms of advancing the group's research effort, this is probably the most potentially important role that can be played by a Principal Investigator.

Yet the role of intra-group broker, facilitator and conflict resolver combined with that of principal negotiator, business manager and chief public relations officer for the group raises the question of a limit on the responsibilities which can sensibly be assigned to the Principal Investigator. Particularly, it suggests to this author that the Principal Investigator should not be engaged as a regular research team member in the tasks of data gathering, analysis and the evaluation of findings. This is suggested for two reasons: he is not likely to have the time; and he is likely to be a party "at interest" in conflicts which he attempts to resolve. The danger that the multidisciplinary research team will become the "staff" of a Principal Investigator so engaged, and that the substance of the research activity will become the Principal Investigator's "own" project, is thus avoided.

On the other hand, this is not meant to suggest that he be divorced from the substance of the research activity. Clearly, if he is to attempt to maintain the group as a "team," the Principal Investigator must be informed concerning both the content and procedures of ongoing research--he must understand what is being studied and how it is being investigated.

An Exploration Concluded

At the outset of this paper, it was stated that this study was an exploration into both the theory and the actuality of interdisciplinary research activity in contemporary American universities. Thus, addressed primarily to the subject of interdisciplinary research, the study was intended to illuminate its theoretical meaning and potential utility, its practical problems and prospects. The author hopes that that intention was at least partially fulfilled. Clearly, the foregoing analysis suggests the need for a further examination of the formal and informal authority-responsibility structures in the university, a careful exploration of its processes of "community" decision-making and a closer analysis of institutional guidance and leadership within the university. The chief value of this paper may be that which resulted indirectly from the search for variables most closely associated with the success or failure of interdisciplinary efforts--a better understanding of some of the most important forces at work in the modern American university.

APPENDIX A

INTERVIEW SCHEDULE

Identification and Background of Respondent

1. Mr. _____, before talking about multidisciplinary research activity at _____ (college or university) and NASA's Sustaining University Program Research Grant to the University, it would be helpful to have some information on yourself. What is your formal educational background? In what field is your major degree?
2. What are your teaching fields? Which of these do you consider most important in terms of your own interests? Are you presently teaching (or have you recently taught) outside your primary fields?
3. In which areas have you done your most recent research? Have you been engaged in research activity outside these areas recently? In which journals have you recently published?
4. In which department or departments do you presently hold appointments? Are they teaching or research appointments? Which department do you consider to be your "home?"
5. In which professional associations do you presently hold membership? What professional conferences have you recently attended?
6. At the present time, what connection do you have with research activity at your university that is supported by NASA's Sustaining University Program?

_____ Principal Investigator	_____ Project Research Faculty
_____ Advisory Council	_____ Graduate Student
_____ University Administration	_____ Other (_____)

How long have you held this position? In the past, have you been associated with the NASA-supported research activity in other capacities?

7. Your responsibilities, in connection with the SUP-supported research activity, consume how much of your time? What other responsibilities do you presently have?

Origin and History of the NASA/University Relationship

8. From where did the impetus for the original proposal to NASA come? How did the University first find out about NASA's Sustaining University Program? Was a proposal solicited by NASA? Were particular NASA personnel (e.g., Mr. Webb), either in Headquarters or in the field centers, important in generating University interest in NASA's Sustaining University Program?
9. To what extent, and in what ways, were NASA personnel involved in the development of the SUP/R grant proposal which NASA finally accepted? To what extent did NASA influence or affect the research topics chosen for study, the particular pattern of organization and management subsequently adopted by the University in administering the grant-supported research, and/or the choice of university personnel that were to be involved in the research activity?
10. Was the development of the first accepted proposal to NASA primarily the work of one person (either faculty or administrator), one academic department or school, or one particular group of researchers? What role did each of these groups play in designing the proposal? Who at the university did the most to generate the interest of potential research personnel? Who actually wrote the original proposal document?
11. From the University's perspective, what central purposes was the original grant intended to achieve? To what extent was it intended to strengthen individual faculty or graduate student research personnel; the academic departments, schools and colleges; the institution as a whole?

Organization and Administration of the

Grant-Supported Research Program

12. What research projects and which personnel are presently being supported by the SUP/R grant? Which academic disciplines are currently represented in the research activity?
13. In connection with the SUP-financed research activity, what role has the Principal Investigator played? What decisions does he make in connection with the supported research--decisions involving the substance of the research activity or the methodologies employed, financial (i.e., budget) decisions, personnel decisions, daily administrative decisions, and/or others? How was the Principal Investigator chosen for the position? During the period of the grant, have other persons acted as Principal Investigator? What has been the relationship between the Principal Investigator and the Advisory Council, the research personnel, the University administration, the academic departments, and/or NASA?

14. What has been the role of the Advisory Council? What kinds of decisions have they made (e.g., policy, financial, administrative, personnel, etc.)? What is the present membership (by name and departmental affiliation) of the Advisory Council? What has been the relationship between the Advisory Council and the Principal Investigator, the research personnel, the University administration, the academic departments, and/or NASA?
15. What continuing role does NASA have with regard to the supported research activity? How much contact has there been between University personnel (both researchers and administrators) and NASA personnel (both at Headquarters and at the field centers)? What have been the primary concerns of NASA's technical (or program) monitors? In what ways have they encouraged multidisciplinary research activity?
16. What roles have the academic departments and schools, their Chairmen and Deans, and other administrative personnel had in connection with NASA/SUP-supported research activity at the University?
17. Does the central university administration have a Research Officer and/or Office? If so, what role does this Officer and Office play in the research activity supported by NASA's Sustaining University Program?
18. In general, on what has the NASA support money been spent?

☐ Faculty Salaries	☐ Facilities and Equipment
☐ Graduate Student Salaries	☐ Expendable Supplies
☐ Supporting (secretarial	☐ Computer Time
and technical) Salaries	☐ Travel
☐ Library Resources	☐ Publications Costs
☐ Other (_____)	
19. In the period since the original grant was made, how have subsequent proposals for new research under the NASA grant originated and developed? Have subsequent research efforts been formulated by individual faculty members, graduate students, program administrators, University administrators and/or NASA personnel? Has the formulation of most subsequent proposals been the work of one man or several? Has formulation of a new proposal ever been the work of a multidisciplinary team?
20. With regard to the research activity supported by supplementary grants from the Sustaining University Program, how, by whom and according to what criteria have decisions been made within the University to support specific research personnel and projects?

Output: Measuring the Multidisciplinarity of

Research Activity

21. With regard to that research activity supported by NASA's Multidisciplinary Grant to the University with which you are the most familiar, how much interaction has occurred between and among research personnel from the various disciplines involved?
22. What has been the nature of the interaction among these researchers (e.g., both informal and formal consulting on each others research projects; co-investigators on substantive research; the use of common facilities, equipment and/or data; co-authoring articles, papers and/or books; attendance at seminars; attendance at research team meetings; attendance at professional conferences; multidisciplinary team teaching; the co-advising of a single graduate student or the advising of graduate students from another discipline; etc.)?
23. What research reports, working papers, conference papers, publications and other written studies have been authored by researchers from different disciplines? Which journals have been the primary vehicles for publishing the research findings with which you are most familiar? Does the University have a monograph or research report series that has published material generated by the NASA supported multidisciplinary research activity?
24. What conferences, meetings and/or seminars (both at the University and elsewhere) have been attended by researchers from various disciplines?
25. What new courses have been developed as a result of the interaction between researchers across disciplinary lines? Which courses have had a change in their content as a result of the multidisciplinary research activity of their instructors?
26. What changes have occurred in advanced degree requirements as a result of the multidisciplinary research activity supported by the Sustaining University Program grant?
27. Have any of the theses or dissertations which have been supported by the multidisciplinary grant been cross-disciplinary in content? Have the graduate students who have been associated with supported research had faculty advisors from disciplines other than their own? Have graduate students crossed disciplinary lines to do research outside their own fields?
28. To what extent have researchers from different disciplines worked together in developing new proposals (either to NASA or to other agencies) for additional multidisciplinary research activity, fellowship programs, library development, curriculum studies, course offerings, facilities and equipment, and/or special purpose centers or institutes?

Characteristics of the Environment Surrounding

Research Activity

29. In your experience, does this University place an unusually important emphasis on its research role? To what extent is faculty research and publication requisite for advancement within the university? Does the emphasis on research and publication vary among the departments and schools within the University? If so, in which areas is it the most (and the least) emphasized as a criteria for advancement? What other criteria are most important?
30. Is there an officer of the University administration responsible for coordinating or overseeing all university research activity? What are the responsibilities of his office?
31. How large in dollar and personnel terms is the university's research activity? What percentage of this activity is supported directly by the University itself? What is the magnitude, in dollar and personnel terms, of research activity supported by the national government? By NASA?
32. What portion of the University's external research support comes in the form of project-type support to individual research personnel? What portion comes in the form of "institutional" support to the University?
33. What percentage of the University's total budget (including all expenditures regardless of the source of funds) is expended to support research activity?
34. To what extent does the University emphasize a "public service" role to the locality, the region or the state? To what extent does the University emphasize professional training as opposed to the education of scholars and future college professors?
35. Is there both a teaching-faculty and research-faculty appointment system at the University? What is the difference between these positions?
36. Is the University a privately or publicly supported institution?
37. To what extent is the University considered primarily a graduate institution? Currently, what are the undergraduate student and graduate student enrollments? How many teaching faculty are there at the University?
38. How much emphasis is placed on multidisciplinary research and teaching at the University? Are there historical factors at work which make multidisciplinary activity particularly easy or difficult at this University? Have officers of the University administration, Deans, Department Heads, faculty groups or others made public statements concerning multidisciplinary

activity at the University? Have any of the University's own funds been earmarked for stimulating or supporting multidisciplinary activity?

39. Is multidisciplinary research activity particularly associated with certain people, departments, or schools at the University?
40. To what extent does the University make use of multidisciplinary team teaching? Is this particularly associated with certain departments or schools? Does the University employ a system of Joint Appointments? Does the University offer multidisciplinary courses and seminars? How much flexibility is allowed in graduate degree programs at the University for taking courses outside of the student's discipline? Are there multidisciplinary degree-granting programs at the University? Are there multidisciplinary non-degree-granting, teaching programs at the University?
41. To what extent are graduate students permitted or encouraged to engage in multidisciplinary research activity (either as Research Assistants, or Investigators working on their own Thesis or Dissertation research) at the University?
42. What multidisciplinary research Centers, Institutes or Laboratories are presently in operation or planned at the University? Which disciplines are involved in their activities? For what purposes were they established as separate research or teaching units?

The Intra-Project Decision Making Process

43. Among the research personnel who have been brought together into a multidisciplinary research team, how have substantive responsibilities typically been divided and allocated among the team members?
44. Has intra-project decision-making been accomplished by unilateral action of one person or has it been accomplished collegially? Of particular interest are decisions involving adjustments in the team's budget and expenditures; changes in the research design; methodologies to be employed; the use of data generated by the research personnel; and the form, content and quality of reports and publications that result from research activity.
45. How and by whom have the specifications for the research output of the multidisciplinary team been determined? What influence has NASA had in determining the form, content and/or quality of the research output?

Inputs: Identifying the Relevant Personal,

Professional, Institutional and

Situational Variables

46. With regard to the SUP-supported multidisciplinary research activity with which you have been most closely associated, what was the disciplinary makeup of the research group (identified by academic training, teaching areas, previous research areas, and departmental affiliation)?
47. To what extent did the researchers from various disciplines work in close physical proximity?
48. How much interest in and commitment to the idea of multidisciplinary research activity was expressed by members of the research group?
49. On the multidisciplinary research projects with which you are most familiar, what percentage of his total time was contributed to the project by each researcher? Was the contribution of each researcher planned and programmed according to a time sequence for the total research project?
50. Considering each of the following factors individually, and on the basis of your own experience with multidisciplinary research activity, I would appreciate very much your evaluating the items in terms of their relevance in either encouraging and promoting or discouraging and impeding successful multidisciplinary research activity:
 - a. The interest and support (or lack thereof) of the University administration and faculty colleagues.
 - b. The use of common work facilities, equipment and/or data.
 - c. The use of common leisure and service facilities.
 - d. The use of common supporting (technical and secretarial) personnel.
 - e. The lack of opportunities to meet and converse (on a professional or academic level) with colleagues from other disciplines.
 - f. Lack of understanding of the techniques and methodologies of other disciplines.
 - g. The use of different languages by various disciplines.
 - h. Emphasis within the departments and the university on applied and problem oriented knowledge. Emphasis on basic knowledge.
 - i. The friendship of research personnel outside the university setting.
 - j. The programming of research activity in a logical time and task sequence.
 - k. The personal interest and commitment of research personnel to the idea of multidisciplinary research.
 - l. Mutual professional and intellectual respect for colleagues in other disciplines and for the subject matter which they study.

- m. The personality and personal characteristics of research personnel (e.g., independence, professional and academic security, communicative ability, patience, ingenuity, resourcefulness, innovativeness, age, professional position, local esteem and respect, etc.).
- n. A history or tradition of multidisciplinary research on the campus.
- o. A history of tradition of strong departmental autonomy and control.
- p. Conservatism and rigidity in departmental organization, procedures and decision-making.
- q. The availability (or lack of availability) of financial support (external or internal) specifically for multidisciplinary research.
- r. The need for research support to supplement academic salary.
- s. A narrowness of perspective, knowledge and interest that comes from specialized "disciplinary" education and training of the persons engaged in research.
- t. The independence and security of affluent faculty.
- u. The problem of making financial arrangements in which support comes from the budgets of two academic departments or schools.
- v. The existence of University accounting systems which link faculty effort (both teaching and research) to the department or school.
- w. The lack of interest and willingness by one's students to work outside their disciplinary fields (such as might come about because of fear that this will make it difficult to find subsequent faculty appointment).
- x. A research design that was designed by someone external to the project (such as an over enthusiastic university administration or the supporting agency).
- y. Criteria for advancement and tenure at the university which do not recognize or underevaluate multidisciplinary research activity.
- z. The lack of acceptable or attractive outlets for publishing material generated through multidisciplinary research.
- aa. The fear of research personnel that "significant and recognizable (both academically and professionally) contributions to knowledge" cannot easily be made outside of the well defined fields of traditional academic disciplines.
- bb. Historic patterns of externally funding university research by grants and contracts to individual faculty for project-type activity.
- cc. The research "empire-building" and entrepreneurship of individual faculty at the university.
- dd. Unreasonable demands made on research personnel by supporting agency personnel.

51. What specific factors in your opinion are most relevant and important in terms of their support of multidisciplinary research activity? What specific factors are most relevant and important in terms of their being barriers to multidisciplinary research activity? What appear to be the most important problems (and what

are the most important causes of difficulty) in the successful cooperation of research personnel across disciplinary lines? What conditions and forces seem to be most useful in overcoming the barriers to cross-disciplinary research activity?

Personal Evaluation of the Process and Outputs
of Multidisciplinary Research

52. What do you consider to be the most significant and appropriate measures for evaluating multidisciplinary research (e.g., the written documents and publications which then become contributions to a body of literature; professional and university conferences and meetings; improved course content; improved curricula; the personal enrichment of research personnel; the support of good graduate students; the cooperation itself--the process as product--; or other criteria)?
53. Using those of the mentioned criteria which you think most useful, what would your judgment be of NASA/SUP-supported research at your university? Using standard criteria, how would you evaluate the research as contributions to their own disciplines?
54. Is multidisciplinary research activity any different from disciplinary research activity in terms of rewards to the individual researcher being consummate with his effort and input?
55. What, if any, advantages do you see in engaging in multidisciplinary research activity? What disadvantages?

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