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ABSTRACT

This report, published in two volumes, provides a documentary record of the National Science Foundation's (NSF) Science Development Program (SDP). Information is given on overall university funding levels and on other development programs, with SDP goals and procedures described in detail. Using information on budgets and goals as well as summaries of grant impact (contained in Volume II of the report), the author of Volume I has combined this information with that from final grant reports and follow-up site visits to summarize and discuss problems and possible detrimental effects as well as benefits of the SDP. (Author/PEB)

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The NSF Science Development Programs

Volume I:

A Documentary Report

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Foreword

The National Science Foundation's Science Development Programs (SDP) were announced in March 1964. When the grant-making activity ended in 1972, 31 university SDP grants ($179 million), 11 Special SDP grants ($12 million), and 73 Departmental SDP grants ($42 million) had been made with the goal of broadening the apex of the quality pyramid of research and education in science and engineering. These programs grew out of a national concern for the quality of education and for the ability to maintain the rapid pace of scientific and technological innovation in all parts of the Nation.

Many programs contributed to the growth in capacity and quality of the Nation's institutions of higher education. The SDP focused on long-range plans to improve the quality of all aspects of science and engineering research and education in graduate level institutions. They stimulated many institutions to draw up such plans and provided a small, but significant part of the funds for implementing them. The effects of the SDP were tempered by growth in enrollments and funding, followed by continued growth in some geographic regions and economic recession in others. The full effects and benefits may not be felt for some time.

This report, "The NSF Science Development Programs, Volume I: A Documentary Report," and "Volume II: Budgets, Statements of Goals for Each Grant, and Grantees' Summaries of Grant Impact," was prepared between January 1974 and September 1975 by Fred E. Stafford. Volume I gives a factual report of the funding situation for universities and other programs operating at the time of the SDP; the goals and administrative procedures of the programs; the names of grantees and summaries of grant allocations; and, the effects of the SDP. In the chapter on Results and in the Conclusion, Dr. Stafford gives his own impressions, identified as such, of the success of the program.

Volume II of the report gives the budgets and statements of goals for each of the 115 grants, and the grantees' summaries of grant impact. These thoughtful summaries prepared by the University administrators provide an insight into a critical period in the development of higher education in the United States.

Richard C. Atkinson
Director

SUMMARY

The NSF Science Development Programs

Purpose

The purpose of this report, which is published in two volumes, is to provide a documentary record of the National Science Foundation's (NSF's) Science Development Programs (SDP). To place the SDP in perspective, information is given on overall university funding levels and on other development programs. The SDP goals and procedures are described in detail. Tables, arranged in several different ways, identify the supported activities. Statements of budgets and goals (prepared by NSF) and summaries of grant impact (prepared by the grantees) are given in Volume II for each of the 115 grants. Based on these summaries, the final grant reports, and follow-up site visits, Volume I summarizes and discusses the problems and possible detrimental effects, as well as the benefits of the SDP. Although the scope of the present study was limited to gathering objective information and identifying all the effects of the SDP on the grantees, the author was able to reach certain subjective conclusions about the programs. These are presented briefly and are identified as such.

At the termination of the SDP in 1971-72, the NSF asked the National Research Council/National Board on Graduate Education to design and carry out an initial evaluation of the SDP. This study resulted in two reports. The first is a detailed technical report by the Project Director (David E. Drew). It is concerned, in part, with 21 site visits made during the evaluation study, and, primarily, with a statistical analysis of 10 numerical indicators. The second report is by the NBGE and presents the general interpretation of the data and the generalizations drawn from the study by the NBGE.

The present report documents the SDP in both greater breadth and greater detail than was possible for the NRC/NBGE. This body of data seems to sustain conclusions that, in some instances, are different from those reached by NRC/NBGE. These discrepancies are discussed.

I. Introduction

During the 1960's, the Nation was faced with a rapidly increasing number of undergraduate students, a more rapidly increasing number of graduate students, and an exploding body of scientific and technological knowledge. The NSF University and Departmental Science Development Programs (U and D SDP) provided $233 million to about 260 departments or activities in 102 graduate-level institutions (total enrollment: 1.54 million students) for the purpose of upgrading their science and engineering research and education activities as shown in the following table.

AMOUNTS AWARDED, NUMBERS OF AWARDS, AND STARTING DATES FOR THE THREE TYPES OF SCIENCE DEVELOPMENT PROGRAM (SDP) AWARDS

				Date		
Type of Award	No of Grants	Total Awarded (Millions)	Average Grant Size (Millions)	First Award	Median Initial Award	Last Award
University SDP	31	$179	$6	4/65	5/66	6/69 5/72
"Special" SDP	11	12	1	4/66	7/68	9/70
Departmental SDP	73	42	0 6	6/67	8/69	5/71
Total	115	$233				

(The last nine supplemental awards under the University SDP were made in May 1972 Eleven USDP proposals resulted in "special" SDP awards The Departmental SDP category includes both Departmental SDP awards and those made in the 1970 Science Development Program which had a similar format but broader goals than the Departmental SDP)

II. The Milieu of the Science Development Programs

At the start of the 1960's, there was increased awareness of the prosperity of research-based industries near certain academic centers of research, increased concern that all individuals in all regions of the country have equal access to high quality education, and increased concern for the quality of offerings in the Nation's educational institutions.

From 1960 to 1972, degree credit enrollment in all institutions of higher education increased from 3.6 million to 8.3 million students. Current fund income of all institutions increased from $5.8 billion in 1959 to $26.2 billion in 1971. Donations to, and budgets of, individual institutions increased greatly, even if the institution's enrollment did not increase.

Many sources contributed to these increases in funding. Among the programs most similar to the SDP were the Ford Foundation grants for engineering education and its Special ("challenge") Program in Education. The latter included $230 million in grants to 18 Ph.D. granting institutions and $119 million to 66 colleges. It required that the grantees raise an additional $1 billion from non-Federal sources. Related Federal programs included support of facilities, institutional (formula) support, and institutional support for development. Among programs in the latter category were the College Science Improvement Program, COSIP (NSF, 166 grants for $31 million to 160 4-year institutions, and 23 consortium grants totalling $2.2 million), the Sustaining University Program (NASA, 416 grants totalling $224.8 million to 175 institutions), Project THEMIS (DoD, 118 grants totalling $94 million to 77 institutions), the Interdisciplinary Laboratories, IDL (ARPA, $158 million to 12 institutions), the Health Science Advancement Awards (NIH, 11 grants totalling $26 million to 11 institutions), and part of the Academic Computational Facilities Awards Program (NSF, $71.2 million to 184 institutions).

III. The Science Development Programs

The goals of the SDP were presented in detail in the annual budget justifications presented to the Congress, and were summarized in the published announcements made by NSF:

(1) For the University SDP the goal was:

to encourage graduate level institutions judged to have the greatest potential to develop into outstanding centers for science and engineering research and education with the ultimate objective of achieving excellence throughout the broad scope of the institutions' programs. Awards were made for the purpose of

a) raising a few institutions to the point of excellence, and
b) significantly improving the quality of the science and engineering education and research activities of institutions with the potential of ultimately achieving excellence.

(2) In the case of the Departmental SDP, the goal was:

to improve the quality of science and engineering education and academic research in specific individual departments or areas in graduate-level institutions which had developed significant strength in at least one field of science.

(3) Starting in 1970, the SDP were reorganized. Three-year grants similar in size to those of the Departmental SDP were awarded with the goal of strengthening:

a) mathematics, natural sciences, and engineering;
b) the social sciences;
c) the interdisciplinary activities; and,
d) groupings of activities directly related to problem-solving activities in the national interest.

Superimposed on these goals were those of achieving (A) geographic and (B) demographic distribution of strong centers for science and engineering education and research.

The numbers of awards made and the average award amounts have been summarized at the beginning of this summary. Details are given in the main text Tables 11 to 13 and Appendices B-2 through B-6. The University SDP awards generally included two to ten grantee departments or activities. "Special" SDP awards generally included one or two, but could include as many as five activities. Departmental SDP awards generally included one department or one interdisciplinary activity. The budgets and specific goals of each grant, and grantees' summaries of grant impact are given in Volume II. Table 13 and Figure 5 show that the program managers responded to the sometimes contradictory directives to achieve geographic and demographic distribution of the awards.

Table 12 shows the distribution of SDP funds by subject area, while Appendix B-5 permits one to see at a glance all of the universities that received grants for a given area. The areas receiving the most support were:

Physics and Astronomy	(45 departments, $63 million)
Chemistry, Chemical Physics, and Biochemistry	(40 departments, $43 million)
Biological Sciences	(39 departments, $36 million)
Engineering	(50 departments, $26 million)
Social Sciences	(34 departments, $22 million)
Mathematics and Statistics .	(25 departments, $17 million)
Environmental Sciences	(16 departments, $11 million)

IV. Discussion

A. Effects on the Entire Target Population

The Ford Foundation Special ("challenge") Program in Education (1959-1966) focused attention onto the needs of education, stimulated institutional planning for excellence, and accelerated organized fund raising by inviting a small number of private institutions to apply for very large grants. The SDP were open to all applicants; approximately 200 Ph.D.-level[*] institutions, public and private, competed for a high accolade and large grants on the basis of realistic long-range plans for, and progress already made toward achieving long-range goals formulated by their respective faculties and administrations.

The SDP are believed to have had strong effects on most of the approximately 3,000 departments in about 200 institutions—grantees, declinees, and others—in their target populations. These effects were to:

1) help identify the problem of improving academic science as an institutional problem;
2) encourage realistic institutional planning for science development, including involvement of a large cross section of the university population in the identification of needs and goals, and realistic means of achieving the goals;
3) draw attention to the importance of both teaching and research as inseparable aspects of education in science;
4) provide a review of the proposals, feedback to the institution, and stimulus for use of external review committees;
5) provide a mechanism for inter-institutional exchange of ideas; and,
6) stimulate a constructive rivalry between grantee and nongrantee departments, sciences and nonsciences.

B. Direct Effects on the Grantees

Direct effects on the grantees include the accolade, which boosted morale, helped raise standards, and facilitated approaching prospective faculty, students, and sources of funds. Grant funds were in budget categories (*e.g.*, equipment, support staff, visiting lecturers) and had temporal flexibility not normally available to the departments. The SDP grant funds, however, provided only a part of the resources used in development. The State governments, foundations, donors, and various Federal programs helped provide facilities and equipment. In addition, the institutions made increases, sometimes very large, in their allocations to the grantee activity operating budgets.

C. Direct Results

Many aspects of the institutions' activities were benefited, as shown by the grantees' final reports and by our post-grant site visits. The main result was in the improvement of the faculties, as evidenced by a number of independent measures. The most direct result of research active and intellectually alive faculty was on undergraduate and graduate instruction:

- *Undergraduate instruction* benefited through creation and upgrading of courses for majors and nonmajors, use of SDP provided equipment and personnel in laboratories and courses, introduction of new teaching methodologies, and creation of new degree programs.

  Undergraduate instruction benefited also from an increase in undergraduate independent study and research participation, which turn out to be among the most important parts of the students' academic experience.
- *Graduate instruction and research*, as expected, were improved in quality. Indicators of improved quality are the ability of the faculty members to win honors and research support in national competition, increased publication rates, and success in placing the Ph.D. degree recipients. The NRC/NBGE evaluation, however, indicates that the numbers of Ph.D.'s produced generally were not increased relative to the increases in the control institutions.
- *Other departments or schools in the grantee institution* benefited from improved service courses, and sharing of facilities and ideas. In addition, the grantee departments helped provide

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[*] The initial SDP announcement did not restrict applicants to Ph.D. level institutions. Proposals were received from all types of educational institutions. Grants were made, however, only to Ph.D. granting institutions, perhaps giving rise to the incorrect impression that the SDP were not concerned with improving undergraduate instruction. The College Science Improvement Program (COSIP) responded to the science education needs of 4 year institutions.

intellectual leadership and set higher standards for courses and for promotion or tenure.

Other effects have rippled out and even today benefit large numbers of people:

- *K-12 education* was affected by university admissions and first-year course standards, teacher training, science fairs, and participation of faculty husbands or wives in local school systems.
- *Junior colleges and colleges* were benefited through interactions similar to, but more direct than those for K-12.
- *The community and state* benefited from the grantees' interaction with local school systems, extension courses, service to state commissions and agencies, and service to regional industry. The strengthened institutions are considered to make their regions more attractive to industry.
- *Research relevant to current national problems* carried out by grantee departments includes projects related to mineral resources, solar energy, energy conversion, and quality of the environment.

Problems and Detrimental Effects. The main problem cited by some administrators is finding continued support for activities strengthened by the SDP. One university president, however, comments that this is the sort of problem to which administrators gladly turn their efforts.

Decisions about the possible detrimental effects must involve perspective and judgment. The questions are, "Did the SDP cause:

1) over-commitments to tenured faculty, facilities, or certain areas of science and engineering?
2) over-commitment to graduate programs to the detriment of undergraduate education?
3) over-production of Ph. D.'s?
4) jealousy and hard feelings among non-grantee departments?
5) undue depletion of non-SDP institutions?"

For question 2, the answer is unambiguous: the SDP had a strongly beneficial effect on undergraduate instruction. With respect to 3, over-production of Ph.D.'s, the NRC/NBGE reports indicate that SDP grantee Ph.D. production did not increase relative to that of the controls. It seems that the SDP improved the training—and ability to get a job—of individuals who, in any case, would have earned the Ph.D.

With respect to questions 1 and 4, there is no question that SDP were intended to elicit commitments to build quality in carefully selected areas. This appears to be a sound strategy for institutional development when resources are limited. Faculty, depending perhaps on whether their own aspirations are likely to be fulfilled, may be unhappy with the SDP engendered commitments. The statements of the university administrators in Volume II, however, are almost uniformly favorable or strongly favorable in tone. In those universities in sound financial condition, strong SDP departments are unquestionable assets. Those universities under severe financial stress also seem to regard the SDP strengthened departments as important assets for the institution. Whatever imbalance that may have been caused by SDP seems to have been accepted as a necessary risk inherent even in well-founded plans for institutional improvement.

With respect to question 5, the SDP was intended to broaden the geographic and demographic distribution of universities. As intended, the SDP grantees are assets to their respective regions and compete effectively for the limited funds available. At the same time, some of the Nation's strongest universities are reported to be under severe economic stress. It was not in the province of the present study to determine whether this problem was a result, undue or otherwise, of the SDP.

D. Evaluation

The National Research Council/National Board on Graduate Education (NRC/NBGE) Reports

The two NRC/NBGE reports by the project director and by the NBGE are based primarily on a statistical analysis of 10 numerical indicators and on-site visits to 15 grantees and 6 controls. Six of the numerical indicators were directed primarily toward quantity and four toward quality.[*] In order to identify better the effects of the SDP, data were gathered for the period 1958-72. A linear model was used to predict results for the grantees in the absence of the grants. Conclusions were based on a comparison of the values of the numerical indicators for the grantees with those of the controls and with those predicted by the linear model. (The Highlights section of the NBGE report is reproduc-

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[*] Six quantity-directed indicators are numbers of faculty, publications, publications per faculty member, first-year graduate enrollments, total graduate enrollments, and numbers of Ph.D.'s produced. The four quality-directed indicators are Graduate Record Examination scores of entering graduate students, "selectivity" (i.e., average Scholastic Aptitude Test scores) of the graduate students' baccalaureate institutions, Cartter ratings of schools in which new Ph.D.'s accepted jobs, and nonacademic starting salaries.

ed in the text of the present report.) There are some disagreements between the NRC/NBGE reports and the present report. The most important of these are:

- *Controls.* The present report indicates that the SDP had effects on the grantees and on the institutions used by NRC/NBGE as controls. Funds from both the Federal and the private sector were rapidly increasing. Thus, non-SDP institutions had access to extensive resources that could have been used for development. The use of these resources is believed to have been influenced by the SDP. Also, the amounts of funds provided by the SDP were small compared to those from other sources. The project directors report recognizes part of this problem, but the NBGE report seems to have overlooked it. This is critical because the NBGE assessment is based on comparison of the University SDP grantees with the "medium" quality controls.
- *Elapsed time.* The median award dates for the University and Departmental SDP grants are, respectively, May 1966 and August 1969. The last-award dates are, respectively, 1972 and 1971. Statistical data collected by NRC/NBGE extend at best through 1972. The NRC/NBGE reports have correctly noted that the first effect on USDP grantee publication rates might not be seen until 1970, with no effect expected for the DSDP grantees before 1972. They do not note, however, that a graduate student recruited in fall 1966 would not start graduate work until 1967, and would not receive his or her degree until 1971 to 1973. The NRC/NBGE study, therefore, is premature in trying to assess the quality of Ph.D. degree recipients from grantee departments.
- *Use of nonacademic starting salary as an indicator of departmental quality.* Examination of the data presented in the project director's report shows that Ph.D.'s from the "high" control institutions (*e.g.*, Harvard, Wisconsin, Cal Tech) got the same or lower starting salaries in nonacademic positions than did the Ph.D.'s from the "medium" or "low" controls. These starting salaries, therefore, are not a valid indicator of quality. The NRC/NBGE, however, use this indicator to conclude that Ph.D.'s from SDP institutions did not find more attractive nonacademic positions than Ph.D.'s from the controls. Even if the data extended beyond 1970, this conclusion is not valid.

Other points, such as faculty size, "selectivity," and sample composition, are discussed in the text.

Conclusion

The SDP had far-reaching beneficial effects on all of the Nation's science and engineering research and education, and specifically on the SDP grantees. The SDP helped identify science development as an institutional problem, motivated all institutions to prepare well founded long-range plans, and provide critically needed support to about 260 departments or activities in 102 institutions.

Working together, the NSF, its consultants, and the university administrators have built strong programs that are assets to the institutions. In only one instance does an administrator seem to regret the SDP grant. Otherwise, the SDP have brought needed and valuable strength to the teaching, research, and community service programs of the grantees. Many of the 260 grantee departments have become the strongest in their particular regions. Some are among the strongest in the country.

Preface

This report documents the goals, methods, and results of the National Science Foundation's Science Development Programs (SDP).

No program operates in isolation. The events and thinking that led to the SDP gave rise in other agencies to programs with similar goals. These programs are described briefly in Chapter II. Additional information is given in the appendices for the programs that were most similar. These descriptions suggest that the Federal and private sector programs were all parts of one closely coupled, strongly interacting system.

The goals of the SDP might have been described in any of several different ways. The present verbatim use of budget justifications spanning the life of the SDP, plus the final program announcement, is the most accurate representation of what the President proposed and the Congress approved as the specific goals of the SDP. This information is more detailed than that which might be obtained only from the published program announcements.

The descriptions of the administrative procedures (Chapter III) rely heavily on descriptions written by the SDP staff. These descriptions are a faithful representation of what I have seen in the grant files.

There is a sense of excitement that marks certain activities. The author joined the NSF in December 1973, having had no direct connection with the SDP. The program had been terminated and the last grants had been made some 1½ to 2 years previously. Yet, there was still clearly evident a sense of excitement and high purpose associated with the SDP. It cannot be described adequately, but nonetheless was an important part of the way the programs were administered and a determinant of their results.

Chapter IV is a synopsis of the results of the SDP. It is drawn from the follow-up site visits, the final technical reports, and the summaries presented in Volume II. These summaries could not be complete in their coverage due to the limited space available. They do offer however, engrossing insights into the effects of the grants.

The intent of Chapter IV was to identify all of the effects of the SDP. To quantify the effects on, and benefits accruing to each institution would be a logical and challenging extension of the present study.

In almost all instances, we have presented only the objective information form our own observations and from the grantees' reports. The exceptions are clearly indicated. These are value judgments calibrated on my recent experience as a faculty member which I believe will represent the consensus of any group of informed observers. No attempt was made to compare the progress of the grantees to that of comparable nongrantees. Although none was found, no systematic attempt was made to identify deleterious effects on nongrantee institutions.

This work was started and carried out under the general direction of the Assistant Director for Research, Edward Creutz (now Assistant Director for Mathematical and Physical Sciences and Engineering), and the Deputy Assistant Director for Research, Edward P. Todd (now Deputy Assistant Director for Astronomical, Atmospheric, Earth, and Ocean Sciences). It was under the immediate supervision of William E. Wright, Division Director for Mathematical and Physical Sciences.

Celia Heil took responsibility for gathering the grantee summaries of grant impact and for preparation of the tables and manuscript. Richard Honaker and Gerald Butrimovitz aided in these activities.

J. Merton England, formerly of the Institutional Programs staff and now the Foundation's historian, permitted use of unpublished manuscripts. My counterparts in the Grants Office of NSF, Joseph G. Danek and William S. Kirby, cooperated closely in certain aspects of this work. William S. Kirby prepared 27 of the statements of goals in Volume II. Information, comments, and suggestions were offered by D. Don Aufenkamp, Joseph F. Carrabino, Frank J. Dudek, J. Merton England, John F. Lance, Joshua M. Leise, James Mayo, William G. Rosen, and Donald A. Speer. The following individuals were kind enough to comment on all or parts of the manuscript: Laura P. Bautz, William Biel, William D. Commins, William V. Consolazio, Enoch L. Dillon, J. Merton England, Jerome H. Fregeau, Robert M. Johnson, William S. Kirby, Frederic A. Leonard, Louis Levin, Harry J. Piccariello, Ruth Ann Verrell, and Roman J. Wasilewski.

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Fred E. Stafford
October 1975

NSF SCIENCE DEVELOPMENT PROGRAMS
VOLUME I: A Documentary Report

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List of Abbreviations

ARPA	Advanced Research Projects Agency of DoD
DoD	Department of Defense
DSDP or G	NSF Departmental Science Development Program or Grant(s)
FY	Fiscal Year (In the then current Federal practice FY 1975, for instance, refered to the period, July 1, 1974 to June 30, 1975.)
HSAA	Health Science Advancement Awards (NIH)
IDL	Interdisciplinary Laboratory Program of the Advanced Research Projects Agency (ARPA) of DoD. Name later changed to MRL (Materials Research Laboratory)
MRL	Materials Research Laboratory Program (NSF)
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NRC/NBGE	National Research Council/National Board on Graduate Education, an operating unit of the National Academy of Sciences
NSB	National Science Board, the policymaking body of the National Science Foundation
NSF	National Science Foundation
OE	Office of Education of the Department of Health, Education and Welfare
SDP	Science Development Programs (Used inclusively to refer to the NSF Departmental, University, and "1970" Science Development Programs)
SSDG	NSF Special Science Development Grant(s)
USDP or G	NSF University Science Development Program or Grant(s)
1970 SDP	NSF Science Development Program as reorganized in 1970. In this report, grants made under this program are grouped with the Departmental SDG

CHAPTER I

Introduction

Aware of science's contributions to its well-being and spurred on by Sputnik, the Nation perceived through the Seaborg Report (1960) that, "over the next 15-years, the Nation should seek to double the number of universities doing generally excellent work in basic research and graduate education."[1] Educational, economic, and political considerations, including concern for equal access to education (as expressed in the Higher Education Facilities Act of 1963, P.L. 88-204), called for broad geographic and demographic distribution of these universities.

Private foundations and donors, State legislatures, and the Federal Government all responded with a greatly increased flow of funds to universities. With matching funds, for instance, the Ford Foundation "challenge" grants of $25 million each to Stanford and Chicago involved a total of $200 million. The Ford "challenge" program alone made awards to 18 Ph.D.-granting institutions ($230 M) and 66 colleges ($119 M) that involved $1.3 billion with matching funds. Income of higher education institutions increased from $5.8 billion (1959) to $12.7 billion (1965) to $26.2 billion (1971).

Among several NSF responses to the need for strengthening education in science, the Science Development Programs (SDP) had the following objective:

> Strengthening the quality of science and engineering in the principal institutions and regions of the Nation, with major emphasis on undergraduate and graduate education and research.[2]

With its first awards announced by the President, the SDP promised large awards-in-aid to the universities that could formulate the best plans for strengthening the quality of their science programs, and could demonstrate the financial ability to maintain the strengthened programs. The SDP provided a motivation toward quality, incentive for central planning, and part of the wherewithal for more rapid improvement. The SDP focused the attention of educators, administrators, and potential public and private donors on the means of achieving and the benefits of increased quality, as well as those of increased enrollments.

The number of institutions and departments affected was large. Within some institutions, competitions were held to see which departments might participate in a proposal. As of January 1971, these competitions and other internal procedures resulted in over 100 proposals from 92 institutions for the University SDP, and a total of over 300 proposals for both programs. As shown in Table 1, 31 USDP and 11 Special SDP grants resulted from

TABLE 1. NUMBERS OF AWARDS, AMOUNTS AWARDED, AND STARTING DATES FOR THE THREE TYPES OF SCIENCE DEVELOPMENT PROGRAM (SDP) AWARDS

Type of Grant	No of Awards	Total Funds Awarded (Millions)	Average Grant Size (Millions)	Date		
				First Award	Median Initial Award	Last Award
University SDP	31	$179	$6	4/65	5/66	6/69 [2]5/72
"Special" SDP	11	12	1	4/66	7/68	9/70
Departmental SDP[1]	73	42	0.6	6/67	8/69	5/71
Total	115	$233				

[1] Because of their similarity, the Departmental SDP awards and the awards made under the Science Development Program as revised in 1970 (described in Chapter III) are placed in this category.

[2] The last nine supplemental awards in the University SDP were made in May 1972.

the USDP proposals, and 73 Departmental SDP grants resulted from proposals submitted to that program.

When the Science Development Programs terminated in 1972, the Foundation contracted with the National Research Council/National Board on Graduate Education (NRC/NBGE), an operating unit of the National Academy of Sciences, to design and carry out an independent evaluation while the relevant information, documents, and personnel were still available. The evaluation was in two parts. The first was a statistical analysis of ten numerical indicators for the grantees and for three groups of controls chosen on the basis of departmental rating in the Cartter[3] assessment of quality in graduate education. The period of 1958 to 1972 was covered in order to better identify the effects due solely to the SDP. The second part was comprised of site visits, a content analysis of the site visit reports, and summary evaluations; the names of the institutions visited are not given. The study resulted in two reports. The first, by the project director, gives detailed technical information and data.[4] The second report, by the National Board on Graduate Education, summarizes the study's findings and adds the general interpretations of the data and the generalizations drawn from the study by the Board[5]

Purpose. The purpose of the present report is to document the SDP in both greater breadth and greater detail than was possible for the NRC/NBGE. To place the SDP in perspective, we describe the milieu in which SDP functioned. Then the legislatively approved goals of the programs, and the programs' administrative procedures are presented. Detailed tables show how the SDP funds were distributed by region and by discipline. An analysis is presented of how the programs achieved their results. In Volume II of this report[6], there is an individual statement of the budget and goals of each grant, and a summary by the grantee of grant impact and ways in which the program might have been improved. This body of information is summarized in this report. These data seem to sustain conclusions that are, in some instances, different from those presented in the NRC/NBGE reports. The discrepancies will be discussed.

FOOTNOTES, Chapter I

[1] U S President's Science Advisory Committee, "Scientific Progress, the Universities, and the Federal Government," (U S Government Printing Office, Washington, D.C 20402, 1960)

[2] As stated in a Director's program review on October 15, 1970 The SDP goals are presented in detail in Chapter III

[3] Allan M Cartter, "An Assessment of Quality in Graduate Education," (American Council on Education, Washington, D C , 20036, 1966) The study was carried out during 1964 and 1965

[4] David E Drew, "Science Development: An Evaluation Study," (National Academy of Sciences, Washington, D.C., 20418, 1975)

[5] National Board on Graduate Education, "Science Development, University Development and the Federal Government," (National Board on Graduate Education, Washington, D.C 20418, 1975)

[6] U S National Science Foundation, "The NSF Science Development Programs: Volume II, Budgets, Statements of Goals for Each Grant, and Grantees' Summaries of Grant Impact," (Fred E Stafford, ed.) (NSF 77-17) (National Science Foundation, Washington, D C 20550, 1977)

CHAPTER II

The Milieu of the Science Development Programs

The purpose of this chapter is to depict in broad strokes the milieu in which the Science Development Programs functioned and to show their relationship to other public and private programs. Following a description of the overall funding situation for universities, a particular effort is made to document those programs most closely related to the SDP..

A. Events and Thinking Leading to the Increased Support of Higher Education[1, 2]

The needs for warfare-oriented science and technology generated during the early 1940's led to a channeling of resources to a handful of American universities which, by virtue of self development started in the 1890's or early 1900's, already possessed outstanding competence in academic science. Subsequent to the war, those universities which had played so dominant a role in the Government's research programs continued to be the favored places for graduate study by an overwhelming proportion of the most talented baccalaureates in science. The influence of distinguished faculties, outstanding facilities and equipment, and superior students underscored the prestige and scientific capability of this upper echelon of universities.

As the Nation's investment in academic science grew, the simple continuation of project research support led to a disparity in distribution of Federal funds, both institutionally and geographically. The few strong institutions, already capable of conducting outstanding programs of research and training, became the continued beneficiary of a large share of Federal funds for academic science. By fiscal year 1966, for example, approximately $2.17 billion of science support was awarded by Federal agencies to U.S. institutions of higher education; the top 20 universities (based on receipt of Federal funds) received $0.813 billion or 37.5 percent of this total.[2] These 20 universities produced 41.9 percent of the Ph.D.'s in science in 1965-66. Yet, 20 universities constituted less than 9 percent of all American universities and less than 1 percent of all ~~U.S.~~ colleges and universities. In the immediate geographic areas of some of these major universities there sprang up prosperous technology-based companies; in the opinions of some observers, these areas seemed to receive a disproportionate share of Federal research and development contracts and funds.

The two decades following World War II were marked also by rapid increases in knowledge in the sciences and engineering, and by concern for the quality of engineering and science education at all levels. In addition, there was concern about a rapidly increasing college and university population, and about equal opportunity in education through equal access to high quality institutions.

The general situation is described in Alan T. Waterman's 10th year report on the National Science Foundation published in May 1960. In his conclusion, Waterman states:

> A National problem to which the Federal Government has paid relatively little attention. . .is that of support for educational institutions to develop their own capabilities in science and engineering. . .They have received little aid of a sufficiently general type to enable them to carry out their own plans for growth in science and engineering and to maintain a proper balance between these activities and others in which they engage.[3]

In November 1960, the President's Science Advisory Committee noted in the "Seaborg Report" that:

> . . .American science in the next generation must, quite literally, double and redouble in size and strength. . .It is the simple truth that if this country is to safeguard its freedom and harvest the great opportunities of the next generation of science, the level of its scientific investment must be multiplied and multiplied again.
>
> Yet the right word is *investment*. What

> this country spends on excellence in the sciences is not money gone with the wind. It is money that brings us handsome returns, and of many kinds. . .[4]

A series of documents illustrate, in detail, thinking going on during this period within the National Science Foundation. They describe the role of graduate education in American life, characteristics of quality, and the details of the productivity and funding of academic science. Recommendations are made for action by the institutions, the states and regions, and the Federal Government.[5,6,7]

B. Overview of University Funding During the 1960's

This section attempts to sketch the overall growth in enrollment and funding of universities during the 1960's.

The levels of Federal obligations for all of higher education (1962-1975) are shown in Table 2. Annual total obligations for basic research increased from $602 million to $1.3 billion. Facilities and equipment support reached a high value of $822 million in 1967, while "other institutional support" increased from $33 million to $355 million. Similarly, the total annual "current-fund income" (from all sources) for all institutions increased from $9.5 *billion* (1963) to $26.2 *billion* (1971).[8]

Table 1 shows that the SDP obligated $233 million between 1965 and 1972 or, on the average, about $33 million annually. Even considering that the SDP involved only 102 institutions, with about 1/5 to 1/6 of the Nation's total student population, the SDP obligations are small compared to, for instance, the figures for basic research shown in Table 2.

Table 3 shows that total enrollment in institutions of higher education increased from 3.6 to 8.3 million students between 1960 and 1972. Enrollment in public institutions increased threefold, from 2.1 to 6.2 million. Enrollment in private institutions, however, increased from 1.5 million (1960) to 2.0 million (1965) and then held constant.[8] The last lines in Table 3 show that the SDP directly affected institutions with about 1/5 to 1/6 of the Nation's student enrollment.

It is not within the province of this report to examine in detail the funding situations of each of the 180-odd institutions in the target population of the SDP. Three examples will be cited to suggest the situations at most private and public institutions. First, Ford "challenge" grants of $25 million each to Chicago, Columbia, NYU, and Stanford carried commitments for these institutions to raise, over 5-year time periods, an additional $300 million from non-Federal sources, for a total of $400 million.

Second, to cite a particular institution as an example, the University of Southern California (USC) received a University SDP award for $7.5 million in 1965. During the period 1965 to 1972,

TABLE 2. FEDERAL FUNDS SUPPORTING HIGHER EDUCATION IN EDUCATIONAL INSTITUTIONS (MILLIONS OF DOLLARS) AND CURRENT FUND INCOME (BILLIONS OF DOLLARS)[1]

	New obligational authority					Outlay		
Type of support, level, and program area	1962	1963	1965	1967	1969	1971	1973	1976 (estimated)
Higher education	1,210	1,397	2,052	3,634	3,347	4,835	5,985	6,630
Basic research in U.S. educational institutions proper	602	691	784	1,032	1,020	1,064	1,177	1,275
Research facilities	121	157	191	260	238	227	223	181
Training grants, fellowships, and traineeships	299	377	479	713	662	1,037	1,184	1,116
Facilities and equipment	37	41	384	822	482	618	236	126
Other institutional support	33	43	93	169	173	266	339	355
Other student assistance	103	69	100	590	769	1,781	2,824	3,477
Other higher education assistance	11	16	18	54	9	9		
Current fund income (billions of dollars)	n/a	9.5	12.7	16.8	21.5	26.2	n/a	n/a

[1] SOURCE W. Vance Grant and C. George Lind, "Digest of Educational Statistics, 1974 Edition" (National Center for Educational Statistics Publication 75-210) (U.S. Government Printing Office, Washington, D.C. 20402, 1975), Tables 138 and 125. Current-fund income not available for 1962, 1973, and 1975

TABLE 3. DEGREE CREDIT ENROLLMENT (MILLIONS OF STUDENTS) IN INSTITUTIONS OF HIGHER EDUCATION BY CONTROL OF INSTITUTION (1960-1972)[1]; ENROLLMENT IN SDP INSTITUTIONS (1972)

Year	Total	Public	Private
1960	3.6	2.1	1.5
1962	4.2	2.6	1.6
1964	5.0	3.2	1.8
1966	5.9	3.9	2.0
1968	6.9	4.9	2.0
1970	7.9	5.8	2.1
1972	8.3	6.2	2.1
1972 USDP	0.61	0.49	0.12
D + S SDP	0.92	0.78	0.14
Total SDP	1.54	1.27	0.27

[1] W. Vance Grant and C. George Lind, Digest of Educational Statistics, 1974 Edition (National Center for Educational Statistics Publication 75-210) (U.S. Government Printing Office, Washington, D.C. 20402, 1975) Table 87.

Estimated

USC completed or had under construction $75 million of new facilities. Its "Master Plan" of 1963 originally called for over $100 million in development (facilities, faculty, curriculum), and was later increased in amount. During the grant period, 1965-1971, its annual "instruction and research" budget increased from $21 million to $44 million while its enrollment increased only slightly. State supported universities often experienced large increases in enrollment, resulting in larger increases in construction and operating budgets than those mentioned for USC.

Third, for a representative chemistry department (with 25-30 faculty and 50 to 150 graduate students, and with a Cartter ranking between 20 and 30 in the country), the operating budget in this period might have been $½ to $1½ million from the university plus $½ to $2 million in outside awards, grants, and contracts. It will be seen that the largest chemistry allocation in a USDP grant was $3.8 million, including a large sum for construction.

The twenty other allocations for chemistry ranged from $2.1 to $0.4 million. The median was $1.3 million or $260,000 per year. This sum, if going entirely into the annual operating budget, might represent an increase of 20 percent to 50 percent, which the university would have been committed to maintain after the end of the grant.

C. Ford Foundation Programs

In the private sector, there were many foundations and individual donors that contributed to the increased university budgets described above. We single out for consideration the Ford Foundation Programs because they are similar to, and seem to have set an example for the SDP.

The Ford Foundation had already started in 1958 to make grants for the purpose of strengthening engineering faculties, developing potential teachers, attracting students, encouraging imaginative experiments, accelerating programs, initiating curriculum experiments, and stimulating transition to a science-oriented engineering education.[9] Some of the larger awards are listed in Table 4.

In 1959, the Ford Foundation started its Special ("challenge") Program in Education.[9, 10] Under the terms of this program, the grantees were required to raise, within 3 to 5 years and from nongovernment sources, up to four times the grant amount, hence the nickname "challenge" grants. The purpose of the program was to assist selected institutions in different regions of the country to reach and sustain wholly new levels of academic excellence, administrative effectiveness, and financial support, *i.e.*, to become regional and national centers of excellence. This was to be accomplished by: (1) strengthening the universities' total achievement; (2) using funds in any way to advance long range plans; and, (3) helping broaden the base for continuous financial support from alumni, business, and industry. The awards were based on: (a) needs; (b) accomplishments; (c) potential for advancement; and, (d) fund raising ability. Ford "challenge" grants were made only to private institutions and were invitational; applications were not permitted. The funds were available to

TABLE 4. EXAMPLES OF FORD ENGINEERING GRANTS, 1958-1967[1]

School	Amount	SDP Type[2]	Controls[3]
California (UCLA)	$1,384,000	—	Med P
Carnegie-Mellon	2,545,000	U	
Case-Western Reserve	9,000,000	U	
Cornell	8,750,000	—	High CMP
Illinois Inst. of Tech	5,000,000	D	
Michigan	1,416,823	—	Med C
Pennsylvania	3,000,000	—	Med CMP
Stanford	4,890,000	—	High CMP
Texas	975,000	U	

[1] Ford Foundation Annual Reports, 1958-67 (Ford Foundation, New York, N.Y.) Only the larger grants are indicated. These entries represent grants made for several different purposes: engineering faculty development, curriculum and teaching facilities (including those for the basic sciences), etc.

[2] U (University) and D (Departmental) Science Development Grant recipients.

[3] This column indicates whether a department in the institution was used by NRC/NBGE as a "high," "medium," or "low" control for chemistry (C), mathematics (M), or physics (P). A "high" control is a non-SDP grantee department with a high rating in the Cartter "Assessment of Quality in Graduate Education."

the entire institution, not just its scientific departments.[11] Table 5 shows that $230 million was awarded to 16 universities, plus Claremont and Bryn Mawr Colleges. An additional $119 million was awarded to 66 colleges, for a total of $349 million. With matching funds, a total of $1.3 billion was involved.

TABLE 5. FORD FOUNDATION SPECIAL PROGRAM IN EDUCATION ("CHALLENGE") GRANTS TO UNIVERSITIES, 1960-1966[1, 2]

School	Date of Award	Amount (Millions)	SDP Type[3]	Control[4]
Brandeis	1963	$6.0	S	
	1965	6.0	S	
Brown	1961	7.5	—	High: M
	1965	5.0	—	Med: CP
Bryn Mawr	1962	2.5	D	
Chicago	1965	25.0	—	High: CMP
Claremont	1965	5.0	D	
Columbia	1966	25.0	—	
Denver	1960	5.0	D	
Duke	1966	8.0	U	
Emory	1966	6.0	D	
Johns Hopkins	1960	6.0	—	Med: CMP
	1962	6.0	—	
NYU	1964	25.0	U	
Notre Dame	1960	6.0	U	
	1964	6.0	U	
USC	1963	6.5	U	
	1965	7.5	U	
Stanford	1960	25.0	—	High: CMP
St. Louis Univ	1965	5.0	—	
Tulane	1964	6.0	U	
Vanderbilt	1960	4.0	U	
	1966	11.0	U	
Washington Univ (St. L.)	1965	15.0	U	
		$230.0		

[1] "Toward Greatness in Higher Education. A First Report on the Ford Foundation Special Program in Education," (Ford Foundation, New York, N.Y. 10022, 1964) with addenda dated Sept. 1, 1971. Ford Foundation Annual Reports, 1958 to 1972 (Ford Foundation, New York, N.Y. 10022)

[2] An additional $119 million was awarded to 66 colleges, for a total of $349 million. With matching funds, a total of $1.3 billion was involved. (We, for present purposes, have classed Claremont and Bryn Mawr as universities.)

[3] U (University), S (Special), and D (Departmental) Science Development Grant recipients

[4] This column indicates whether a department in the institution was used by NRC/NBGE as a "high," "medium," or "low" control for chemistry (C), mathematics (M), or physics (P). A "high" control is a non-SDP grantee department with a high rating in the Cartter "Assessment of Quality in Graduate Education."

D. Federal Programs[12]

In the Federal sector, three types of programs emerged that are relevant to the present discussion: support of facilities; institutional (formula) support; and, institutional support for development.

Support of Facilities

The **Health Research Facilities** Act of 1956 (National Institutes of Health, NIH) provided public and nonprofit institutions with grants-in-aid for up to 50 percent of costs for new construction, remodeling and alteration, and equipping new and existing buildings to be used for research in the sciences related to health. The purpose of the grants was to expand capacity, improve quality, and promote equitable geographic distribution of research in health sciences.

The **Health Manpower Training Facilities Program (NIH)** provided 55-60 percent of the total costs for undergraduate and graduate health professions teaching facilities, teaching facilities for nurses, and multipurpose and graduate facilities for these professions.

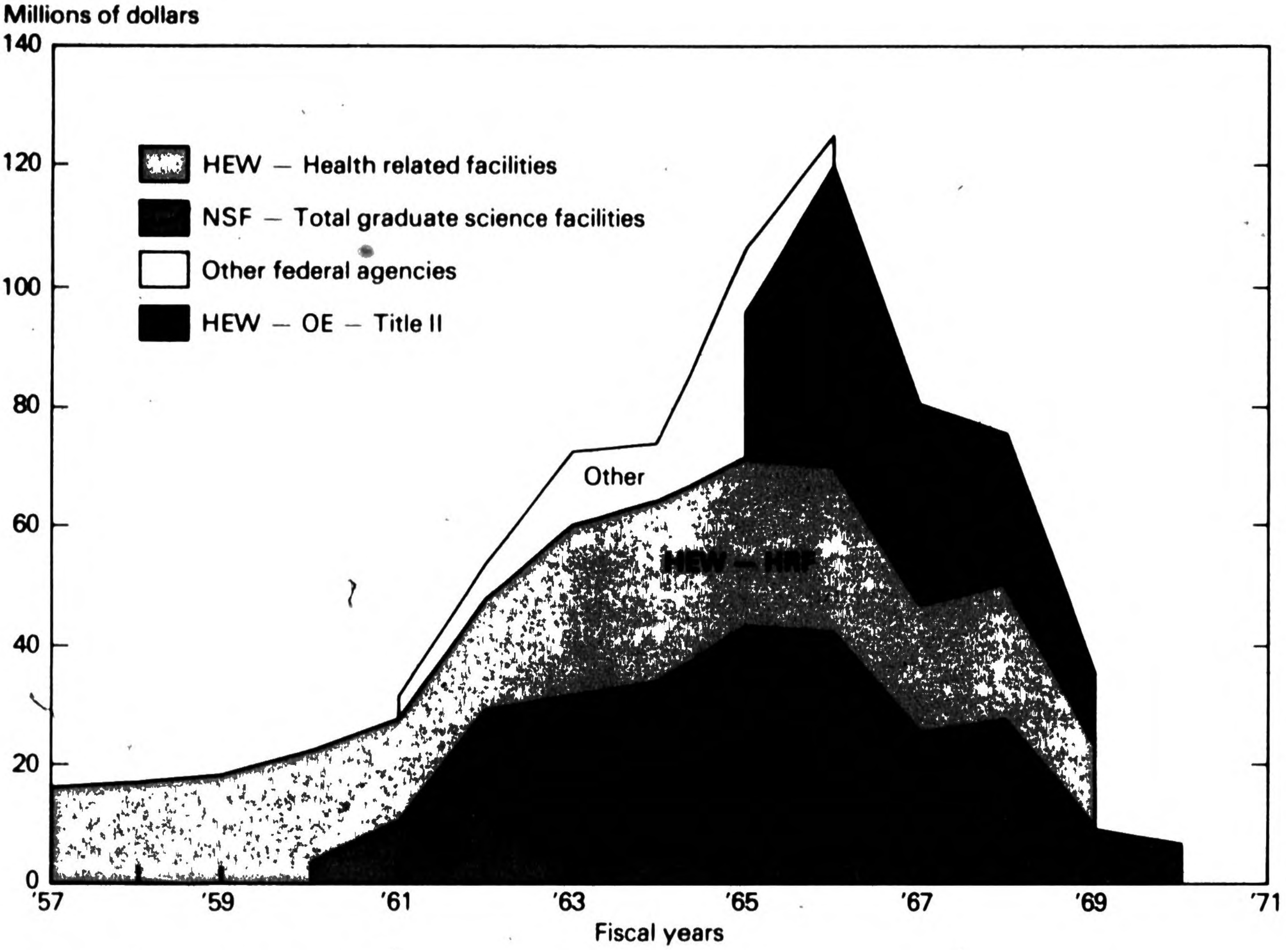
The **Higher Education Facilities Act of 1963 (Office of Education)** provided undergraduate facility matching grants (Title I), graduate facility matching grants (Title II), and loans for all levels (Title III). The purpose of Title I was to expand student enrollment capacity with emphasis on development of public community colleges and technical institutes. The purpose of Title II was to attain wider geographic distribution of graduate schools; it included support for the humanities, fine arts, and teacher education, as well as for the sciences. Not more than 12½ percent of the total appropriated funds could be made available to any one state.

The **Graduate Science Facilities** program (NSF) was inaugurated in 1959 as the Graduate Laboratory Development program. Between FY 1960 and FY 1970 it provided 977 grants totaling $188.16 million to assist in construction of laboratory space and acquisition of general purpose equipment for such space. The equipment and space so acquired had a total value of approximately $500 million. About one-half of the funds granted were for the physical sciences, 23 percent for the life sciences, 15 percent for engineering sciences, and 10 percent for the behavioral sciences. A list of grants was given each year,[13] and a cumulative listing of awards for 1965-1970 has been published.[14]

In Figure 1 the total Federal grant funds for graduate science facilities are shown as a function of time for fiscal years 1957-70. Funding ceased after 1970. Figure 1 represents total expenditures of about $¾ billion.

Institutional (Formula) Support

The amount of a "formula" grant is determined on the basis of a fixed formula from the value of competitive grants awarded to an institution.



SOURCE National Science Foundation

Figure 1. Total Federal Grant Funds for Graduate Science Facilities by Fiscal Years 1957-1970

General Research Support Grants were provided by the National Institutes of Health (NIH) on a formula basis to health professional schools (including schools of nursing, pharmacy, and veterinary medicine), hospitals, and nonacademic research institutions that had received at least $100,000 during the prior year from NIH for research project grants. In FY 1971, the program was funded at $43.4 million.

Biochemical Sciences Support Grants (NIH) were provided on a formula basis to support health related research in academic institutions other than health professional schools that had received research project grants totaling $200,000 in the prior year. In FY 1971, the program was funded at $6.8 million.

Institutional Grants for Science (NSF) were intended to sustain and improve the quality of academic science in colleges and universities that already showed evidence of quality through winning Federal research awards or grants from NSF for research training or participation. They were computed by applying a graduated formula to the amount of Federal (except Public Health Service) research and NSF research participation funds reported in the latest CASE (Committee for Academic Science and Engineering) data. These funds could be carried over from one year to another and used for any purpose in support of engineering and science except indirect costs.

Table 6 shows the total annual obligations for NSF Institutional Grants for Science. The number

TABLE 6. OBLIGATIONS FOR NSF INSTITUTIONAL GRANTS FOR SCIENCE, FY 1961-1974

Fiscal Year	Number of Institutions	Obligations (Millions)	Average Obligation per Grant (Thousands)
1961	248	$1.5	$6.0
1962	302	3.7	12.3
1963	397	7.6	19.1
1964	370	11.4	30.8
1965	376	11.4	30.3
1966	401	14.5	36.2
1967	517	15.2	29.4
1968	498	14.1	28.3
1969*	—0—	—0—	
1970	634	14.5	22.9
1971	659	14.5	22.0
1972	628	12.0	19.1
1973	660	8.0	12.1
1974	675	6.9	10.2
1975	—	—0—	—

* Because of a change in date of awards from June to November, no obligations for Institutional Grants were incurred in FY 1969

of institutions benefiting from these grants increased from 248 in FY 1961 to 675 in FY 1974. As shown in the last column, the average annual obligation per participant varied between $6,000 and $36,200.

Institutional Support for Development

A program for **Strengthening Developing Institutions** of the Office of Education (OE) of the Department of Health, Education and Welfare provided undergraduate institutions with block grants for cooperative arrangements with other developing institutions, stronger institutions, and business and industrial organizations. Projects included arrangements for faculty and student exchanges, development of new curriculums and materials, work-study programs, joint use of facilities, strengthening quality of instruction, fellowships for junior faculty, etc.

The **College Science Improvement Programs (COSIP A AND B)** (NSF) accepted proposals "from predominately 4-year institutions, including those for cooperative projects. It was the Foundation's intention through COSIP to provide aggressive institutions with a competitive incentive for orderly long-range development of their science programs. The intrinsic scientific and educational soundness of specific activities proposed was therefore not the sole criterion for award. High priority was given institutions that exhibited plans for coordinated development from careful consideration of the existing situation and future potential."[15]

Between 1967 and 1973, 170 grants totaling $31 million were made under COSIP A to 160 individual institutions, and 24 grants totaling $2.2 million were awarded under COSIP B to groups of institutions for consortium activities. Five recipients of the individual grants also received Science Development Program Grants (Drexel University, Marquette University, Tennessee Technological University, William and Mary College, and University of Wisconsin-Milwaukee). Documentary and evaluative reports on the COSIP A and B programs have been published.[15, 16, 17]

Another program, COSIP-D was aimed at those 2- and 4-year institutions which historically and predominantly served ethnic minorities. This program was designed to assist these institutions in their efforts to bring their science instruction to satisfactory levels. COSIP-D was initiated with 4-year colleges in fiscal year 1972, and was extended to 2-year colleges in fiscal year 1973. To date (1975), 82 institutions have received $20 million in grants. The program is now called Minority Institutions Science Improvement (MISIP).

The **Sustaining University Program** of the National Aeronautics and Space Administration (NASA) provided block grants for graduate training in the space-related sciences. Multidisciplinary research projects were supported, facilities were funded, and 3-year predoctoral traineeships were supported on an annual basis in engineering, physical sciences, biological sciences, and other disciplines with direct relationship to the space program. Trainees were selected by the faculty of the participating institution. Between 1962 and 1971, $224.8 million was obligated as shown in Table 7.[18] Appendix A-1 lists the number of awards

TABLE 7. SUMMARY OF FUNDS OBLIGATED BY THE NASA SUSTAINING UNIVERSITY PROGRAM, 1962-1971[1] [2]

	Net Obligations (Millions)	No. of Grants	No. of Institutions
Graduate training	$105.5	225	153
Multidisciplinary Research	73.4	158	91
Facilities	42.6	34	31
Total	$221.5 [3]($224.8)	416	175

[1] SOURCE Office of University Affairs, National Aeronautics and Space Administration, Washington, D.C. 20546

[2] Please see Appendix A-1 for a more detailed listing of grants

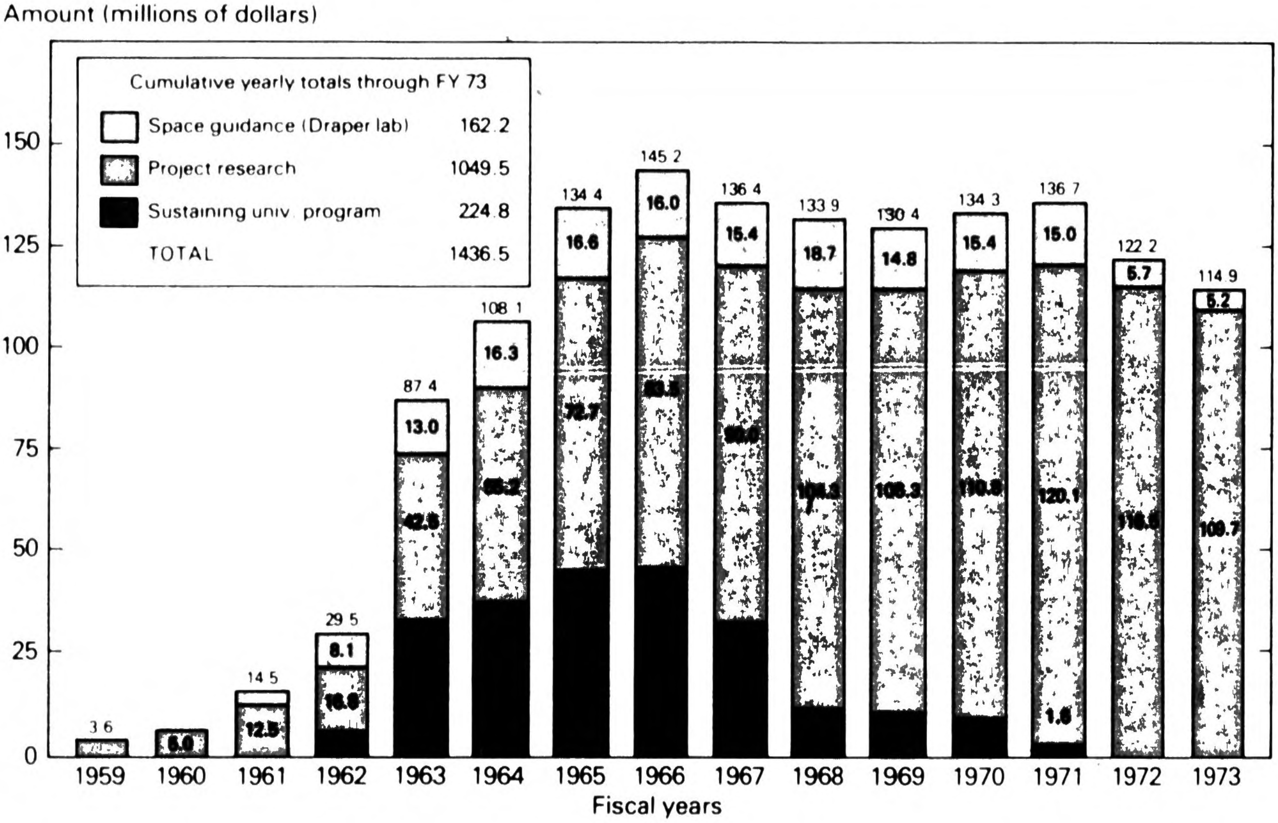
[3] Gross obligations were $3.3 M higher, i.e., $224.8 M

and amounts by institution. Figure 2 shows the award amount, by year, for the Sustaining University Program as well as the amounts spent by NASA for project research.

Project THEMIS of the Department of Defense (DoD) was initiated in fiscal year 1967 to develop new academic centers of excellence in science and technology. Through Project THEMIS, the DoD attempted to strengthen the Nation's universities, increase the number of institutions performing high quality research, achieve a wider geographic distribution of research funds, and thus enhance academic capability in science and technology. The projects that were selected for funding were chosen on the basis that they would contribute to both the long-range educational goals of the universities, and the long-term research needs of the DoD. Project THEMIS also favored those institutions which had not previously received substantial DoD support. However, Project THEMIS, while meeting some of the long-range research needs of the DoD and, at the same time, aiding many colleges and universities, was narrower in scope and purpose than the Foundation's institutional programs. The participating universities were enthusiastic about Project THEMIS, but the DoD had mixed feelings about project results. Project THEMIS was terminated by Congress at the end of fiscal year 1971.[19]

Between 1967 and 1970, there were 118 Project THEMIS grants totaling $88.49 million, with an additional $6 million planned for FY 1971. Appendix A-2 lists the names of recipients, program topics and departments, and the amounts of the awards. Fifty institutions that received Departmental or Special SDP, and 16 that received University SDP grants also received THEMIS awards.

The **Interdisciplinary Laboratories (IDL)** for materials research were established in 1961 by



Note: Excludes Federally Funded Research and Development Centers
SOURCE: NASA OFFICE OF UNIVERSITY AFFAIRS

Figure 2. NASA Obligations to Universities, 1959-1973

ARPA (the Advanced Research Projects Agency of the Department of Defense) to: (1) satisfy a pressing need for training larger numbers of highly competent personnel capable of dealing with problems in the area of materials; and, (2) develop new interdisciplinary approaches to materials research problems by the funding of major central research facilities and a broad range of research in materials-related disciplines. Between 1961 and 1972, $158 million were spent for facilities, equipment, and personnel. After transfer to NSF, the program continues as the Materials Research Laboratories (MRL) with diminished emphasis on goal (1) and increased emphasis on goal (2), particularly with regard to interdisciplinary research. The current annual funding level is $13.9 million. Table 8 indicates the names of the 12 original IDL institutions, as well as those of the more recently established MRL's.

TABLE 8. INTERDISCIPLINARY MATERIALS RESEARCH LABORATORIES CURRENTLY SUPPORTED BY NSF[1]

Institution	Comments[2]
Brown University	
Carnegie-Mellon University[3]	(USDG)
Case Western Reserve University[4]	(USDG)
University of Chicago	
Cornell University	
Harvard University	
University of Illinois	
University of Maryland	(USDG)
Massachusetts Institute of Technology	
University of Massachusetts, Amherst[3]	(DSDG: Psychology)
University of North Carolina	(USDG)
Northwestern University	(SSDG)
University of Pennsylvania	
Purdue University	(USDG)
Stanford University	
Pennsylvania State University[5]	

[1] Twelve of these laboratories were originally supported by APRA (1961 to 1972) as Interdisciplinary Laboratories (IDL) and then continued as Materials Research Laboratories (MRL) by NSF (1972-)

[2] U S and DSDG indicate University Special and Departmental Science Development Grants

[3] Initiated June 15 1973

[4] Initiated September 1 1974

[5] Initiated May 15 1974

The **Health Sciences Advancement Award Program (HSAA)** (NIH) was intended to expand the national capability for research in the health sciences by increasing the number of distinguished biomedical research and research training institutions within the Nation. The program was designed to assist academic institutions to strengthen significantly their activities in the health sciences by: (1) supporting the advancement of new and existing health research and training endeavors where an appropriate institutional case for such advancement existed; and, (2) encouraging the development of health science activities in institutions that possessed considerable strength in related fields of science.[20]

Over 148 applications were received, and 11 awards totaling $26.35 million were made, as shown in Table 9, which shows that eight of the HSAA grantees also were University SDP grantees. Because this program was most similar in nature to the University SDP, we include in Appendix A-3 a brief description of the goals of each grant. The University SDP grant to the University of Iowa was similar to the HSAA in that departments in the health professional schools and the undergraduate colleges were involved.

TABLE 9. HEALTH SCIENCE ADVANCEMENT AWARDS (NIH), 1966-1974[1,2]

Name of Institution	Project Period	Total Awarded	USDP[3]
University of Virginia	6/01/66-5/31/71	$2,199,571	U
Cornell University	6/01/66-5/31/71	1,780,233	
Purdue University	6/29/67-6/30/72	2,542,352	U
University of Oregon	6/29/67-6/30/72	2,097,200	U
Vanderbilt University	6/29/67-6/30/72	2,491,265	U
University of Colorado	6/29/67-6/30/72	2,654,802	U
Washington University	6/29/67-6/30/72	2,731,258	U
Rice University	6/19/68-6/30/73	2,130,074	U
U. of Calif. at Davis	6/19/68-6/30/73	2,468,767	
University of Kansas	6/01/69-5/31/74	2,638,288	
Duke University	6/01/69-5/31/74	2,516,190	U
Total		$26,250,000	

[1] SOURCE Division of Research Resources, National Institutes of Health Bethesda, MD 20014

[2] Please see Appendix A-3 for detailed statements of goals

[3] Indicates University SDP grantees

The **Academic Computational Facilities and Operations Program** (NSF) was established to provide partial support to universities and colleges for the purchase, rental, and operation of electronic computers and related equipment required by their science programs. This program was, in part, considered to be one of the institutional support programs of the Foundation. Between FY 1956 and 1970, 184 institutions received grants with a total value of $71.2 million.

Graduate Traineeships were awarded to institutions, who in turn chose the trainees. This program could be considered part of the activities to help develop institutions. In 1964, the NSF program started with 109 institutions sharing 925 traineeships in engineering. In 1965, the program was broadened to include also the mathematical and physical sciences; 163 institutions received 2,784 fellowships, of which 1,859 were new starts. It was later broadened to include all of the areas supported by the Foundation. A detailed list of awards is given each year.[13] The last starts under this broad program were made in FY 1971. Traineeships continue to be awarded, however, for energy-related programs.

E. Summary

Many institutional programs were operative during the 1960's, some of them prompted by a Presidential directive in 1965[21], to broaden the distribution of Federal research funds. Of these programs, the Ford, the SDP, COSIP, and the Health Science Advancement Awards stressed institutional planning. The Ford "challenge" program was limited to private institutions by invitation. The amount of these institutional funds seems to be small compared to the Federal funds, or to the total funds available to institutions for construction and development. The implication, which needs to be examined further, is that a nongrantee department might, and in general did, attract large amounts of non-SDP funds for its own development.

FOOTNOTES, Chapter II

[1] This section is based primarily, but not exclusively on reference 2

[2] U.S. Congress: House Committee on Science and Astronautics; Subcommittee on Science, Research, and Development. Hearings, 91st Congress, 1st Session, 1970 National Science Foundation Authorization, Volume II. (U.S. Government Printing Office, Washington, D.C. 20402, 1969) pp. 526 ff.

[3] Alan T. Waterman, "The National Science Foundation: A Ten Year Resume," Science *131*, 1341 (1960).

[4] U.S. President's Science Advisory Committee, "Scientific Progress, the Universities, and the Federal Government," (U.S. Government Printing Office, Washington, D.C. 20402, 1960).

[5] William V. Consolazio, "The Dynamics of Academic Science: A Degree Profile of Academic Science and Technology and the Contributions of Federal Funds for Academic Science to Universities and Colleges," (NSF 67-6) (U.S. Government Printing Office, Washington, D.C. 20402, 1967).

[6] U.S. National Science Foundation, National Science Board, "Toward a Public Policy For Graduate Education in the Sciences," (NSB 69-1) (U.S. Government Printing Office, Washington, D.C. 20402, 1969).

[7] U.S. National Science Foundation, National Science Board, "Graduate Education: Parameters for Public Policy," (by Lawton M. Hartman) (NSB 69-2) (U.S. Government Printing Office, Washington, D.C. 20402, 1969).

[8] W. Vance Grant and C. George Lind, "Digest of Educational Statistics, 1974 Edition," (National Center for Educational Statistics Publication 75-210) (U.S. Government Printing Office, Washington, D.C. 20402, 1975).

[9] Ford Foundation Annual Reports, 1958 to 1972 (The Ford Foundation, New York, N.Y. 10022).

[10] Ford Foundation, "Toward Greatness in Higher Education: A First Report on the Ford Foundation Special Program in Education," (Ford Foundation, New York, N.Y. 10022, 1964). An addendum to the report is dated September 1, 1971.

[11] Howard E. Page, "The Science Development Program," in "Science Policy and the University," Harold Orlans, ed. (The Brookings Institution, Washington, D.C. 20036, 1968) pp. 101 to 119. A description of the Ford "challenge" grants appears in the discussion of Page's paper, pp. 116-118.

[12] Unless otherwise noted, this discussion is based on material compiled by the staff of the Science Development Programs.

[13] U.S. National Science Foundation, "NSF Grants and Awards," (U.S. Government Printing Office, Washington, D.C. 20402). This report is published annually.

[14] U.S. Congress: House Committee on Science and Astronautics; Subcommittee on Science, Research, and Development. Hearings, 92nd Congress, 1st Session, 1972 National Science Foundation Authorization. (U.S. Government Printing Office, Washington, D.C. 20402, 1971) pp. 850-855.

[15] U.S. National Science Foundation, "College Science Improvement Programs, COSIP A and B Report," R.A. Verell and R. F. Watson, eds. (NSF E-75-41) (U.S. Government Printing Office, Washington, D.C. 20402, 1974).

[16] David E. Drew, "On the Allocation of Federal Funds for Science Education," ACE Research Reports, 5, No. 7 (American Council on Education, Washington, D.C. 20036, 1970).

[17] David E. Drew, "A Study of the NSF College Science Improvement Program," ACE Research Reports, *6*, No. 4 (American Council on Education, Washington, D.C. 20036, 1971).

[18] Letter communication from the Office of University Affairs, National Aeronautics and Space Administration, Washington, D.C. 20546.

[19] Letter communication from the Special Assistant to Deputy Director (Research and Advanced Technology), Office of the Director of Defense Research and Engineering, Department of Defense, Washington, D.C. 20301.

[20] Annual Report for Fiscal Year 1969, Division of Research Resources, National Institutes of Health, Public Health Service, Bethesda, MD 20014.

[21] U.S. National Science Foundation, "Annual Report, Fiscal Year 1966," (NSF 67-1) (U.S. Government Printing Office, Washington, D.C. 20402) pp. ix ff.

CHAPTER III

The Science Development Programs

A factual and interpretive summary of the events leading up to the establishment, and the early experience of the University SDP has been given by Page[1, 2] who was Head of the Office of Institutional Programs while the SDP were being formulated, and eventually was Deputy Associate Director for Institutional Relations. Page has also summarized some of the later developments.[3] Discussions of the University and Departmental SDP appear also in the 1970 NSF Authorization Hearings.[4]

A. Goals (Summary)

(1) For the University SDP, the goal was:

to encourage graduate level institutions judged to have the greatest potential to develop into outstanding centers for science and engineering research and education with the ultimate objective of achieving excellence throughout the broad scope of the institutions' programs. Awards were made for the purpose of:

a) raising a few institutions to the point of excellence; and,

b) significantly improving the quality of the science and engineering education and research activities of institutions with the potential of ultimately achieving excellence.

(2) In the case of the Departmental SDP, the goal was:

to improve the quality of science and engineering education and academic research in specific individual departments or areas of science in graduate level institutions which had developed significant strength in at least one field of science.

(3) Starting in 1970, the SDP were reorganized. Three-year grants similar in size to those of the Departmental SDP were awarded with the goal of strengthening.

a) mathematics, natural sciences, and engineering;

b) the social sciences;

c) interdisciplinary activities; and,

d) groupings of activities directly related to problem-solving activities in the national interest.

Superimposed on these goals were those of achieving (A) geographic and (B) demographic distribution of strong centers for science and engineering education and research.

This summary of goals is based on the detailed information presented in the next section.

B. Goals (Evolution with Time, and Relationship to Other NSF Programs)

Over the life of the SDP, goals and budgets for the programs were presented annually by the President to and approved by the Congress. Policy decisions on how to achieve these goals were made by the National Science Board (NSB), the policymaking body of NSF. Because of interaction with the academic community and guidance given by the Executive branch, the Legislative branch, and the NSB, the goals of the programs evolved with time. Because any evaluation of the SDP must, in part, judge how well these legislatively approved goals were met, we present here excerpts from the budget justifications for the years 1964, 1966, and 1968. For 1970, we use the public announcement of the revised SDP. All of the public announcements accurately reflect the legislatively approved goals, but are less detailed than the justifications. Although budget justifications were presented to Congress annually, the sampling presented here adequately represents the goals of the SDP.

To round out the presentation, we give also: brief comments on SDP-related administrative developments within NSF; a section on the policy of demographic and geographic distribution of grants; and, excerpts from the 1968 budget justifications that show the relationships between all of the NSF institutional programs. (All of these programs were active in 1968.)

1964

The President's budget recommendation presented to the Congress for FY 1964 proposed what was later to be named the University Science Development Program (USDP). The abstract of the justification for this proposal stated:

> The Science Development Program will be initiated in FY 1964. This program is

> designed to enable a number of institutions to plan for stronger programs in research and education in the sciences and engineering. Institutions selected for support will be able to assemble more competent and qualified scientists and engineers on their staffs, to introduce highly desirable new curricula, to secure needed equipment and facilities, and to attract larger numbers of qualified students. The coherent assistance which will be provided will accelerate the development of a number of carefully selected institutions having the potential for developing into centers of scientific excellence.[5]

The proposed operation and goals were then described in greater detail.

> In FY 1964, the new program will be generally announced, and qualified institutions invited to submit proposals requesting assistance for their development in science on the basis of carefully worked out plans. Each institution will be expected to appraise its own strengths and deficiencies, and to propose plans and programs that will provide the environment which the institution considers essential for its own development in science. These needs might involve, for example, the establishment of a new department to provide a balanced scientific program, development of new or revised curricula, strengthening of the science or engineering faculty, or a long-term program for the procurement of science facilities and equipment.
>
> Specific emphasis will be given to the particular kinds of support needed to supplement the programs of each institution. The merit of an institution's proposal for a Science Development grant will be evaluated on the basis of factors such as (1) soundness and feasibility of development plans, (2) willingness to commit the institution's own resources to science development, (3) recent evidence of growth potential as shown by expanded research programs, efforts to stimulate faculty improvement and to acquire more competent faculty, construction of science facilities and procurement of teaching or research equipment, and increased ability to attract and graduate able students.
>
> Science Development grants will supplement the institution's own resources for the period necessary to assure the accomplishment of the planned expansion and strengthening of the science programs. It is expected that most grants will be for an initial period of 3 years. There will follow a period during which Foundation Science Development Program support gradually will be reduced and ultimately withdrawn. The institution will subsequently be expected to fund the expanded programs from other sources, including existing NSF programs.
>
> The development of a broadened national base for high quality education in the sciences and engineering can only be accomplished through concentration of effort at selected institutions. The intent is to increase the number of institutions having excellent programs in science and science education, and this will necessitate making a relatively small number of large grants rather than many small grants. Limiting factors may be the availability of highly competent scientists and engineers, and the availability of institutional resources to provide adequate faculty salaries and research opportunities.
>
> The Science Development Program will aim to bring about the development of an institution's potential without adversely affecting the programs of other institutions through competition for personnel in scarce categories. Eligibility for participation in the Science Development Program will require carefully developed plans for recruiting additional faculty, for further training of current faculty members and for salary policies which are consistent with those prevailing in comparable institutions. It is expected that institutions participating in the Science Development Program will be enabled to offer research and educational opportunities for additional first-rate young scientists and engineers such as those now concentrated in the few top-ranking institutions.[6]

The Science Development Program was announced in March 1964.[7] Administratively, it was within the Foundation's Research Directorate. At that time, the program was not limited to any particular set of institutions, although applications were discouraged from institutions whose excellence was already recognized and from the many others that could hardly have expected to be competitive. As the Director of NSF wrote to the Director of the Office of Science and Technology just after the distribution of the announcement:

> Eligibility could have been limited so that only graduate schools with certain patterns of productivity could apply now, with the expectation of including more institutions in future years. The concept for institutional responsibility for planning applies to all colleges and universities and, certainly, science development concepts also apply to liberal arts colleges. The Foundation chose not to be restrictive though it is estimated that at most only a small number of 4-year liberal arts colleges will be grantees in the initial years. It is believed that the announcement will be well-received and that institutional representatives will recognize that only a few grants will be made each year.[8]

(In fact, the developmental grants were limited to the stronger Ph.D.-granting institutions until the start of the Departmental SDP and the College Science Improvement Program, to be described below. Eventually, of the first 26 DSDP grants made, 9 were to institutions that had competed for, but not received USDP awards.)

In October 1964, a Science Development Advisory Panel, an external panel, was established. In March 1965, a Science Development Program Committee (later renamed the Science Development Award Committee) was created by the National Science Board. This committee reviewed the recommendations for Science Development Grants.

The first four grants were announced by President Johnson on May 4, 1965, saying:

> These grants are only a beginning. . . . Education is an urgent matter for all our people in all parts of the country and at all levels. This new program will build the apex of the educational pyramid while our other programs broaden and strengthen the base. These are important steps in maintaining the scientific leadership which this country has achieved. . . .[9]

Demographic and Geographic Distribution

In administering its programs, and especially the SDP, the Foundation was aware of a clearly stated[10] national policy assuring to "this and future generations of American youth amplest opportunity for the fullest development of their intellectual capabilities." In the 1965 Annual Report[11] the Director indicated that ". . .Federal policy has evolved in the direction of stronger emphasis on the democratic principle that every citizen is entitled to an opportunity for the best education he has the capacity to absorb effectively, and in the field he finds best suited to his talents." This was taken within the SDP to indicate a demographic, as well as a geographic concern: within a given region or population center, each segment of the population should have equal opportunity for high quality education through equal access.

The distribution of research funds also was of concern. In May 1965 the Director of the NSF suggested to the Federal Council for Science and Technology that it might contribute to meeting "the need to find new and more effective ways of helping build increased strength in science throughout all parts of the country." For this purpose the Foundation Director:

> recommended that the Council should consider adopting a set of policy guidelines which would (a) explicitly affirm the importance of a national need; (b) make that need a visible and continuing matter of attention; and (c) provide common reference points for the further development or initiation of agency policies and programs in response to it.
>
> . . .To perform its function, the Federal Government must depend upon academic research. The Federal Government is also firmly committed to expand the opportunities for and improve the quality of higher education generally. Consequently, the time, the circumstances, and a concern for the future make it appropriate for the Federal Council to affirm explicitly that the Federal agencies which sponsor academic research have a corollary responsibility for strengthening the capabilities for research and education of colleges and universities in all parts of the country.[12,13]

The proposal suggested "four basic cornerstones for building increased strength in science throughout the country:" (1) "to maintain and even enhance outstanding quality in those graduate institutions where it exists;" (2) "to assist those graduate institutions, among the many which possess acknowledged research and educational competence, together with demonstrable potentialities for effecting significant qualitative improvements;" (3) "to make funds for research available to promising younger members of science and engineering faculties who have not yet achieved reputations, and whose chances of securing Federal research support, under the accepted and desirable criteria of merit and high quality, are understandably minimal;" and, (4) "to buttress this effort to lift the quality of education by providing assistance in establishing adequate laboratory facilities, research equipment, library resources, etc., at the undergraduate level through forms of institutional support, and by supporting the development of improved curricula and teacher training." The Director pointed out that "Each of these courses represents not a separate choice but, in view of the end sought, an essential element in a single strategic design."[12,13]

On September 13, 1965, the President issued a policy directive to all Federal agencies for the purpose of clarifying and amplifying national objectives for Federal programs concerned with the support of academic science, "Strengthening Academic Science Capability for Science Throughout the Country." This policy directive is discussed in the NSF Annual Report for 1966,[14] which comments that, "The significance of this Presidential Statement is that it directs the various agencies to the proper cognizance of the importance to the national welfare of strengthening the scientific capabilities of the whole academic community."

1966

The question of geographic distribution is mentioned specifically in the justification of the budget proposed to the Congress for FY 1966:

> The Science Development Program was initiated in FY 1964 to assist the build-up of institutions that have generally strong academic programs but are not, at present, able to conduct first-rate research and education in a broad range of scientific disciplines. Although the primary focus of this program is upon the potential of an institution for significant development, a considerable degree of geographic dispersion is expected among the participating institutions. The program is designed to help a small number of institutions each year to move forward rapidly to a higher level of quality both in research and in science education. Relatively large sums will be granted to those institutions which present the most convincing proposals for upgrading a department or combination of science activities.[15]

Throughout the life of the University SDP, special situations arose in which it was necessary to respond to USDP proposals with "Special" SDP grants. As the name states, each case was different; there was no particular set of circumstances that gave rise to an SSDP grant. These grants were smaller in amount, more limited in scope, and were for only 3 years with no expectation for a supplemental grant.

Because of the need for the special grants, and because of extensive discussions within and without the Foundation, the budget for FY 1966 also called for the creation of the Departmental SDP:

> Based on the Foundation's experience during the first 2 years of the Science Development Program, it is proposed that the scope be broadened and a small fraction of the proposed FY 1966 budget (a few million dollars) be used to make smaller grants to a larger number of institutions, whose needs would not be met by the program as currently defined. The institutions will submit proposals for these smaller grants to the Foundation which will be evaluated in the same manner as for the larger Science Development grants. However, an attempt would be made to make grants to institutions having different levels of existing competence, and consideration would be given to the particular educational requirements of the areas in which the institution is located. The grants made under this phase of the program are expected to be for various purposes and typically could include funds for research, faculty improvement, scientific equipment, laboratory renovation, science library resources, or other special programs.
>
> In time, of course, many of the activities supported by these small grants will pass from the developmental stage to a level of competence such that they can compete on equal terms for support under programs in which immediate capability is the primary criterion.[15]

The same budget called also for creation of the College Science Improvement (COSIP) program within the Foundation's Education Directorate.

The Departmental SDP and the COSIP Program were both announced on October 28, 1966.[16] Because the academic community anticipated the DSDP by the preparation of proposals, the first grants could be made in June 1967. Following the announcement of the Departmental Science Development Program,[16] the Division of Institutional Programs was reorganized (January 1967) under an Associate Director for Institutional Relations who had been appointed effective November 14, 1966. Previous to this reorganization, the SDP were under the general supervision of the Associate Director for Research.

Late in 1967, the National Science Board Committees on Science Development Awards and Institutional Relations raised questions about whether the "criteria" for evaluating University Science Development Proposals had changed since the program began in 1964. The following paragraph is from an unpublished account.[13]

Fundamentally, these questions concerned the program's objectives and harked back to the idea of fostering a "second twenty" university "centers of excellence." As the Associate Director (Institutional Relations) assessed the matter, "the question. . .seemed to be whether we are aiming, particularly in the case of the USD program, at increasing a few institutions to a point of 'excellence' or whether we are attempting to reach farther down into the existing quality spectrum and are recommending, in some instances, grants which aim at a significant improvement in quality rather than achievement of true 'excellence'." In his view, NSF was quite properly "following a mixture of the two." In the two programs designed for improvement of graduate-level institutions,

> . . .we have not adhered to the notion that 'excellence,' as distinct from high quality, must be clearly in sight in order to merit support. We propose that this is the proper course to follow in order to achieve a significant expansion of the high quality base of science education and academic research which, we believe, the Nation needs. We have no illusions about spreading such support widely in the near future. The amounts of money available to us, now and for the foreseeable future, are so small as to preclude assistance in any but the relatively few institutions which demonstrate the greatest potential for improvement.[17]

1968, Brief Descriptions of All NSF Institutional Programs

During FY 1968, all of the NSF institutional development programs were active. To show clearly the role of the University and Departmental SDP in the spectrum of activities and goals of these programs, we quote from the summary given with the justification of the budget proposed for FY 1968.[18]

INSTITUTIONAL SUPPORT FOR SCIENCE

Activity Summary

The Foundation's programs of institutional support for science are conducted in accordance with its statutory responsibility to strengthen basic research and education in the sciences, as specified in the National Science Foundation Act of 1950. These programs have the dual objective of (1) assisting colleges and universities in their efforts to upgrade their programs and capabilities in science education and academic research to a condition of excellence and (2) helping educational institutions to maintain strength in science where it already exists. Accordingly, the Foundation conducts four major programs in the "Institutional Science Improvement" category and three in the category "Maintaining Institutional Strength in Science." The four programs for institutional science improvement are University Science Development, Departmental Science Development, College Science Improvement, and a portion of the Academic Computational Facilities and Operations program. The three programs for maintaining institutional strength in science consist of Institutional Grants for Science, Graduate Science Facilities, and the remaining portion of the Academic Computational Facilities and Operations program.

The two program categories, or areas of program emphasis—"Institutional Science Improvement" and "Programs for Maintaining Institutional Strength in Science"—are discussed [in detail] in a later section. The following paragraphs summarize the individual programs.

Institutional Science Development

The major objective of each of the three Institutional Science Development Programs is to assist colleges and universities in their efforts to improve their programs and capabilities in academic research and science education. Under Institutional Science Development, the Foundation provides support for those institutions that (1) have not reached the forefront of scientific excellence but have current strength in the sciences and potential that can be developed with the help of the Foundation, (2) have taken action to improve their scientific activities, (3) have prepared or are preparing well conceived plans for achieving science improvement goals, and (4) are willing and able to commit some of their own resources to the improvement program. Specific purposes and requirements of these programs are as follows:

University Science Development

The University Science Development Program is intended to provide significant financial aid, in the form of relatively large grants, to a limited number of carefully selected academic institutions that are not yet among the very foremost in scientific excellence but have substantial existing strength in science, have demonstrated sound planning for improvement, and are judged by the Foundation to have the greatest potential to develop into outstanding centers for academic research and science education on a broad front over a 3- to 5-year period. Support under this program is provided to assist in the improvement of scientific capability with the ultimate objective of achieving excellence throughout the broad scope of the institutions' programs of research and science education. Great latitude is allowed the institutions as to the specific purposes for which funds may be requested and may include personnel, facilities, and equipment; however, the proposed uses must be clearly indicated in the institution's proposal and must form a part of a comprehensive plan for science development.

Departmental Science Development

The Departmental Science Development program has the objective of improving the quality of science education and academic research in specific individual departments or areas of science in graduate level institutions which have developed significant strength in at least one field of science but are not yet ready to move into the top ranks of excellence on a broad front. The program is intended to help develop such individual departments into strong centers of quality which, in turn, may provide stimulus for upgrading other science departments within the same institution. The program is intended primarily for institutions which offer graduate level research and education programs at either doctorate or master's level and will not normally include undergraduate level institutions. Departmental Science Development grants will be made for periods of approximately 3 years, at an average level of about $200,000 a year, or $600,000 for the 3-year period. Funds provided under such grants may be used for a variety of purposes, such as partial support for additional staff, stipends for graduate students, scientific equipment and renovation of laboratory space, etc.

College Science Improvement

The College Science Improvement program which was initiated in FY 1967, is a comprehensive program for the improvement of the science capabilities of predominantly undergraduate level educational institutions. The initial target group of this program consists of about 600 predominantly undergraduate institutions, ranging from 4-year colleges that conferred a minimum of 100 baccalaureates during the 3-academic year period from 1962-63 through 1964-65, up through institutions which grant science Masters' degrees, to and including institutions that granted less than 10 Ph.D. degrees in science during the base 3-year period. This program is intended to assist undergraduate level institutions to develop the full range of undergraduate education in the sciences and to expand opportunities for undergraduates to become interested in scientific careers. The program provides for improvement in faculty, subject matter, methods of instruction, curricula and individual courses, facilities, equipment, and teaching materials. The College Science Improvement Program is designed to complement, rather than duplicate, the program authorized by Title III of the Higher Education Act of 1965.

Maintaining Institutional Strength in Science

Institutional Grants for Science

The Institutional Grants for Science program provides general-purpose funds to colleges and universities for the maintenance of strong programs of education and research in the sciences by blending and balancing their many science activities and strengthening weak spots, in accordance with their own particular priorities, requirements, and judgments. This program has the purpose of assisting higher educational institutions receiving Federal research grants to maintain the strength of their programs of scientific research and education, particularly by correcting imbalances which may result from their acceptance of research grants. Funds awarded under this program may be employed as the institutions decide, so long as the funds are used solely for science activities and are not used for indirect costs. Because the gaps, imbalances, and needs that this program is intended to correct are generally somewhat proportional to the amount of research conducted on the basis of individual research grants awarded to the institution, the Institutional Grants for Science Program is designed so that the size of individual grants is determined by a formula based upon the amount of Federal research project support the institution has received. . . .

Graduate Science Facilities

The objective of the Graduate Science Facilities program is to assist the Nation's high quality graduate level science institutions to maintain and expand their graduate science programs by providing funds for construction or renovation of facilities for the conduct of basic research and graduate science training. The prime criterion for the awarding of graduate science facilities grants is the merit of the institution's science groups for whom support is requested. Grants awarded under this program require that the recipient institution provide, from non-Federal sources, funds at least equal to the Foundation's contribution. . .

Academic Computational Facilities and Operations

The Academic Computational Facilities and Operations program was established to provide partial support to universities and colleges for the purchase, rental, and operation of electronic computers and related equipment required by their science programs. . . The Foundation's program has the dual purpose of providing significant assistance to the academic institutions in improving and expanding their computational capabilities and of helping them to maintain and upgrade high quality computational capability where it already exists. Consequently, it is a two-part program. One aspect of the program seeks to establish pilot operations by which it is hoped to learn how to improve academic computational capabilities for education and research by the establishment of needed computer facilities where they do not yet exist; by significantly improving existing facilities; by developing major adaptations of advances in computer technology, such as communication links and advanced programming techniques, to the requirements of academic science; by training of teachers and developing curricular materials in computer science; etc. The other aspect assists colleges and universities to maintain and upgrade the quality of research and educational services rendered by their existing computer centers, including helping them to keep pace with the rapid advances in computer technology, such as by acquisition of improved computers as they become available . . .[18]

1970

The last two starts in the University SDP were made in 1969. The last three Special SDP grants were made in July and September, 1970. In 1970, the University and the Departmental Science Development Programs were combined into a single activity called simply the "Science Development Program." The new program was announced in June 1970.[19] Because SDP is used in this report to refer collectively to all of the Science Development Programs, this revised program (which made its last grants in May 1971) will be called the "1970 SDP." Grants made under the 1970 SDP are grouped with those of the Departmental SDP.

Although the size, uses, and duration of awards were similar to those of the Departmental SDP, the goals were expanded.

DESCRIPTION OF PROGRAM

The Foundation's Science Development Program spans a continuum focusing on three major objectives:

1. Improving the base of academic science and engineering in the principal institutions of higher education with due consideration for the needs of science, the emerging universities, major population areas, and geographical regions of the Nation.
2. Encouraging broad-area program development and innovation in academic science with a view toward increasing the Nation's interdisciplinary-multidisciplinary capability in scientific research and education.

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3. Strengthening existing, or creating *de novo*, centers, institutes, programs, and areas of science and engineering that contribute directly to the solution of technological and societal problems of national importance.

For administrative purposes, this continuum of overlapping development programs may be separated into four distinct categories:

(1) a category for mathematics, the natural sciences, and engineering;
(2) a category for the social sciences and the computer sciences;
(3) a category for interdisciplinary-multidisciplinary activities formed by two or more disciplines or areas of science and engineering; and
(4) a category for groupings of science areas, centers, and institutes that are directly related to problem-solving activities in the national interest. All of these categories assume close association between research and science education at the appropriate levels.

In category (4), which is problem-oriented, the nature of the effort required is such that the educational component, where it does exist, is most likely to be at the advanced or senior postdoctoral level.

Eligibility

Except for those already recognized as being outstanding, all institutions of higher education in the United States, its territories, and possessions are eligible for the mathematics, natural sciences, and engineering component of the development program (category 1), if they have approved graduate programs in science or engineering. All institutions of higher education that now have graduate programs in science or engineering are eligible to apply for social science support as well as for the interdisciplinary-multidisciplinary program (categories 2 and 3). Any appropriate grouping of individuals or organizations is eligible to apply for support to the areas of science, centers, or institute approach to problem solving in the national interest (category 4). In some instances, the Foundation will consider requests from institutions or consortia for planning grants which will allow them to consider more systematically their move into areas of education and research related to societal problems. An institution may not have more than one proposal in each category under consideration at a given time.

An NSF University Science Development (USD) grantee institution is eligible for supplemental support. It is also eligible for support for mathematics, natural sciences, and engineering (category 1) only after its USD award terminates. Recipients of USD or Departmental Science Development (DSD) awards (whether or not the grant is still active) are ineligible for support in those areas in which they have already received development awards. University Science Development awardees may elect to follow the general rules of eligibility cited rather than to apply for supplemental support.

Within the above restrictions any institution may receive one award during each 12-month period from each of the following categories: mathematics, natural sciences, and engineering (category 1); social sciences (category 2); and interdisciplinary-multidisciplinary activities (category 3). Few awards of the center/institute type (category 4) will be made, for activities of this nature are likely to be of long duration and to entail considerable financial and resource commitment on the part of NSF and the institution.[19]

Some of the proposals submitted for this Program, especially in category (4), were modified and subsequently funded under the NSF Research Applied to National Needs (RANN) Program.

C. Administration[4]

The procedures for preparing and evaluating the University and Departmental SDP proposals were described separately for each program in the justifications of the budgets presented to the Congress and in the 1970 Authorization Hearing.[4] The two sets of procedures, however, were similar to one another. We will present only one description of both.

Proposals

From the Foundation's point of view, the development of academic capabilities for high-quality programs in science and engineering had to relate to major institutional upgrading. This point of view recognized that institutions plan their expansion and improvement on departmental bases and that, with dynamic leadership, it is groups of scientists and educators with related and common interests, usually departmental, that move the institution up or down the quality spectrum.

This upgrading in quality takes time. For this reason, it was decided that, although an initial USDP grant would be limited to a 3-year period, a 2-year supplementary grant would be considered when sufficient progress could be demonstrated by a grantee during the initial grant phase. Although most institutions received supplemental awards, some of the departments or activities included for support under the initial award were excluded from participation in the supplemental award. Special and Departmental SDP awards were made for only a 3-year period with no expectation of a supplement.

All branches of science and engineering were eligible to participate in the SDP. These included the life, physical, mathematical, engineering, environmental, and social sciences. Cross-disciplinary and interdisciplinary programs among the sciences and engineering were eligible for support. The Foundation's program announcements were structured purposely to encourage innovation and invite fresh approaches to planning.

To justify the substantial grants necessary to accomplish the objectives of this program, each participating institution had to:

1. Prepare a comprehensive plan for accomplishing a significant upgrading of the quality of its science activities within the 3- to 5-year period of the grant;
2. Demonstrate that it had sufficient existing strength to serve as a base for the proposed development; and,
3. Show that it possessed adequate resources to give reasonable assurance that the institution's goals, as proposed in the plan, could be achieved and maintained.

Each institution applying for a University Science Development grant was required to submit the following information concerning its development plans:

1. A major exposition of the profile and plans of the institution, including a clear presentation of the institutional development plan from the educational, scientific, administrative, and financial points of view. In this context, a university explained how its science development plan, as set forth in its proposal, was constructed and how it related to the institution's over-all plans.
2. The purposes for which Foundation support would be used during a period of 3 years of the 5-year plan.
3. The major changes that could be expected if the plan were achieved; specifically, the programs that were to be upgraded.
4. The estimated budget for the 5-year science development plan, showing the amount requested from NSF and the amount to be contributed from the institution's other sources.
5. A description of how the institution intended to maintain the achieved levels of strength after the end of Foundation support.

The ways in which SDP grant funds were to be used to translate institutional plans into institutional performance were as varied as the plans themselves. There were three ingredients, people, equipment, and facilities:

- *More and different people:* professional and junior professional; subprofessional and technical; secretaries and clerical; services—curriculum development, computer, travel; graduate student support; and, undergraduate support.
- *Equipment,* etc.: laboratory apparatus; field equipment; supplies.
- *Facilities, new or renovated:* campus labs, offices, classrooms; field labs and stations.

An SDP proposal generally sought funds for expansion of faculty, support of postdoctoral scientists and graduate students, and augmentation of technical or clerical staff. Often a need existed to provide sophisticated research and training equipment, specialized materials, and particular services. In some cases, development plans included a request for funds for the construction, modernization, or renovation of research and teaching laboratories. SDP grant funds could be used for any of these purposes, but their allocation and expenditure had to conform with a grant budget agreed upon by both the Foundation and the recipient institution. Payment of indirect costs was not permitted with SDP award funds. While there were no specific matching requirements, the university assumed a substantial part of the increased costs of the planned improvement in addition to normal support for the participating science areas.

Evaluation of Proposals

In general, the evaluation process, as shown below, involved mail reviews by scientists and administrators who commented substantively on each scientific department and academic program involved in a development plan. External reviews which evaluated the administrative and financial framework within which a development program would operate also were obtained. Where an institution's plans included expenditures for facilities, the Foundation's architectural services staff reviewed relevant plans. The proposal evaluation process included the following levels of review:

1. Program level:
    a. Proposal managers—senior scientists,
    b. Mail reviews: By NSF scientists and science administrators; by non-NSF scientists and science administrators from universities, industry, nonprofit organizations, and other Federal agencies.
    c. Site visits—2 days on campus with top administrators, departmental chairmen, faculty and scientists; comprehensive site visit reports; integration of mail reviewers' and site visitors' comments.
    d. Staff evaluation and recommendations.
2. Agency review by Associate Director for Institutional Relations, Executive Associate Director, and Director.
3. NSF Science Development Advisory Panel review.
4. National Science Board Institutional Committee review.
5. National Science Board review.
6. The making of the grant—Director.
7. Postgrant sessions providing feedback to the institution president regardless of positive or negative action.

An important part of the evaluation of a successful SDP proposal was the site visit. Generally a 2-day visit was involved. The agenda encompassed intensive interactions among visitors, university administrators, and science faculty. The visiting team usually consisted of six members. Two of the team members were from the Foundation professional staff, the proposal manager (SDP staff) and one other senior NSF official. The other four *ad hoc* team members were nationally known scientists and administrators having no affiliation with the affairs of the university being evaluated, typically a senior university administrator and three scientists who were university professors and/or department chairmen. Eighteen university presidents participated in the review of the first 46 proposals. Each SDP proposal presented special problems and situations which led to some variation in the "mix" of site visitors. For example, it may have been important to include in the team a financially-oriented individual such as a university controller or academic vice president for finance. Subsequent to the visit, each site visitor wrote a comprehensive report including specific action recommendations based upon both the proposal and the visit itself. The final determination on the action to be taken by the Foundation was, therefore, based on the judgments of a large number of reviews and evaluations.

The success of any program depends on the individuals involved. The names of the NSF professional and administrative staff who were directly involved are listed in Appendix B-1. Many of the professional staff were on leave from universities on 1- or 2-year "rotational" appointments. Some had had previous experience in university administration, and some returned to high administrative posts. It is evident that they had great skill in choosing and leading their site visit teams. These visitors were highly accomplished, but not yet in such demanding high-level positions that they did not have the time to participate fully in the evaluations. These visitors carried their full normal professional obligations; they sometimes made the visits and wrote the reports at considerable personal sacrifice. Many of their names are recognized today among those of the highest level science and university administrators.

Reports

Reporting requirements evolved as experience with the program grew. The following set of requirements comes from the 1970 Science Development Program announcement[19] and reflects also the requirements imposed on Departmental and (supplemental) University SDP awards made just prior to that date.

> **Reports**
>
> A Science Development Program Fiscal Report is required annually (soon after the anniversary date of the grant) and upon completion of the grant.
>
> Progress reports will be required at the end of the first year and each year on the anniversary of the grant. A final report is required at completion.
>
> The progress report should include such matters as the changes that have occurred in the "department or science area" and at the Institution, as well as such changes as can be ascribed to the development grant. There should be a discussion of deviations that may have occurred from the described plan with reasons for such changes. Any major changes contemplated in the future should also be brought to the Foundation's attention.

Personnel

The report should include a listing of all the new staff members, academic and nonacademic, including postdoctoral associates. For each new academic appointment (including postdoctoral associates) there should be included a brief bibliographic sketch, similar to those which appear in *American Men of Science*. Include a statement of what part of his salary comes from NSF funds and the sources and amounts of the balance of the salary. If any academic staff have left the department in the previous year, this should be noted together with their new institutional affiliations. Statistics on graduate students should be provided, including number (full-time, part-time, first-year, advanced) and baccalaureate sources of first-year students. Comparison with the previous year's graduate student statistics should be made. Discussion of recruitment and support of graduate students is encouraged. Other personnel changes (technical, secretarial, see salaries and wages category in the SD fiscal report) during the report period should be mentioned.

Equipment, Supplies, and Other Expenditures

List major equipment purchased and other significant expenditures. Explain any deviation from the original plan.

Research

Submit a bibliography of departmental (or science area) contributions to scientific literature during the period covered by the report. Provide a list of all grants and contracts active in the department, including names of principal investigators, title of project, amount in dollars, duration, and source of support.

Education

List any new courses, programs or activities associated with graduate or undergraduate education and their relationship to the science development plan.

Degrees Awarded

Provide statistics on baccalaureate, master's, and doctor's degrees awarded by the department and compare to earlier years and comment on trends. Brief accounts relating to baccalaureates who are continuing on in graduate work and career choices of masters and doctorates are of interest when available.[19]

Subsequently, the requirements for the final report were clarified to request specifically comments on "the effects—both good and bad—of the Science Development Programs," and on "Detrimental Effects of the SDP." Under "detrimental effects" were questions asking whether the SDP attracted funds away from other areas, caused over-commitments, caused an oversupply of Ph.D.'s, or detracted from undergraduate education.

The reporting requirements were set up so that knowledgeable scientists could monitor and eventually evaluate progress. For the convenience of evaluators, it might have been desirable to require more "numerical indicators" that might be used as part of a statistical analysis. Unfortunately, it is not even now known which of these indicators are truly related to departmental or institutional quality. And, if such indicators were known, it is not clear that they could be obtained for all institutions, much less obtained in consistent form for both the grantees and the nongrantees who could be used as controls. The requirements listed in the excerpt above represent a compromise between gathering information of known value and making undue demands on the grantees.

Some reports give information related to a personnel-to-workload ratio: *i.e.*, (faculty + teaching assistants + staff) to (lower division + upper division + graduate + independent study/research credit hours). For purposes of figuring teaching load, some institutions assign greater weight to upper division and research credit hours, but there seems to be no uniform practice. If uniform reporting standards for each science area could be agreed upon, this would be valuable information. In reading the final reports, this author finds that some of the most useful data are those based upon peer group evaluation:

- scholarships and fellowships awarded in national (or statewide) competition to (a) undergraduates and (b) incoming graduate students;
- national and, separately, regional awards and honors to the faculty, including Academy memberships, prizes, Sloan and Dreyfuss fellowships, Career Development Awards, etc.;
- editorships, etc; office in national societies;
- invited lectures given by the faculty elsewhere;

- distinguished outside lecturers coming to the grantee department;
- annual funding level of external and, separately, internal grants and contracts for research and teaching; and,
- internal awards and ratings as for teaching, if comparative data are given for the rest of the institution.

D. The Grants

Proposals Received

As of February 1, 1969, 113 University SDP proposals requesting $470 million had been received from 92 institutions, 9 of the proposals being supplementary ones. Table 10[4] shows in greater detail the statistical history of USDP proposals.

By the time the last USDP start was made in September 1969, two additional institutions had received awards. (In Table 10, Case Institute and Western Reserve University were counted as two separate institutions.) By the end of the program in 1971, a total of 11 institutions received Special SDP awards. Among these was a "planning award" made to the University of Connecticut. About 200 proposals resulted in a total of 73 awards under the Departmental and the 1970 SDP.

Awards

Table 1 has already summarized the number of grants, total amounts, and award dates for each program. Table 11 lists, in alphabetical order of States, all of the grants that were made. Figure 3 shows the location of the 31 University Science Development Grants. Figure 4 shows the location of the University, Special, and Departmental Science Development awards. Because of their similarity, and the overlap between programs, grants made under the Departmental SDP and the 1970 Science Development Program are grouped together as Departmental SDP grants.

Appendix B in this volume, and Volume II[20] (which had to be published separately because of its bulk) provide detailed information on the grants. Appendix B-2 lists the names of the grantees in alphabetical order of grantee institution and summarizes the scientific areas supported. Appendix B-3 lists the grants by type of grant (University, Special, or Departmental). Volume II of this report[20] presents the goals and budget for each grant, and then a summary of grant impact written by the grantee.

The distribution of funds by area of science is summarized in Table 12, while the more detailed distribution of funds by discipline is shown in Appendix B-4. Appendix B-5 shows in further detail the distribution of individual grants by discipline. This table can be used, for example to determine which departments in a given discipline received awards, and to see the amounts involved. This table should be used with care, however, because in some cases support was given only to a segment of a department, perhaps because it was contributing to a specific interdisciplinary program. These tables reflect mutually agreed upon changes in budget.

The question of the seemingly neglected biological sciences has been discussed by Page,[2] who indicates that the institutions had not included them in the proposals. Page speculates that the universities might have looked to NIH for support in this area, or that the biological sciences on most campuses were in a transition stage not yet ready for development.

A special category for the social sciences was included in the 1970 "Science Development Pro-

Table 10. UNIVERSITY SCIENCE DEVELOPMENT PROGRAM TO FEBRUARY 1, 1969

USD PROPOSALS, USD GRANT ACTIONS, SPECIAL GRANTS, AND DECLINATIONS, WITHDRAWALS, AND OTHER ACTIONS

Fiscal year	Proposals[1]		USD grant actions[2]		Special grants		Declinations (31); withdrawals (24); other actions (3)	
	No.	Amount	No.	Amount	No.	Amount	No.	Amount
1965	68	$276,204,525	8	$27,394,000	0	0	2	$8,338,275
1966	12	48,921,238	10	36,375,000	1	$700,000	39	144,018,869
1967	12	53,213,688	8	33,169,000	3	2,449,000	11	44,398,868
1968	14	69,139,700	7	27,207,000	2	2,424,000	6	24,179,254
1969	7	22,991,300	0	0	0	0	0	0
Total	113	470,470,451	33	124,145,000	6	5,573,000	58	220,935,266

[1] The total of 113 proposals, which includes 9 supplemental proposals, were submitted by 92 institutions Of the 113 proposals received, 18 are currently under evaluation, they request a total of $75,925,000

[2] Thirty institutions have received USD grants The supplementary grant to Case Western Reserve University and the amendments to the University of Rochester and Indiana University are counted as grant actions

Table 11. SCIENCE DEVELOPMENT PROGRAM GRANTS LISTED BY STATES[1]

State	No. of Grants	Institution	Old Grant Numbers	New DID Numbers	Code[2]
Alabama	0				
Alaska	1	Alaska, U of	GU-3856	7002950	
Arizona	2	Arizona, U of	GU-1534	6500022	U
		Arizona State U	GU-3169	6800427	
Arkansas	0				
California	6	Calif., U of, at Sta. Barbara	GU-3860	7002951	
		Calif., U of, at Sta. Cruz	GU-3162	6901026	
		Calif., U of, at San Diego	GU-3863	6901051	
		Claremont Grad. School	GU-2653	6700138	
		Claremont Grad. School	GU-4039	7002956	
		Southern Calif., U of	GU-1559	6500024	U
Colorado	4	Colorado School of Mines	GU-3854	6901048	
		Colorado State U	GU-3847	6901045	
		Colorado, U of	GU-1532	6500053	U
		Denver, U of	GU-2635	6800286	
Connecticut	3	Connecticut, U of	GU-3853	6901047	S
		Wesleyan U	GU-2630	6800282	
		Yale U	GU-4044	7104011	
Delaware	1	Delaware, U of	GU-2606		
D.C.	1	Georgetown U	GU-3857	7002950	
Florida	2	Florida State U	GU-2612	6700136	U
		Florida, U of	GU-1533	6500021	U
Georgia	2	Emory U	GU-3861	6901050	
		Georgia, U of	GU-2590	6700220	U
Hawaii	1	Hawaii, U of at Manoa	GU-3855	7002948	
Idaho	0				
Illinois	3	Illinois Inst. of Tech.	GU-3161	6800424	
		Illinois, U of at C. C.	GU-2652	6800291	
		Northwestern U	GU-3851	6800437	S
Indiana	3	Indiana U	GU-2003	6500028	U
		Notre Dame, U of	GU-2058	6600042	U
		Purdue U	GU-1589		U
Iowa	1	Iowa, U of	GU-2591	6600077	U
Kansas	1	Kansas State U	GU-3185		S
Kentucky	2	Kentucky, U of	GU-2614	6700137	S
		Louisville, U of	GU-2628	6800280	
Louisiana	3	Louisiana State U at B. R.	GU-1558	6500023	U
		New Orleans, U of (formerly Louisiana State U at N. O.)	GU-2632	6800284	
		Tulane U of Louisiana	GU-1593	6500026	U
Maine	0				
Maryland	1	Maryland, U of	GU-2061	6600076	U
Massachusetts	5	Boston University	GU-3846	6901044	
		Brandeis University	GU-3852	6700139	S
		Clark University	GU-3173	6901027	
		Clark University	GU-2584	6700132	
		Massachusetts, U of Amherst Campus	GU-4041	7002957	
Michigan	4	Michigan State U	GU-2648	6800287	U
		Michigan Tech. U	GU-3172	6800430	
		Oakland U	GU-2650	6800289	
		Wayne State U	GU-2055	6700103	S
Minnesota	0				
Mississippi	1	Mississippi, U of	GU-3833	6901036	
Missouri	2	Missouri, U of at Rolla	GU-2587	6700133	
		Washington U (St. Louis)	GU-1147	6500042	U
Montana	1	Montana, U of	GU-4042	7002958	
Nebraska	2	Nebraska, U of at Lincoln	GU-3163		
		Nebraska, U of at Lincoln	GU-2054		S
Nevada	0				
New Hampshire	1	New Hampshire, U of	GU-3845	6901043	
New Jersey	2	Rutgers, The State U	GU-1592	6500025	U
		Stevens Inst. of Tech	GU-3191	6901034	
New Mexico	2	New Mexico, U of	GU-2582	6700130	
		New Mexico State U	GZ-244		S

New York	15	Clarkson Coll. of Tech	GU-3165	6800425	
		CUNY, City College	GU-2629	6800281	
		CUNY, Hunter College	GU-2651	6800290	
		New York U	GU-3186	6800432	U
		Polytech Inst. N. Y. (formerly Polytechnic Institute of Brooklyn)	GU-1557		U
		Rensselaer Poly Inst	GU-3182	6901030	
		Rensselaer Poly Inst	GU-2605	6800278	
		Rochester, U of	GU-4040	7104010	
		Rochester, U of	GU-1154	6500018	U
		SUNY, Albany	GU-3859	6901049	
		SUNY, Albany	GU-3171	6800429	
		SUNY, Binghamton	GU-2634	6800285	
		SUNY, Binghamton	GU-3844	6901042	
		SUNY, Stony Brook	GU-3850	6800436	S
		Yeshiva U	GU-3835	6901037	
North Carolina	3	Duke University	GU-2018	6600040	U
		North Carolina State at Raleigh	GU-1590	6600039	U
		North Carolina, U of at Chapel Hill	GU-2059	6700219	U
North Dakota	0				
Ohio	4	Bowling Green State U	GU-3170	6800428	
		Case Western Reserve U	GU-1145	6400017	U
		Kent State U	GU-3840	6901038	
		Ohio U (Athens)	GU-2603	6700134	
Oklahoma	1	Oklahoma State U	GU-3160	6800423	
Oregon	2	Oregon State U	GU-3848	6901046	
		Oregon, U of	GU-1146	6500017	U
Pennsylvania	6	Bryn Mawr College	GU-3181	6901029	
		Carnegie-Mellon U	GU-2056	6600041	U
		Drexel Inst of Tech	GU-2583	6700131	
		Lehigh U	GU-2586		
		Lehigh U	GU-3190	6901033	
		Pittsburgh, U of	GU-3184	6800431	U
Puerto Rico	0				
Rhode Island	0				
South Carolina	2	Clemson U	GU-3843	6901041	
		South Carolina, U of	GU-3183	6901031	
South Dakota	0				
Tennessee	3	Tennessee Tech U	GU-2581	6700129	
		Tennessee, U of	GU-2611	6700135	S
		Vanderbilt U	GU-2057	6700104	U
Texas	9	Houston, U of	GU-2589		
		Rice U	GU-1153		U
		Southern Methodist U	GU-4043	7002959	
		Southern Methodist U	GU-3841	6901039	
		Southern Methodist U	GU-2604		
		Texas A&M U	GU-3159	6800422	
		Texas A&M U	GU-3865	7002954	
		Texas Tech U	GU-3862	7002952	
		Texas, U of at Austin	GU-1598	6500027	U
Utah	3	Utah State U	GU-2649	6800288	
		Utah, U of	GU-3866	7002955	
		Utah, U of	GU-3164		
Vermont	0				
Virginia	3	Virginia Polytech Inst. and State U	GU-3192	6901035	
		Virginia, U of	GU-1531	6500020	U
		William and Mary, College of	GU-3842	6901035	
Virgin Islands	0				
Washington	3	Washington State U	GU-2631	6800283	
		Washington State U	GU-3864	7002953	
		Washington, U of	GU-2655	6800292	U
West Virginia	1	West Virginia U	GU-2034		S
Wisconsin	2	Marquette U	GU-2588		
		Wisconsin, U of at Milwaukee	GU-2608		
Wyoming	1	Wyoming, U of	GU-2607	6800279	

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[1] See Appendix B-2 for an alphabetical listing with indications of scientific disciplines supported

[2] U = University Science Development Grant (31 grants)

S = Special Science Development Grant (11 grants)
All other grants were made under the Departmental SDP and the 1970 SDP

Table 12. SCIENCE DEVELOPMENT PROGRAMS: SUMMARY OF NUMBERS OF GRANTEE DEPARTMENTS OR ACTIVITIES AND FUNDS BY SUBJECT AREA[1]

	Univ. SDP		Dept'l & Spec'l SDP		Total	
	No.	Amount ($ Thousands)	No.	Amount ($ Thousands)	No.	Amount ($ Thousands)
Biological and Medical Sciences	31	30,924	8	5,002	39	35,926
Chemistry, Chemical Physics, and Biochemistry	25	34,152	15	8,792	40	42,944
Computer Research	5	5,500	1	525	6	6,075
Engineering	32	15,689	18	9,832	50	25,521
Environmental Sciences	9	6,971	7	3,542	16	10,513
Library, Scientific	2	1,395	0		2	1,395
Materials Research[1]	5	6,158	3	2,000	8	8,158
Mathematics and Statistics	18	12,265	7	4,264	25	16,529
Physics and Astronomy[1]	30	53,811	15	9,505	45	63,316
Social Sciences	17	12,053	17	9,976	34	22,029
Surface Studies	0	0	1	555	1	555

[1] Please see Appendices B-4 and B-5 for more detail. Funds for certain areas were not always separately identified in the grant budgets. Funds for astronomy awarded to Departments of Physics and Astronomy were listed under "Physics", hence the combined listing in this table. Some of the funds for Materials Research are included under the headings for Chemistry, Engineering, and Physics.

gram" in order to stimulate proposals in this area.

Finally, identified interdisciplinary centers supported by the SDP are listed in Appendix B-6.

Geographic and Demographic Distribution of Grants

The geographic distributions of University, and of Special plus Departmental SDP funds are shown in Table 13. Table 14 shows the fall 1972 enrollments (in thousands of students) by geographic region. Between the time of the proposal (median date between 1966 and 1969) and 1972 there was a 40 to 50 percent increase in the enrollment in all of the public institutions, and about a 10 percent increase in the private institutions.

Figure 5 shows the geographic distribution of SDP funds in several different ways. The top bar graph shows the *percentages* of University and of Departmental plus Special SDP funds per region. The next row shows the percentages of total dollars awarded to each region. The Middle Atlantic, South Atlantic, and East North Central regions received the largest amounts, and New England and the East South Central Region the least.

The populations of these regions are not equal. The third row, (C), of Figure 5 shows the number of SDP dollars per person in each region. On this basis, the Mountain and the South Atlantic States ranked highest.

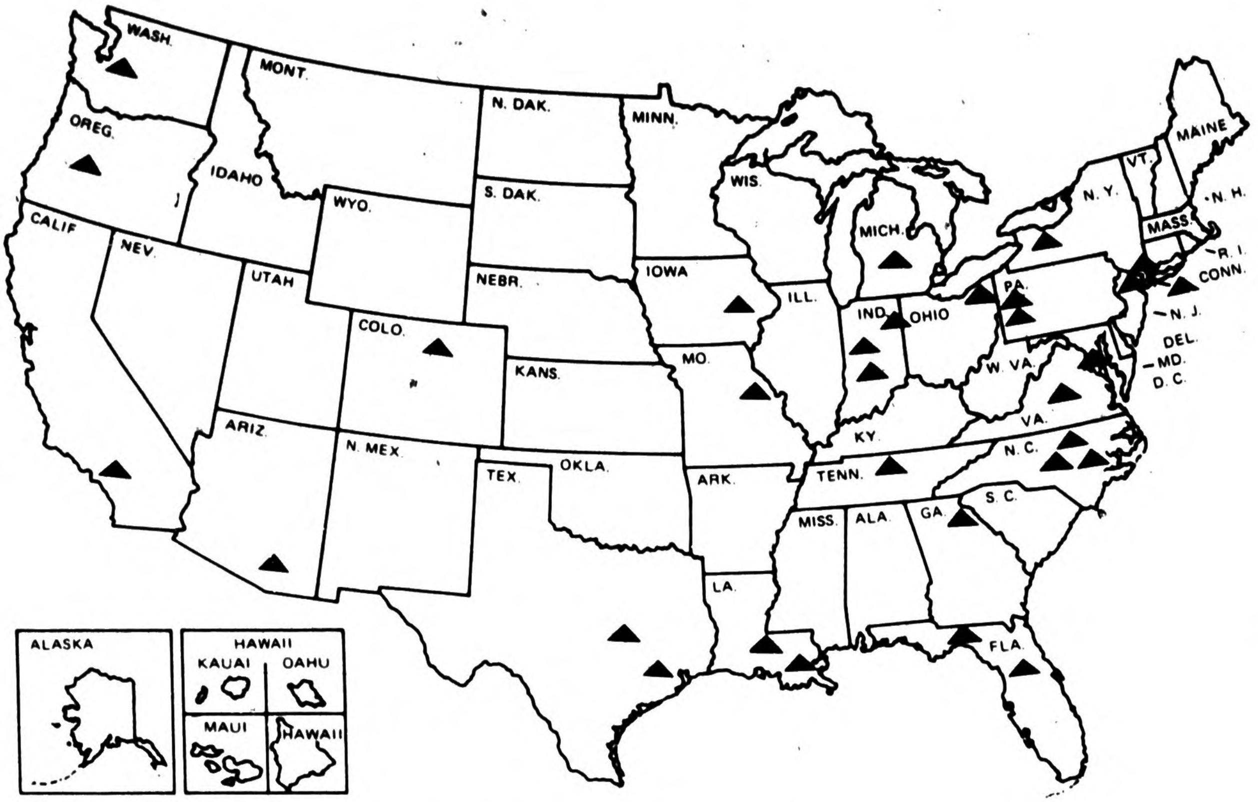
The purpose of the SDP was, however, to strengthen all activities of existing doctoral-level

Table 13. DISTRIBUTION OF UNIVERSITY SDP, AND DEPARTMENTAL PLUS SPECIAL SDP FUNDS BY GEOGRAPHIC REGION

(Thousands of Dollars)[1]

	University SDP Funds			Special and Departmental SDP Funds			Total SDP Funds		
Geographic Region	public	private	total	public	private	total	public	private	total
#1 New England	0	0	0	1,207	5,719	6,926	1,207	5,719	6,926
#2 Middle Atlantic	9,158	21,196	30,354	5,278	6,218	11,496	14,436	27,414	41,850
#3 South Atlantic	39,422	3,177	42,599	3,639	1,022	4,661	43,061	4,199	47,260
#4 East South Central	0	5,403	5,403	3,624	0	3,624	3,624	5,403	9,027
#5 East North Central	18,743	14,826	33,569	4,468	2,840	7,308	23,211	17,666	40,877
#6 West South Central	12,816	7,110	19,926	3,057	1,750	4,807	15,873	8,860	24,733
#7 West North Central	6,727	7,009	13,736	2,914	0	2,914	9,641	7,009	16,650
#8 Mountain	12,658	0	12,658	6,142	500	6,642	18,800	500	19,300
#9 Pacific	13,258	7,473	20,721	4,657	957	5,614	17,905	8,430	26,335
TOTAL	112,772	66,194	178,966	34,986	19,006	53,991	147,758	85,200	232,957

[1] Because of rounding, subtotals may not add correctly



Note: For the names of the grantee institutions, please see Table 11, grants listed by states.

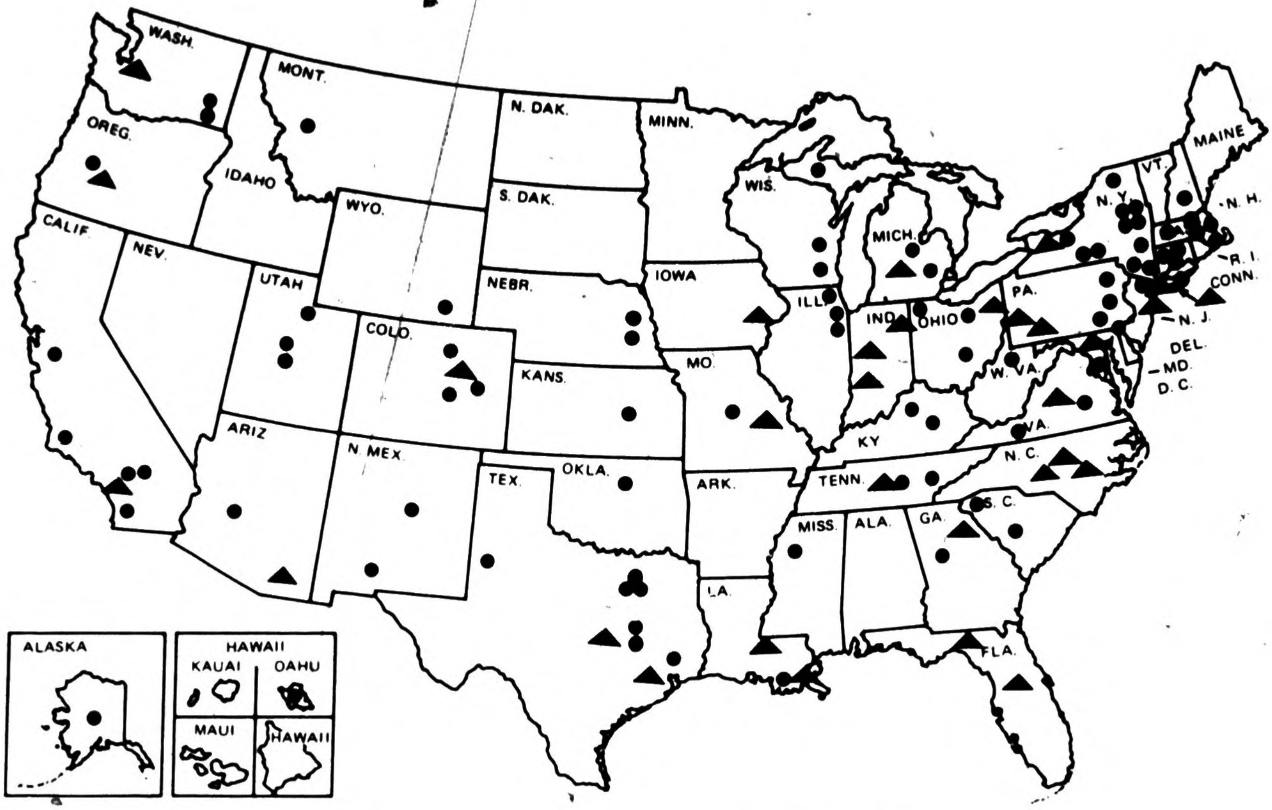
Figure 3. Geographic Distribution of the University Science Development Grants (▲)

institutions that had already achieved some strength, *i.e.*, to broaden the apex of the educational pyramid. One measure of the availability of possible SDP target institutions in each region is the number of Ph.D.'s awarded. The fourth row, (D), of Figure 5 shows the number of SDP dollars per Ph.D. awarded in 1963-64. On this basis, the Mountain and the South Atlantic States again ranked the highest, with East South Central coming up strongly.

Comparison of Rows B, C, and D shows that the New England States always ranked lowest. The South Atlantic States always ranked highest or second highest. The main differences between Row B and Rows C and D are for the East South Central, the West South Central, and the Mountain States, which rank high in the per capita and the per Ph.D. plots.

The question of demographic distribution of funds is examined in Figure 5, Row E. This bar graph shows the total SDP dollars awarded; the heights of the bars are identical to those in Row B. The light sections at the tops of the bars for the New England, Middle Atlantic, East North Central, and Pacific States show funds awarded institutions believed to serve primarily their local urban areas. The largest component of this type was in the Middle Atlantic States: CUNY-City College and Hunter College, Drexel University, NYU, Polytechnic Institute of New York (Brooklyn), University of Pittsburgh, and Stevens Institute (The names of the institutions used in computing the other "demographic" components are shown in the figure note.)

The implication of this figure is that one cannot make a judgment about the geographic distribution of funds simply on the basis of funds awarded per region or per person as in Rows B-D. Even though a region (in this case, New Jersey, New York, and Pennsylvania) already had universities of excellent reputation, certain segments of the population



Note For the names of the grantee institutions, please see Table 11, grants listed by states.

Figure 4. Geographic Distribution of the University (▲), Special, and Departmental (both of the latter are shown by ●) Science Development Grants

Table 14. FALL 1972 ENROLLMENT IN UNIVERSITY SDP, AND IN SPECIAL PLUS DEPARTMENTAL SDP GRANTEE INSTITUTIONS BY GEOGRAPHIC REGION[1]

(Thousands of Students)

	Students, University SDP Schools			Students, Special & Departmental SDP Schools			Total Students		
Geographic Region	public	private	total	public	private	total	public	private	total
#1 New England	0	0	0	52	40	92	52	40	92
#2 Middle Atlantic	51	46	98	77	37	114	129	83	212
#3 South Atlantic	148	9	157	85	16	101	232	26	258
#4 East South Central	0	7	7	74	0	74	74	7	81
#5 East North Central	102	18	120	144	31	175	247	48	295
#6 West South Central	68	12	80	96	11	107	164	23	186
#7 West North Central	21	11	32	42	0	42	63	11	74
#8 Mountain	50	0	50	129	9	138	178	9	187
#9 Pacific	50	20	70	81	1	83	131	21	152
TOTAL	489	124	613	780	145	925	1,269	269	1,538

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[1] Hazel C Poole 'Education Directory 1973-74 Higher Education (DHEW Publication no (OE) 74-11404) (U S Government Printing Office Washington D C 20402 1974) Because of rounding subtotals may not add correctly

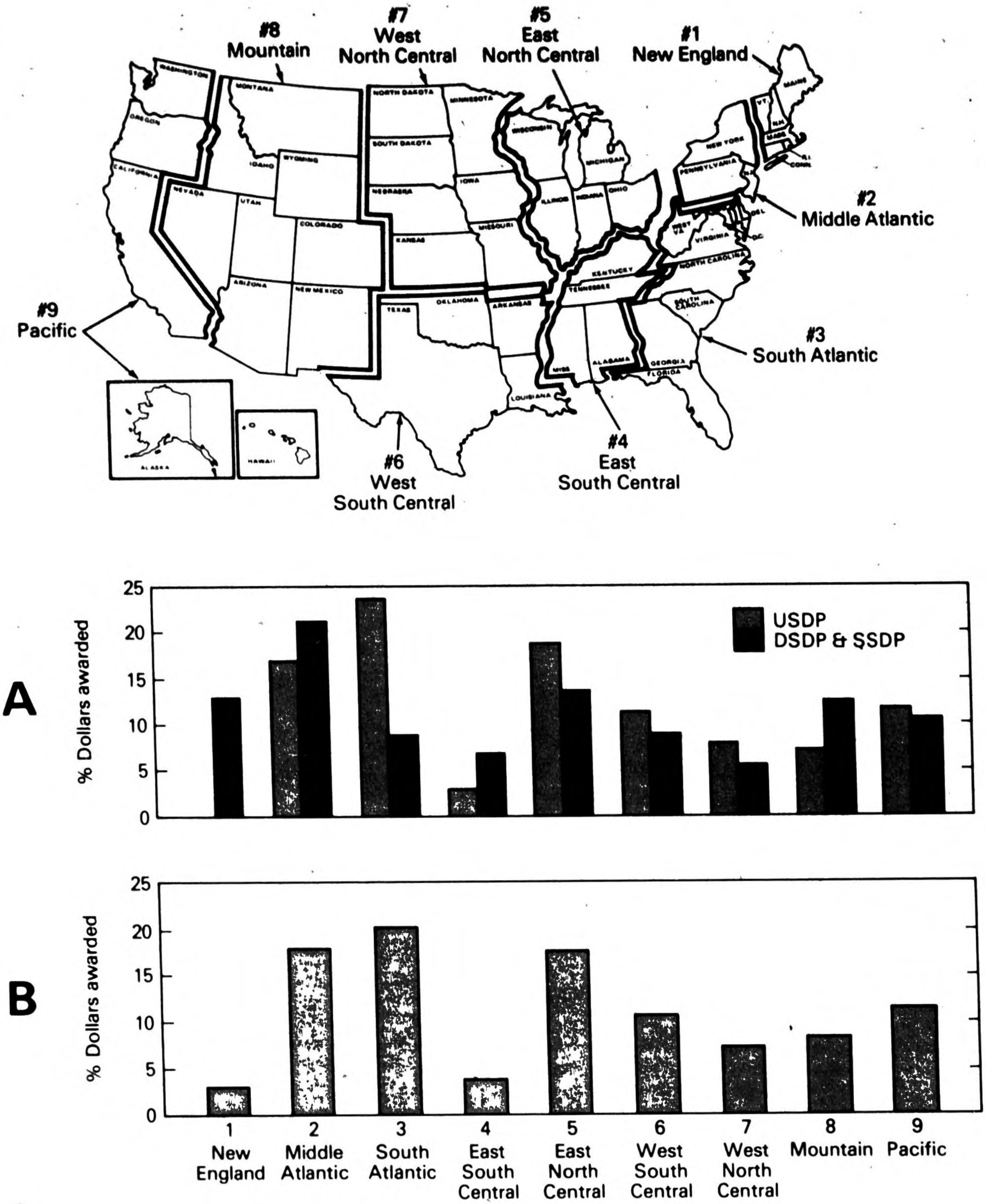
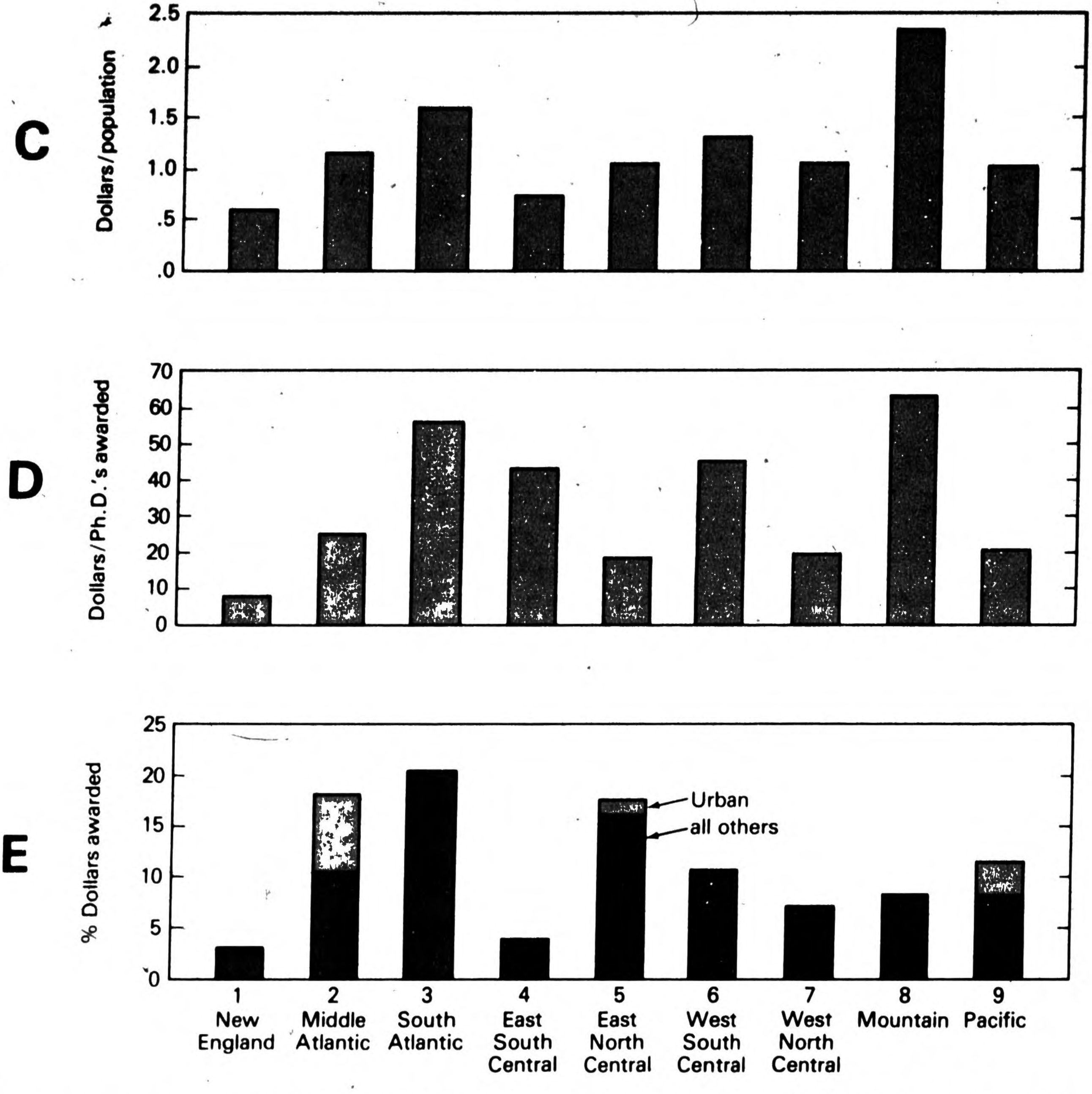


Figure 5. Distribution of Science Development Program Funds by Standard Geographic Region (Part 1)



Row A shows the percentages of funds awarded, respectively, in the University SDP and in the Departmental plus Special SDP grants. Row B shows the percentages per geographic region of the total SDP funds awarded. Row C shows the funds awarded to each region divided by the population of that region. Row D shows the funds awarded to each region divided by the number of Ph.D.'s awarded in that region in 1963-64. In Row E, awards to urban institutions are shown by the outline at the top of the bars only for areas 1, 2, 5, and 9. Urban institutions considered are: New England (Boston University); Middle Atlantic (CUNY-CCNY and Hunter, Drexel, NYU, PINY, Pittsburgh, Stevens); East North Central (Marquette, IIT, Chicago Circle, Wisconsin-Milwaukee); Pacific (University of Southern California).
SOURCE: National Science Foundation

Figure 5. Distribution of Science Development Program Funds by Standard Geographic Region (Part 1 cont.)

were not served by these universities. The policy of demographic distribution, therefore, called for making grants to institutions in close proximity to recognized strong institutions, *e.g.*, City College and Columbia; Rutgers and Princeton; or USC, and UCLA and Cal Tech. Row E of Figure 5, however, was constructed conservatively, *e.g.*, the funds for Rutgers were not included in the outline portion at the top of the bar graph for the Middle Atlantic Region.

Summary

The policy constraints on the SDP might be paraphrased as (1) to not consider proposals from already excellent institutions, and then (2) to fund proposals from institutions showing the greatest promise, with an eye to achieving geographic distribution of and equal access to strong universities. Figures 5C, D, and E indicate that the program managers, indeed, succeeded in attaining the sometimes contradictory goals of geographic and demographic distribution of grants.

FOOTNOTES, Chapter III

[1] Howard E. Page, "Lessons of the NSF Science Development Program," Educational Record 47, 50-56 (1966).

[2] Howard E. Page, "The Science Development Program," *Science Policy and the University*, Harold Orlans, ed., (The Brookings Institution, Washington, D.C. 20036, 1968) pp. 101-119.

[3] Howard E. Page, "University Science Development—$100 Million Later," Educational Record 49, 250-256 (1968).

[4] U.S. Congress. House Committee on Science and Astronautics, Subcommittee on Science, Research, and Development Hearings, 91st Congress, 1st Session, 1970 National Science Foundation Authorization Volume II. (Washington, D.C., 1969) pp. 526-551

[5] U.S. National Science Foundation. Justification of the Estimate of Appropriations as Submitted to the Congress for Fiscal Year 1964 (Washington, D.C., 1963) pp. 69ff

[6] Reference 5, pp. 85f

[7] U.S. National Science Foundation, "Science Development Program for Colleges and Universities, 1964 and 1965," (NSF 64-7, March 1964) (National Science Foundation, Washington, D.C. 20550)

[8] Memorandum from the Director of the National Science Foundation to the Director of the Office of Science and Technology, March 27, 1964, as quoted by Dr. J. M. England, NSF Historian, in an unpublished manuscript dated August 20, 1968

[9] Reference 4, page 527, and "Statement by the President," Office of the White House Press Secretary, April 30, 1965, for release May 4, 1965

[10] Public Law 88-204, Higher Education Facilities Act of 1963

[11] U.S. National Science Foundation, "Annual Report, Fiscal Year 1965," (NSF 66-1) (U.S. Government Printing Office, Washington, D.C. 20402) pp. xxvi f

[12] "Recommendation for Action by the Federal Council for Science and Technology to Help Build Increased Strength in Science in All Parts of the Nation," submitted by Leland J. Haworth, Director, U.S. National Science Foundation, May 17, 1965.

[13] J. Merton England, unpublished manuscript dated August 23, 1968.

[14] U.S. National Science Foundation, "Annual Report, Fiscal Year 1966," (NSF 67-1) (U.S. Government Printing Office, Washington, D.C. 20402) pp. ix ff.

[15] U.S. National Science Foundation. Justification of the Estimate of Appropriations as Submitted to the Congress for Fiscal Year 1966. (Washington, D.C. 20550).

[16] "Important Notice to Presidents of Universities and Colleges," October 28, 1966, signed by Leland J. Haworth, Director, National Science Foundation; U.S. National Science Foundation, "Departmental Science Development Program," (NSF 68-29) (National Science Foundation, Washington, D.C. 20550, 1968)

[17] Memorandum from the Associate Director for Institutional Relations to the members of the National Science Board (NSB) Committee on Science Development awards and NSB Committee II, January 4, 1968 (NSB/C-68-1)

[18] U.S. National Science Foundation. Justification of the Estimate of Appropriations as Submitted to the Congress for Fiscal Year 1968 (Washington, D.C. 20550) pp. 310 ff

[19] U.S. National Science Foundation, "Science Development Program," (NSF 70-17) (National Science Foundation, Washington, D.C. 20550, 1970)

[20] U.S. National Science Foundation, "The NSF Science Development Programs, Volume II. Budgets, Statements of Goals for Each Grant, and Grantees' Summaries of Grant Impact," (Fred E. Stafford, Ed.) (NSF 70-17) (National Science Foundation, Washington, D.C. 20550, 1977)

CHAPTER IV

Discussion

The decade of the 1960's opened with national concern for providing high quality education to a rapidly increasing number of undergraduate and an even more rapidly increasing number of graduate students. The Seaborg Report of November 1960 laid down for the Nation a goal of doubling the number of universities doing generally excellent work in basic scientific research and graduate education. The reasons were political, social, and economic.

The Ford Foundation "challenge" program (1959-1966), by the very size of its grants, focused attention on the role of higher education and the vast financial requirements for improving its quality. The "challenge" program requirement that an institution raise matching funds forced the institutions to a new dimension of fund raising effort with a high level of professional management.[1] The resulting fund-raising organizations in the institutions continued to function and grow after the Ford challenge requirements had been met.

During this decade, the total level of university funding, and of Federal funding of basic research, facilities, institutional programs, and traineeships all increased markedly (Table 2). Questions raised during budget hearings and a policy directive from the President stressed that these increased Federal funds be widely distributed. Furthermore, the several Federal agencies necessarily interacted to avoid duplication of development awards.

An insistence on comprehensive, long-range planning was one of the distinctive elements of the Ford "challenge" program. The Ford Foundation felt that one of the program's principal results was the impetus the program gave to long-range planning in colleges and universities throughout the country, nonrecipients as well as recipients, public institutions as well as private.[1] Among the Federal programs discussed in Chapters II and III, the emphasis on long-range, institution-wide planning was shared by the SDP, COSIP, and NIH Health Science Advancement Awards (HSAA) Program.

The Federal programs were open to all who would apply, whereas the Ford Program was limited to private institutions by invitation. The difference is significant. A competition for a small number of prizes is known to be able to influence the motivation, awareness, and achievement of a large number of people or institutions. It is one thing to know that one ought to identify strengths in all disciplines, plan to develop them, and then make a start in that direction. But it is quite another thing to feel that one's own plan especially for the sciences might bring a large grant-in-aid. In addition, the fact that the Federal Government would commit its funds for quality improvements in science underlined the seriousness and urgency of the need for science development.

The origin of the SDP within NSF had another clear implication. Receipt of an NSF fellowship or grant was a high accolade. Because it came from NSF, an SDP grant also was considered an accolade.

Especially in a time of rapidly increasing funding, it seems, therefore, that the SDP would have had effects on its entire target population of doctorate-granting institutions.* We will now examine some of these effects. This examination is based on published comments[2] of the SDP staff which were confirmed and expanded on by our readings of the grantees' reports and our site visits. These 12 site visits included meetings with all levels of university personnel from students through President or Chancellor. They were open ended in form and designed to identify as many as possible of the effects of the SDP. Finally, this examination is based on the grantees' summaries of grant impact which appear in Volume II of this report.[3] We note that our contact with nongrantees was limited; our comments about nongrantees are based largely on extrapolation from the experience of the grantees in planning and preparing a proposal, and from knowledge of the total number of proposals received.

A. Effects on the Entire Target Population[2]

Helped Identify Science Development as an Institutional Problem. First, and perhaps most important, the SDP helped identify the problem of improving academic science as an institutional problem. Institutions, themselves, had to be concerned about broad-scaled development. The SDP proposal was a dynamic force, fashioned in the

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* Because of the nature of the first SDP announcement and the precedent of Ford grants to 4-year institutions, planning was stimulated and proposals were received from 4-year institutions. The fruition of this process came through the COSIP program.

context of a university's entire academic enterprise. Thus, science development was to take place from an institution-wide perspective of institutional goals, philosophy, and resources.

Encouraged Institutional Planning. Second, the SDP encouraged realistic institutional planning for science development. The construction of a coherent university science development plan:

(1) that is logical and consistent with existing institutional strengths and long-range institutional plans;
(2) that reflects the interactions among university administrators and faculty; and,
(3) that bears the imprint of decisionmaking, goal-setting, intelligent allocation of resources, and genuine commitment

is in itself an important contribution to institutional development. With such a plan in mind, a university administration was aware of the role within the university, and the needs and goals of each of its departments. It could persuasively convey those needs and goals to those who might provide the institution with funds. And, it could more rapidly identify and plan for trends toward decreasing enrollments or finances.

Different institutions employed different procedures for preparing a proposal. In many, there seems to have been an internal competition based on the internal role of the department (*e.g.*, courses taught, support offered to other departments) and the cogency of the department's own development plan. Our site visits and interviews indicated that this process stimulated:

(1) departmental self evaluation and comparison with professional peers;
(2) cross-discipline and vertical communication within the institution;
(3) revision of internal procedures, especially of those for assuring the quality of tenure appointments;
(4) revision, in some instances, of salary scales; and,
(5) awareness of particular problems and needs.

The post World War II rapid increase in subject matter and technology created within the sciences special needs for sophisticated apparatus in research and teaching laboratories, shops, teaching and research assistants, support personnel, professional travel, and visiting lecturers which had not yet been integrated into the structure of university budgeting. Item 5 refers in part to these needs.

About 90 different institutions submitted proposals to the University SDP. About 300 proposals in all were submitted to both the University and the Departmental SDP. In all, the target population included approximately 200 grantee institutions with about 3,000 eligible departments or activities.

Drew Attention to Research as Inseparable from Teaching. Third, the SDP (and later, COSIP) drew attention to the importance of both research and teaching as inseparable aspects of education in science. In evaluating a proposal, the programs examined the role of faculty as teachers and investigated whether curricular reform and development were part of the university's plan. If new faculty were to be hired with the aid of the grants, their role in teaching was examined.

Provided Proposal Review and Feedback. Fourth, the SDP provided review of the proposals and feedback to the institutions. We have already commented on the qualifications of the SDP staff and their astuteness in choosing mail reviewers and site visitors. The NRC/NBGE evaluation report, which was prepared in such a way as to guarantee anonymity to the visited institutions, remarks:

> The perspicacity of the Foundation's judgments in making awards was noted both at funded and nonfunded institutions and departments. Rarely did it appear, in retrospect, that the Foundation should have given a grant to an institution that it had turned down; the same held true for departments. Almost inevitably, a reassessment of the judgment years later revealed that it had been on target, and university and departmental officials who had worked on the proposal would often admit as much to the site visitors spontaneously.[4]

After a decision on a proposal was made, the university president could ask for a review of the evaluation. Most did. Benefits accruing from the SDP reviews prompted more frequent use of university appointed, external review committees. In at least one instance (Nebraska), a State legislature has started its own development program.

Provided A Mechanism for Inter-institutional Exchange of Ideas. Fifth, the SDP proposals were sent by mail to four to eight reviewers in academe and in industry. These mail reviews were digested and summarized by the SDP staff, and presented as issues to the non-NSF site visitors. These visitors included professors, deans, academic finance officers, and presidents of universities or science-related corporations. Thus, a large and important segment of the science community gained perspective and experience with the goals and methods of planned institutional development.

Stimulated Constructive Rivalry. Sixth, the SDP seem to have stimulated a constructive rivalry between science and nonscience departments within an institution, between grantee and nongrantee science departments within an institution, and between grantee and nongrantee departments in different institutions. What grantees obtained with grant funds was then requested of the institution by other departments as legitimate means of improving their own offerings.

Summary. The SDP were focused on the sciences. A large number of institutions submitted about 300 SDP proposals in competition for a high honor. Many individuals were involved in proposal reviews and site visits. Grants were made to 102 institutions in a target population of about 200 graduate level institutions (or to about 260 out of approximately 3,000 target departments). For these reasons, the SDP are believed to have had strong effects on all of the institutions, grantees, declinees, and others, in its target population. These effects were to:

(1) help identify the problem of improving academic science as an institutional problem;
(2) encourage realistic institutional planning for science development, including involvement of a large cross section of the university population in the identification of needs and goals, and realistic means of achieving the goals;
(3) draw attention to the importance of both teaching and research as inseparable aspects of education in science;
(4) provide a review of the proposals, feedback to the institution, and stimulus for use of external review committees;
(5) provide a mechanism for inter-institutional exchange of ideas; and,
(6) stimulate a constructive rivalry between grantee and nongrantee departments, sciences and nonsciences.

B. Direct Effects on the Grantees

The Accolade

The accolade implicit in receipt of an SDP grant proved to be important. The publicity accorded the program, the prestige of a Presidential announcement of the first grants, and the high esteem for NSF programs in general and for the rigorous selectivity of the SDP helped grantees to recruit outstanding scientists, to attract better students, to secure greater levels of non-Federal support, and to cultivate new sources of support.

The process was self reinforcing. If the accolade of an award brought esteem and interest, these were heightened by the morale of the grantees, their well-founded aspirations and standards of quality, and the authority with which they could describe their plans, their specific needs, and the benefits to be derived from the planned quality increases.

Uses of the Funds

By no means the least important aspect of the grants was the funds awarded. The role of SDP funds, as indicated in the grant summaries of Volume II and as discussed below, was more important than simply providing an increase in operating funds.

Special Budget Categories. Because each institution and each department had special problems, development plans and uses of funds varied. In some cases, the SDP provided initial support for an increase in faculty, graduate student support, postdoctorals, paraprofessionals, or support staff on the basis of an institutional commitment to secure more permanent sources of support during the period of the grant. In other cases, institutional assets were sufficient to provide for an improvement in the personnel-to-work load ratio, but funds were needed to provide adequate facilities or library resources. That intricacies of the institutions' normal sources of funding were such that one institution could receive $100 million for new buildings, but did not get adequate funds for books and back-issues of journals. Another could get instruments, but not the spare parts and the technicians to keep them running. Still another institution could get funds for high quality faculty, but the faculty were expected to perform routine tasks more efficiently performed by clerical personnel. Interestingly, there was an almost universal request for visiting scientists and seminar speakers. Such programs are relatively inexpensive, involving mainly transportation and overnight expenses, yet they are critical mechanisms for encouraging quality in research and instruction.

Flexibility. Most state and some private institutions were on annual budgets and could not make commitments until budgets were approved late in the academic year. In some cases, funds were in such rigidly controlled categories that they could not be shifted to respond to urgent needs or exceptional opportunities. Grantees comment on the effectiveness of SDP funds because of their flexibility in time and in category of use. In fact, grantees were constrained to use SDP funds for the purposes, and within the time-span, stated in the proposal. What was most important was that the proposed budget and the actual grant contained budget items available to the grantee from no other source. And for many departments the ability to plan for the use of funds over a period as long as 3 years was critical, especially in the area of faculty recruitment. It was expected, furthermore, that the original plans might have to be altered during the course of the grant period. The Foundation was able to review quickly, but carefully, requests for such changes and to respond appropriately.

To pick up a metaphor that will be useful later, if science is like an orchard, then the SDP provided a small-to-moderate increment in the fertilizer used by an already moderately successful arborist and large increments in the critically needed trace elements and chemicals, *i.e.* funds in such budget categories as start-up funds, library resources, and distinguished visiting lecturers. The SDP further gave the local administration increased leeway in using just the right quantity and mixture of resources at just the right time.

Increased University Contributions. Universities receiving SDP grants were able to contribute a substantial amount of the funds, over and above the normal support for the participating departments or activities, needed to support the planned improvements. Thus the grant funds allocated to a particular discipline (Volume II)[3] often were only a small part of the cost of the development program. Further, the universities committed themselves to continue to support the increased level and quality of activity. (The changing economic situation has kept some institutions from continuing to meet this commitment. The grantees comment, however, that even if numbers (of *e.g.*, faculty) have not increased as much as planned, quality has indeed increased.) In the case of the University SDP, the additional university expenditures roughly equalled and sometimes largely exceeded the grant amount during the grant period. In the case of the smaller Departmental SDP grants to rapidly developing institutions, institutional contributions have been ten or more times the grant amount.

Increased External Funding.

It was expected that the improvements in facilities and faculty would permit the institutions to compete successfully for the increasing Federal and other research, development, and instructional funds. This would simultaneously help finance the institutions' research and education programs and achieve a better distribution of Federal funds.

In part, this expectation was predicated on increases in the Federal funds available. The relative success between 1965 and 1969, of 12 early grantees in obtaining increased funding for the grantee areas has been tabulated elsewhere.[5] Comparison of the annual levels of funding won in external competition by the grantee activities or departments with those won by nongrantees might be useful, in conjunction with other indicators, in assessing the success of the SDP. Many of the summaries in Volume II[3] indicate that external funding for the grantee departments or areas has remained constant and in some cases increased dramatically.

Summary

In summary, the reports and the site visits indicate that there were four major effects on the grantees. One was the accolade effect, with the attendant increases in self esteem, standards of workmanship, and ease in approaching prospective faculty, students, and donors. In some instances, the accolades were reported to have been effective in warding off budget cuts. The second was the effect of the grant funds. These SDP funds were in budget categories and had temporal flexibility not normally available to the institution. For these reasons, they had effects believed to be greater than might be inferred from their value relative to the total university or departmental budget. The third effect was the increase of university allocations to support the new levels of departmental quality during and beyond the grant period. Grant funds were only a fraction of the funds used in any given development program. The fourth effect was an improved ability to compete for external research and instruction funds; many grantees indicate that they have been successful in competing for funds, but a detailed comparison of the success of grantees relative to nongrantees is needed.

C. Direct Results

The purpose of this section is to identify all of the possible results in preparation for possible future quantification and systematic evaluation. The preceding sections of this chapter indicate that the SDP played an important role in motivating, influencing the course of, and funding development of education and research in engineering and the sciences. Chapter II, Milieu of the SDP, has already indicated, however, that the SDP were only the culmination and focal point of a mood that had permeated the Nation. Section B of Chapter II further indicates that SDP funds were only a small part of all the funds that went into university development, and science development in particular. Consequently, the SDP were only one contributor, albeit an important contributor to the results described below.

Once a science development proposal was reviewed and funded, management of the development program was the responsibility of the university, often at the departmental level. The quality of local management at all levels, including the departmental, was carefully considered before an award was made. While our impression is that in almost all cases the quality of the resulting development programs was very high, there was a spectrum of results. These results depended in a complicated way on the local situation and local management. For instance, of the 45-odd instances where there were two or more grantee departments at a given institution, there are three known cases where one department had done very well while another department had made little or no progress by the end of the grant period. In fact, there were a small number of cases in which one grantee department of a University SDP grant was excluded for this reason from funding under the supplemental grant.

Thus, reminded that the SDP were not the only contributors to institutional development, we present a summary of the results.

Impact on Faculties

Clearly the most important benefit of the SDP was in the form of strengthened faculties. This was accomplished through construction of new facilities, provision of needed equipment and supplies, making time available for research and creation of new courses, and intellectual inputs from postdoctorals, visiting scholars, and lecturers, all of which facilitated upgrading, recruiting, and retaining strong faculty. Progress is indicated by a higher proportion of research-active faculty, increased levels of competitively awarded research and teaching grants, and increased numbers of publications. In many instances, one sees the highest forms of peer group recognition: election to a National Academy; awards of Sloan or Dreyfuss fellowships, NIH Career Research Development Awards, and other fellowships; selection to editorships; and service as consultants to government or industry. (In a few instances—the author estimates not more than 10 to 20 departments out of 260—the departments seem not to have made well-chosen faculty additions and have not progressed as they should have.)

Within the institution, the reports indicate that the grantee departments have attracted increasing numbers of students both in their courses and as majors. When there is student evaluation of courses, the grantee departments are highly rated for courses of a given type (*e.g.*, required courses for nonmajors compared among themselves). Grantee department faculty figure prominently among the recipients of awards for outstanding teaching.

Benefits Accruing from Increased Faculty and Program Quality

The impact on undergraduate and graduate students at the grantee institution is clearly the most direct, and possibly the most important benefit. The other effects ripple out and affect large numbers of people. There is no common denominator by which they can be readily intercompared. The roles and the clientele of different institutions and departments are differently defined, as in the case of State and private universities, commuter and residential institutions, or basic science and engineering departments. Although there are overlaps, there is also a further set of differences between University and Departmental SDP grantees. Some of the Special SDP grantees (*e.g.* Brandeis, Northwestern, Stony Brook) might be properly classed with the University SDP group, others with those of the Departmental SDP. Consequently, not all of the grantees will have produced each of the benefits mentioned below.

Undergraduate Instruction at the Grantee Institution. New faculty were reported, as expected, to bring new ideas with them. Small increases in the number of faculty and support personnel were reported to permit large increases in the time available to create and implement new courses and laboratories. At every institution, courses for both majors and nonmajors were updated or created anew. Students participated in creating the new courses. Research instrumentation and SDP-funded equipment are used in student laboratories. Support personnel maintain these heavily used, and sometimes abused, modern instruments. SDP-supplied personnel and equipment figured in the introduction of new methodologies including computer assisted learning and modular courses. These methodologies often have the greatest impact on nonmajors, and often spread from the grantee to other departments and nearby colleges.

SDP faculty are highly rated in student evaluations and by their deans. They frequently win outstanding teacher awards.

SDP departments helped to create new degree programs, as for prospective teachers, or multiple-field BA/MS programs.

One of the most important and widespread benefits was the development or enlargement of independent study, research participation, and honors programs. Students start these programs as early as the freshman year (undergraduate research, in fact, is in the best sense a "hobby" for some students). The participants are assigned their own laboratory benches and have contact with their faculty sponsors on days, nights, and weekends. Some of this work results in journal publication. (The University of New Orleans specifically mentions publication of over 100 research papers with undergraduates as co-authors.) Most of participants interviewed considered it to be the best part of their academic careers. Faculty have pointed out that the presence of several undergraduate research participants in a course has a marked effect on the intensity of the learning experience for all of the students.

The grantee departments report improved acceptance of their undergraduate majors by medical, professional, and graduate schools, and by employers. (This point, however, has not been quantified.) The institutions' deans report improved acceptance of the grantee departments' service courses by students and by the other departments and schools of the university.

Graduate Instruction and Research. Comments already made about awards and research grants won by the faculty, and about improved undergraduate curricula apply here equally well. Many of grantees report that their Ph.D. graduates are generally successful in finding suitable employment. If this is true, and if there is a general oversupply of Ph.D.'s, then one must conclude that there is no oversupply of Ph.D.'s in the subdisciplines in question, that the institutions find jobs for their graduates in local industries (as mentioned by William and Mary College), and/or that it is the Ph.D.'s from institutions of lower reputation and quality that are having the most difficulty finding suitable employment. In this regard, it is unfortunate that the NRC/NBGE reports[4-6] could not give nonacademic Ph.D. starting salaries beyond 1970, and do not give the lowest decile or quartile salaries. The latter might have been an indication of underemployment. Only institutions rated in the Roose-Anderson report (*i.e.*, not the very weakest institutions) were included in the NRC/NBGE study populations. For each discipline, chemistry or physics, starting salaries were sensibly equal for the "high," "medium," and "low" control groups, and for the University and Departmental SDP grantees. In each discipline, the average annual starting salary increased steadily, reaching average values of $15,000 (physics) and $14,000 (chemistry) in 1970. (Some numerical examples are tabulated in Section D, below.)

Impact on Other Departments or Schools Within the Institution. The grantee departments frequently were included by the institution in the SDP proposal because of their role as service departments. Chemistry and mathematics departments, for instance, offer service courses to large numbers of freshman. (See, *e.g.*, discussion in the Michigan State summary in Volume II.)[3] Students often use their performance in these courses as bases for deciding whether or not to continue in pre-medical or engineering programs. At the institutional level, these and other departments offer support to such areas as biology or geology. Thus, it is not surprising that the grantee departments were noted to be effective in offering service courses, providing resources such as instrumentation, starting interdisciplinary collaborative work, and acting as a base for developing other departments and areas. (By the same token, it would not be surprising if non-SDP institutions also were found to have developed such service departments.)

The grantee departments were reported to set, or help set, high university-wide standards for teaching, scholarly endeavor, service on committees, and promotion to tenure.

The vigor and the quality of the grantee departments were reported to help institutions attract high-quality undergraduate students, as well as grants and endowments. Faculty from the grantee departments have been called upon to serve as high level administrators in the institution.

All departments of an institution are affected by the quality of the institution's long-range plans. The important role of the SDP with respect to planning is discussed in the University of North Carolina summary in Volume II.[3]

K-12 Education. Admission and freshman course standards of institutions that are at the educational apex of a closely defined geographic or demographic region (*e.g.*, City College, Hunter College, NYU, and PINY in New York City, and almost all State institutions) are imparted to the corresponding high school systems. The grantees have a direct influence through training teachers (including special MAST [Master of Arts in Science Teaching], or Doctor of Arts programs), providing refresher programs and seminars, sponsoring science fairs, and providing direct services such as on-line instruction in the use of computers or computer assisted learning projects. The employment of faculty husbands or wives in the school systems, their role as volunteer workers, and faculty insistence on high quality K-12 instruction also have been cited.

Junior College and College Instruction. This interaction is similar to, but more direct than that described above for K-12 instruction. Included are common curricula so that junior college students can transfer automatically to the university, and joint programs to maintain college faculty vitality.

Other Services to Community and State. Over and above the impact of the grantee departments on various parts of the entire educational system, certain departments, particularly in engineering, were effective in offering continuing education and consulting service to local industry and to the state. (See, *e.g.*, the summaries of Clemson University, Colorado State University, and the University of Houston in Volume II.)[3] All grantees were felt to make their regions more attractive to industry, especially those requiring highly trained personnel, and some work directly with State development departments. Grantee department faculty serve as consultants to the State governments.

Research Relevant to Current and Long-Range National Problems. Two points of view were expressed. One was that the SDP caused institutions to overexpand in areas that are no longer relevant to national problems and for which it is difficult to find support. The other was that the high caliber of people hired have been able to direct their interests toward such problems as ecology, energy, and mineral resources. It is not possible to list here all of the relevant research in grantee departments; it is in the nature of basic research that it be useful in many areas. Some readily identified examples are the grantee departments at the University of Arizona and Colorado State University that participate in solar energy utilization projects, and the mineral resources related departments at Louisiana State University, Virginia Polytechnic Institute, Colorado State University, Colorado School of Mines, the University of Montana, and the University of Wyoming. The grantee department at Utah State makes important contributions to a grasslands biome project. While these examples are easily identified, every grantee of which we have knowledge has research and other projects that fall into this category.

Problems and Detrimental Effects

During interviews with grantees, during site visits, and in compiling reports for Volume II,[3] deliberate attempts were made to identify possible problems and deleterious effects caused by the SDP, the ways in which they were administered by NSF, and the way in which SDP funds were utilized by the administrations of the grantee institutions. The grantees' summaries in Volume II,[3] for instance, resulted in part from a request that the final reports discuss "the effects—both good and bad—of the SDP," and the specific suggestion that grantees discuss "Detrimental Effects of the SDP."

Strong programs, which by definition produce increased benefits for the institution(as opposed to programs that are simply costly), require increased budget allocations, and so pose problems for university administrators. Such problems are mentioned frequently in Volume II.[3] Some administrators indicated in conversation that they felt that the SDP carried an implicit and unfulfilled promise that Federal support would be available to help maintain the strengthened programs. (See also summary in Volume II from Stevens Institute.) Even though the present level of Federal support is not satisfactory to many grantees, the summaries in Volume II give the impression that the grantee activities are a welcome burden: the concern of the administration is to avoid weakening or losing a valuable activity. Thus, this problem may actually be taken as an indication of the beneficial results of the SDP.

Many of the questions about detrimental effects are questions of value judgment and could not be resolved within the scope of this study. We present them, therefore, as questions along with such answers as are available:

1. Did the SDP over-stimulate growth, resulting in
   a) over-commitments to expensive but not fully productive (i) tenured faculty and (ii) facilities?
   b) over-commitments to tenured faculty, precluding an infusion of new people and ideas?
   c) over-commitments to certain of the sciences and engineering to the detriment of other sciences, social sciences, and the humanities?
2. Did the SDP cause over-emphasis of graduate programs to the detriment of undergraduate education?
3. Did the SDP result in over production of Ph.D.'s?
4. Did the SDP cause hard feelings, jealousy, and unhappiness among nongrantee departments (rather than the constructive rivalry mentioned earlier)?
5. Did the SDP cause undue or harmful depletion of the faculty and resources of non-SDP institutions, including the already strong institutions?

Over-commitment? There is no doubt that one purpose of the SDP was to cause institutions to choose specific areas for development and then make commitments to those areas. In one sense, then, this question asks how effective were the program managers in culling out institutions that lacked good internal management or a sound financial base, in trimming back programs that were too ambitious, and in selecting only the soundest proposals that would lead to productive growth. It asks whether science development has proved to be appropriate in view of the ensuing changes of the funding situation for science, the decline in economic conditions in some parts of the country and in some universities, and the continued prosperity in other geographic areas and universities. And, implicitly, it asks whether the resulting strengths and weaknesses were due to the SDP or to the effectiveness of local management, which sometimes changed after an award was made. Parts of this problem are addressed in Volume II[3] by the President of New York University:

> A USD Grant is a double-edged sword. Mechanical fulfillment of the plans of the proposal could easily lead to financial disaster for the awardee institution in the face of changing enrollment patterns and changed circumstances. Prudently used, the NSF funds can achieve the desired improvement in quality. . . Care must be exercised in planning, however,, to coordinate funds available for project support with these grants; otherwise, the program will lead to frustrations arising from unfulfilled rising expectation.
>
> Misgivings are frequently voiced about the likelihood that awards of this size for a few disciplines will lead to imbalances in the academic unit as a whole. Our experience indicates otherwise if one looks below the surface. Instead of trying to be "equitable" in distributing inadequate internal resources among all disciplines—and leaving them all inadequately supported—this award provided a basis for our concentrating our resources where they could be used effectively, without doing significant damage to the weak departments (which we could not have put into a position to improve themselves significantly without the award in any case). Furthermore, this approach encouraged other departments to seek to establish a solid basis, financially and educationally, for real improvement, secure in the knowledge that when the prospects were real, the University generally would have the will and the energy to find means to back them up [James M. Hester, New York University][3]

Another part of the answer to these questions lies in the still undetermined relationship between the additional costs of high quality programs and the additional returns in terms of the ability of an institution to attract students, to formulate plans for handling difficult situations, and to attract funds. We were not able to ask the grantees for direct comments about this relationship. An inference may be drawn, however, from the positive tone of the statements in Volume II.[3] While the administrators are fearful and regretful that programs may have to be curtailed, they are positive about what the programs contribute to the institutions. One might note, for instance, the very strongly favorable comments of the President of CUNY (City University of New York)-City College which, according to the press, faces especially severe financial problems.

Between 1960 and 1970, the enrollment in institutions of higher education increased by 120 percent (Table 3). Many of the new faculty hired to teach this increased number of students were fresh Ph.D.'s, meaning that there will be relatively few retirements during the next 20 to 30 years. Because enrollments are expected to plateau and then decrease, there will be little chance to bring in new, young faculty with their new expertise and fresh ideas, causing a problem with what has been termed "faculty vitality." Because the faculty are almost all tenured, it is difficult also to reduce faculty size.

Expected increases in research funds and in graduate enrollments may have caused the increase in faculty size to be larger than if they had been based on increases in undergraduate enrollment alone. In reality, research funds and Federally-sponsored fellowships have become harder to obtain, graduate enrollments in certain disciplines have dropped, and on some campuses undergraduate interests have shifted sharply leaving some departments in some universities overstaffed.

In what ways did the SDP contribute to, or help ameliorate problems of faculty vitality and overstaffing? The earliest SDP proposals were predicated on a continuously increasing economy. By 1968, downturns in the economy and in enrollments had started to become evident so that institutions could adjust their plans and their proposals. One might expect such problems, therefore, to occur with the earliest grants (median award dates: USDP, May 1966; DSDP, August 1969) while the later grantees should have been able to use grant funds to help avoid such problems.

The NRC/NBGE reports[4,5] conclude that NSF funds helped mathematics departments in both the public and private sectors to enlarge their faculties relative to changes in the control groups; in physics and chemistry this increase in size was limited to the public sector. The reports do not specify whether this conclusion refers only to the USDP or to all of the SDP grantees. The reports fail to correlate this increase with undergraduate enrollments. We have observed that SDP public institution enrollments increased by 40 to 50 percent between the time of the proposals and fall 1972. It may be that the faculty increases are due primarily to increases in enrollments in the period under consideration.

On the positive side, the SDP insisted on long-range planning, faculty quality, and scholarly activity. It is likely that the mechanisms set up by the institution to create and review plans for the SDP also helped them to identify quickly and react appropriately to the changes in the academic economic situation. The faculty hired under the SDP are of high quality. They are called to serve in administrative positions, receive offers from other institutions, redirect their research programs to areas of current interest and in which students find jobs, and maintain their intellectual vitality. Thus, it is suggested that the SDP actually helped to avoid or ameliorate problems caused by extensive faculty hiring during the 1960's.

Some exceptions to the positive statements in Volume II are brief statements by Carnegie-Mellon University (where the high proportion of tenured faculty is a problem), and Case Western Reserve University (which felt that the SDP overemphasized increases in numbers of faculty). The President of Claremont Graduate School makes the most negative comment:

> The net result has been the development of a good small and very expensive group of mathematicians whose quality is a private satisfaction, but which has made little impact nationally, and which drains the institution of its resources and prevents use of funds to develop other programs [Barnaby C. Keeney, Claremont Graduate School] [3]

It might be expected that such problems are especially likely in small institutions Statements from other such institutions are positive or strongly positive It would be informative for the reader to look at the summaries from those institutions with for instance, fewer than 9,000 students These include (in the private sector). Brandeis, Bryn Mawr, Clark, Clarkson, Denver, Drexel, Emory, Illinois Institute of Technology, Lehigh, Polytechnic Institute of New York (PINY), Rensselaer, Stevens, Wesleyan, and Yeshiva

A situation quite different from that at Claremont exists at the State University of New York-Albany (SUNYA) Dean Cowling points out

> The large number of nonmajors (2,500) as well as majors (600) in mathematics is in itself silent but compelling testimony to the stimulus the students find in the program as a whole. Roughly 12 percent of the B. A. and B. S. degrees at SUNYA are in mathematics (160) as compared with a national average of around 2 percent. The total number of nonmajors (2,500) is very large for an institution that does not possess an engineering school and hence relatively few curricula mandating mathematics. Thus the quality of the faculty, clearly a result of the development grant, has been found to be most attractive by the students.
>
> We find that similar statistics may be quoted for the Biology Department. During the spring and fall semesters, 1974, the Biology Department had a considerable number of nonmajors (965) and a large number of majors (1,000) enrolled in its program. Some 14 percent of the B. A. and B. S. degrees at SUNYA were awarded in Biology (175) as compared with the national average of around 4.2 percent [Vincent F. Cowling, Dean, Division of Sciences and Mathematics, SUNY-Albany].[3]

Dean Cowling continues to indicate the salutary effects of the grants on the two departments and on the entire Division of Science and Mathematics. The economic situation surrounding this development is described by the Vice-President for Research:

> Since the inception of the NSF Grants, we have witnessed a dramatic change in funding levels, both external (Federal) and internal (New York State); we have witnessed a major decrease in funding at all levels The growth in biological and mathematical sciences at SUNYA which was anticipated at the time of application for the grants has not taken place The major changes that have taken place can be directly attributed to the support received from the Science Development Grants
>
> The principal grant expenditures have been for faculty salaries While the development grants have not made it possible to show a large net gain in numbers of faculty, they have provided avenues of quality improvement among the junior faculty They have allowed the departments to plateau in numbers of personnel at a time when decreasing state

> appropriations for total instructional and support positions for the university center as a whole would have probably resulted in a net decrease since allocations were made according to relative quality among programs, not simply differences in workload [Louis R. Salkever, Vice-President for Research and Dean of Graduate School, SUNY-A].[3]

Among other comments, the President of the University of Maryland indicates that,

> The accomplishments of the scientific units included in the Science Development Programs have been notable.

He expands on this point and continues:

> The question is—where do we go from here? The general weakening of the economy at the State and Federal levels, combined with spiralling costs, has reduced operational support for highly sophisticated research and costly teaching programs. We are faced with a situation of fiscal retrenchment for faculty groups that enjoyed substantial support and growth during the past two decades. It was inevitable from the start that the growth curve would eventually plateau; but this is easier said than accepted or adjusted to. The absence of constructive, consistent national policy on science adds greatly to the uncertainty of both short term and long-range planning.
>
> To the extent that there was a "build-up" in the physical sciences programs at the University this fact did have an impact on availability of funds for programs within the total University. The matching commitment between the State and the government as set forth in the original proposal was faithfully achieved, but not without some costs to those departments not in the Science Development Program. This is particularly true since the University proposal for the Science Development Program was prepared and approved under one State administration and became operational under another State administration.
>
> As a result of the combination of present circumstances, namely the state of the economy (nationally and locally); the changes in program priorities, *e.g.*, energy and environment versus space science; and the stabilization of enrollments—all of these require the University to reexamine its programs in terms of establishing new priorities and to make internal adjustments to accommodate the decisions. To the extent that the Science Development Program contributed to what presently might be regarded as programmatic imbalances, the adjustments that need to be made are more difficult to accomplish [W. H. Elkins, University of Maryland].

Some other institutions must have similar problems. But not all institutions are in severely straitened circumstances. The economies of some parts of the country have remained strong. In those institutions, the problem is not severe or has not arisen.

Another aspect of the "over-commitment" question and its complexity is illustrated by the following anecdotal information. In each of at least two institutions, one of the grantee departments has been highly successful in mounting strong undergraduate programs and attracting external research support. But in both cases, another grantee department has added tenured faculty judged to be weak, leaving the department heavily tenured and with no retirements in the near future. (The two strong departments also are heavily tenured, but possibly will loose faculty to other institutions or to administrative posts. The high proportion of tenured faculty, in this case, is not considered to be as severe a problem.) In one case, a total of seven different individuals have occupied the President's and the Dean's positions since the submission of the proposal. In both cases, the present university administrations have plans for strengthening the weak departments.

It is quite clear that the strong grantee departments are valuable assets for the institution. But are the weak departments "detrimental effects" assignable to the SDP?

To give another example, we have visited three institutions with well-designed, admirably equipped new buildings that are larger and better equipped than if there had been no SDP proposal and grant. In all cases, the buildings were badly needed and judged to be essential to the continued functioning of the university. Two of the buildings house thriving departments that offer exceptional undergraduate programs, attract students to the institution, and maintain vigorous graduate and research programs. Both are recruiting for high level faculty appointments. The third building is underused and, like the first two, has high maintenance bills. If that university succeeds in invigorating the existing programs or creating new ones, the building will be a key asset. Otherwise it will be a financial drain. The final result may not be known for some time.

Finally, we note that what constitutes a programmatic imbalance within a university is a matter of judgment. The most difficult questions confronting university administrators have to do with allocation of funds (or cutbacks) among the institution's strong and weak departments (*i.e.*, when is a department too strong or unacceptably weak?). The actual decision-making seems to depend on finely tuned judgment that is not susceptible to rational analysis. That the long-range planning required for an SDP proposal has helped refine these judgments is mentioned by the University of North Carolina. Whether this planning helped institutions *avoid* programmatic imbalances has not been considered.

Detrimental Effects on Undergraduate Education? In almost all cases, the SDP strongly improved undergraduate education. The only possible exceptions are programs that are primarily graduate in nature, and these did not hurt the undergraduate offerings.

Administrators at the grantee institutions uniformly feel that the grantee departments are among the institution's strongest with respect to standards of course quality, acceptance by the students, acceptance of service courses by other departments, and introduction of new material, programs, and methodologies. Scholarly activity is reported to be essential in order that the faculty give current, exciting courses. Undergraduate research participation, an outgrowth of faculty research, is held to be one of the best parts of an undergraduate's education, and indeed, was one of the several goals of the College Science Improvement Program, COSIP. Finally, SDP funds were used directly in many institutions for course improvement.

Overproduction of Ph.D.'s? The net effect of the SDP seems to have been to increase the quality of graduate training, rather than the numbers of Ph.D.'s produced. Grants were made only to institutions with existing Ph.D. programs. Graduate enrollment would have increased in any event because of the increasing numbers of baccalaureates awarded and the increasing fraction of these baccalaureates seeking to do graduate work. (This point seems to be borne out by the NRC/NBGE study,[4,6] but the President of the University of Maryland takes the opposite view.)[3] Furthermore, an increasing undergraduate population gave rise, especially in the developing institutions, to increasing graduate support in the form of teaching assistantships.

The increased quality fostered by the SDP increased the attractiveness to employers of the resulting graduates. Most grantees maintain that their Ph.D.'s are finding suitable positions, except in certain special disciplines. They feel that the SDP helped them move into energy-related and other current areas in which they now expect a shortage of personnel.

Hard Feelings Among Nongrantee Departments? There is no doubt that different areas of education have different funding situations, and that a deliberate plan to develop a few areas at a time may increase the differences. While we have indicated above that the SDP stimulated creative rivalries and called attention to the legitimate needs of all disciplines, the Louisiana State University and the University of Texas summaries[3] point out that the SDP could also create an image of (unfairly) rich departments and exacerbate the feelings about the differences.

Undue or Harmful Depletion of Non-SDP Institutions? One goal of the SDP was to create strong centers of education and research for geographic and demographic regions not already adequately served. Such centers have been created and they do compete successfully for the limited research and education funds that are now available. There is no doubt that these new centers have been of great benefit to their respective constituencies.

The NBGE report[6] concludes that the SDP grantees in physics (the only discipline so studied) did not develop by recruiting extensively from the leading physics departments. The NRC/NBGE Project Director's report[4] shows that the highly-rated, non-SDP institutions ("high controls") continued to increase in productivity (as measured by publications) during the early SDP period, but perhaps suffered slight declines toward the end (1972) of the period studied. During this period and subsequently, some of the strongest universities have reported serious economic problems. The present study, however, could not examine whether the SDP contributed to these or other problems of the nongrantees.

Assessment of the Results of the SDP

One does not expect equal progress and accomplishment from each grantee, especially given the constraints on the SDP of working towards a geographic and demographic, as well as a disciplinary distribution of grants. The best professional judgment of the present author is that, on the whole, the programs have been highly successful. One grantee, the Polytechnic Institute of New York (PINY) is in difficult financial straits.

The institution, however, feels that the strengths built with the SDP grant have proved far more important than the excess of commitments over available funds.[7] (An analysis of the Polytechnic Institute of Brooklyn-New York University (Heights Campus) merger to form PINY has been published.)[8] Other grantee departments, especially in some universities whose overall enrollment and financial conditions suffered down-turns at the time of the grant, have made not much more progress than that due primarily to the SDP grant monies alone. By some standards these might be considered "failures." Nonetheless, these grantee departments play an important and even critical role in maintaining quality in the institution and in providing their students with the spark of excitement that turns instruction into education; these qualities are just those that are essential for survival of the institution. In one instance, however, a department is described as a private satisfaction, but a drain on institutional resources (Claremont Graduate School).

A number of departments made slow starts. In three cases with which we have had close contact, departments were judged to have made insufficient progress to warrant continued funding under the supplemental grant. And a DSDP grantee clearly would have been in this category were it able to apply for supplement. Yet, in three of these four cases, we know that there have been internal reappraisals. The departments have new chairmen, seem to have taken hold, and are now progressing vigorously.

Most departments in most of the institutions with which I have had contact have made substantial and even spectacular progress. Some, however, are now threatened by particularly severe economic recession in their region or among their clientele. In some of these cases, the grantees feel that the strengths built under the SDP will play an important role in attracting students and funds, and in maintaining the institutions' viability.

Finally, some of the grantee departments are now among the strongest either by regional or national comparisons and are in regions of growing populations and economies. These grantees are doubly important as resources aiding regional growth and as determinants of quality in a situation of institutional growth.

D. Evaluation

General Comments

Over the past decade and a half, there have been major changes in the body of knowledge and in the entire science and engineering educational system. Comparison of standard textbooks in use in 1960 and today demonstrates both points. The colleges and universities have both caused and reacted to these changes. Large increases of Federal funding for universities were prompted by the changes and, in turn, accelerated them. There seems little doubt that, even without SDP funds, most of these changes would have occurred, albeit at a slower pace, at fewer institutions, and in ways that might have been less acceptable. The data presented earlier in this report indicate that the SDP provided only a small part of all of the funds for development or for academic science. Evaluation of the SDP requires first that one understand how the various Federal, State, and private programs interacted with and complemented one another. The SDP could not have worked without some of the other programs, *e.g.*, for facilities which often had costs far in excess of the SDP grant. The SDP seem to have provided, along with the COSIP, Ford, and HSAA programs, a necessary emphasis on long-range planning for quality.

The start of the SDP was a time of increasing finances and undergraduate and graduate enrollments. The end was a time of prosperity in some parts of the country, recession in most. Initial goals and expectations, which in any case would take many years or decades for full realization, have been revised as the financial situation changed. In some institutions, what was once a movement toward increased strength is now an effort to survive. The question of how to assign value to the fruits of the SDP has become even more complex. One of the purposes of the present report has been to provide the documentation on which to base a future evaluation of the SDP.

The NRC/NBGE Evaluation

This evaluation[4,6] included two parts: a statistical treatment of 10 numerical indicators, and a section based primarily on the responses of site visitors (to 16 grantee and 5 control institutions) to a set of 12 questions. As indicated, this study resulted in two reports, a technical report by the Project Director[4] and the interpretations and generalizations made by the NBGE.[6] The Highlights section of the NBGE report states:

> Several technical decisions were made at the outset to help isolate the unique effects of Science Development. First, wherever possible, the data gathered for this study covered the 15 years from 1958 through 1972. Second, all (nonfunded) doctorate-producing universities in the country included in the 1969 American Council on Education survey of graduate

program quality[1] were used as controls. Third, the three fields that received the largest share of Science Development funds—Physics, Chemistry, and Mathematics—were analyzed in greatest detail, as was the nonfunded control field of history. Finally, to define "quality science education" in American graduate schools, multiple indicators (i.e., multiple criteria) were used. The major findings are enumerated below.

1. *Faculty Size.* NSF funds helped departments in all three science fields to enlarge their faculties. In physics and chemistry this increase in faculty size was limited to the public sector.
2. *Faculty Mobility.* An analysis of senior faculty mobility in the field of physics showed that the funded institutions did not develop by recruiting extensively from the leading physics departments.
3. *Scholarly Productivity.* Science Development funding had a positive effect on scholarly productivity as measured by [a] rates of publication in key journals, i.e., the funded departments registered an increase in the number of articles published by their faculty members in journals that have high scholarly impact. This increase, however, was largely a function of the growth in faculty size; the effects on [b] the publication rate of the individual faculty members were minimal [relative to changes in the control groups. Ed.]
4. *Graduate Student Enrollment and Quality.* Receipt of a grant was not closely related to increases in graduate student enrollments. Funded departments, however, were able to attract higher quality graduate students (as measured by [a] an improvement in the scores of first-year graduate students on the Graduate Record Examination), though there was no change in [b] the quality of graduate students if one judges by the selectivity of their baccalaureate institutions. ["Selectivity" is the average combined verbal plus quantitative Scholastic Aptitude Test score for all students in the baccalaureate institution, Ed.]
5. *Ph.D. Production.* Although Science Development funds increased the production of Ph.D.'s in physics, in mathematics that effect was observed only in the public university sector. In chemistry, no impact at all was apparent.
6. *Postdoctorate Employment.* Ph.D.'s from funded institutions differed very little from Ph.D.'s from nonfunded institutions with respect to attractiveness of jobs obtained upon graduation, whether [a] in or [b] outside of academe. New Ph.D.'s in mathematics from private Science Development institutions were somewhat more successful than those from (private) control institutions in obtaining positions at high-quality universities. [Numerical indicators: for (a), average Cartter faculty quality rating of the departments *to which* graduates went to teach; (b) average salaries received by Ph.D. graduates in their first nonacademic job, 1958-1970. Ed.]
7. *Geographical Distribution.* Under the major subprogram, University Science Development (USD), 31 universities in 21 states were funded. Six USD recipients were located in a State that already had at least one leading university according to a combined science measure based on the fields of mathematics, chemistry, and physics. The other 25 USD recipients were distributed among 17 States that did not have a leading university in 1965. Therefore, the goal of geographical dispersion of funds was largely achieved.[6]

Highlights 3, 5, and 6, and perhaps all of the highlights refer only to the University SDP. The data gathered in the present report suggest certain questions about these conclusions.

Goals. While both of the NRC/NBGE reports[4,6] discuss the goals of the SDP, neither makes a clear exposition of the goals. The only source materials cited are the "Seaborg Report"[9] and one of Page's articles.[10] The reports fail to recognize all of the SDP goals and to distinguish between the University, the Departmental, and the "1970" SDP. Thus, the NBGE report states:

Kenneth D. Roose and Charles J. Andersen, A Rating of Graduate Programs (Washington, D.C.: American Council on Education, 1970).

> **It is well to remind ourselves of the two principal objectives of the Science Development program: to augment quality science research resources in the United States and to widen the geographical distribution of these resources.**[11]

According to the material presented in the present Chapter III, the goals should be summarized as:

> to augment the science *and engineering* research *and education* activities at *graduate-level institutions,*

and

> to widen the geographic *and demographic* distribution. . .

Furthermore, our reading of the statements of goals and of the actions of the Foundation leaves no doubt that "education activities" specifically included undergraduate education.

Both reports are ambiguous about whether the University or the Departmental SDP is being discussed at any given moment. For instance, the Highlights sections of both NRC/NBGE reports do not indicate that the conclusions of the statistical study refer only to the University SDP.

Controls. Funds available for academic research and institutional development were rapidly increasing in amount and in geographic dispersion as shown in Chapter II and Chapter III B (Demographic and Geographic Distribution). Federal agencies interacted to be sure that two agencies did not supply development funds for the same program, thus broadening the distribution. Universities were raising large sums from non-Federal sources which they could use to some extent at their discretion. Long-range institutional plans, perhaps drawn up as part of the SDP proposals or inspired by the SDP, helped to raise these funds and suggested ways in which they should be used. (In fact, SDP funds often paid only for a small and variable fraction of the development costs of the grantee activity.) The three departments studied by NRC/NBGE, chemistry, mathematics, and physics, play central roles in training undergraduates and in supporting other disciplines (See *e.g.*, the Michigan State University summary in Volume II). These three departments were the ones most often included in funded SDP proposals and probably would have been the first ones funded internally by the institution.

Thus, three questions are raised:

- To what extent were both control and grantee departments affected by SDP?
- To what extent was there a compensating mechanism that provided non-SDP funds to the controls? How different were the overall funding situations for grantees and controls?
- And if the funding situations turn out to have been the same, which of the numerical indicators used by NRC/NBGE would distinguish differences of quality in a situation of equal funding?

The problem presented by the small size of an SDP grant compared to total Federal funds flowing into an institution was recognized by Drew who comments:

> As a result, there were many difficulties in assessing the impact of Science Development funds. That is, in its peak years, the program was providing about \$1 or \$2 million annually to each recipient institution, out of total Federal awards to that school in the neighborhood of \$15 million. Thus, even if these funds had significant effects, detecting them is quite a challenge in light of the huge amount of other forms of Federal support. Conversely, *any effects that are found will serve to indicate that the mechanism for directing and awarding these Science Development funds was particularly effective. [Italics added.]*[12]

The significance of the italicized statement is seen to be greater when one considers the small size of the SDP grants compared to the total (Federal plus non-Federal) funds available to an institution. Nonetheless, the NBGE have not mentioned this problem in their discussion.[6]

Given this ambiguity about the significance of the comparison of the grantees with the "controls," Highlight (3b) might have been better stated:

> The per-faculty publication rates increased by about the same amounts for both grantees and controls, *i.e.*, by 30-50 percent in mathematics and chemistry, and by 100 percent in physics.

Faculty size. Highlight (1) comments on an increase in faculty size in the public sector. Graduate enrollment, but not total enrollment, was used as a variable in the multivariate analysis. The present data show that total enrollment in the public SDP grantee institutions increased by 40 to 50 percent, while that of the private grantees increased only by about 10 percent. This increase may account for the observed public sector faculty size increase.

Faculty-to-student ratios have been used as indicators of the possibility of quality. The present report indicates, however, that paraprofessional and staff personnel play important roles in modern science departments. Accordingly, the personnel-to-total work load (*e.g.*, weighted credit hour production) ratio suggests itself as an improved quality indicator.

Selectivity. Highlight (4b) relies on the average combined Scholastic Aptitude Test scores of the graduate students' baccalaureate institutions. Chair people of graduate admissions committees at visited institutions point out that NRC does not correlate "selectivity" with candidates' success in winning NSF graduate fellowships. Grade-point averages, Graduate Record Examination aptitude and subject matter test scores, and letters of recommendation are used in the correlation. The NRC/NBGE Project Director's report[4] does not give the selectivity scores for the "High" and "Low" control groups so that one could verify the sensitivity of this measure for individual departments. Until validating data are available, this indicator and the conclusion based on it must be considered suspect.

Elapsed Time. The median University SDP award date was May 1966 (Table 1). The last supplemental award was made in May 1972. Highlights (5) and (6) deal with the numbers and success of Ph.D.'s produced, with the latest data extending to 1972 or 1970 (Highlight 6b). It is noted that if (i) there was no delay to hire new faculty or construct new facilities, (ii) the reputation of the grantee department was immediately enhanced, and (iii) an effective graduate student recruiting campaign was launched on receipt of the grant, the first SDP-affected student would arrive at the median institution in September 1967 and would graduate in the period 1971-1973.

This line of reasoning suggests that the data for Highlights (5) and (6) must be considered as baseline data. Information extending to a later time period is needed to assess the impact of the USDP. (However, see the following comment on "Average Salaries.")

Chapter 6 of Drew's report[4] gives publication rates for Departmental SDG recipients. We believe they are presented for information purposes only. The median DSDG award date was August 1969. If the delay time for the appearance of the first paper includes construction of facilities (0 years), recruiting faculty (1 year), setting up laboratories (1 year for experimental chemistry and physics; 0 years for theoretical areas), writing the paper (5 months), and time for the editing process (1 year), the first paper from the median award date DSDP institution would be January 1972 (theoretical areas) and January 1973 (experimental chemistry and physics). The last year for which data are presented is 1972.

Average Starting Salaries as a Quality Indicator. Highlight (6b) is based only on the average salaries received by Ph.D.'s in their first nonacademic employment in the years 1958-1970. A sample of those data,[14] for physics in the even years, is given in Table 15. The first row shows the average starting salaries (in thousands of dollars) for USDP grantees. The next rows are for the "high" (*e.g.*, Cal Tech, Harvard, Wisconsin), "medium," and "low" (quality) controls, ranked according to the Cartter Assessment of Quality in Graduate Education.[15] This sample, and indeed all of the data presented[14] show that there are no meaningful differences between any of the four sets of salaries. If anything, graduates of the "low" institutions get the highest salaries. These salaries, therefore, are meaningless as an indicator of quality of the degree granting institution. Consequently, Highlight (6b) is invalid.

The lowest quartile or decile salaries are not given. These might have indicated underemployment among the graduates.

Composition of Sample Groups. The effect of varying the composition of the sample is discussed by Drew:

Table 15. AVERAGE SALARIES (IN THOUSANDS OF DOLLARS) RECEIVED BY GRADUATES OF PHYSICS USD AND CONTROL INSTITUTIONS IN THEIR FIRST NONACADEMIC JOBS, 1958-1970[1]

	1958	1960	1962	1964	1966	1968	1970
Physics							
USDP Grantees	11.2	10.6	11.2	12.8	13.3	15.2	14.9
High Controls[2]	10.7	10.6	10.8	11.6	13.3	15.3	15.0
Medium Controls	11.0	10.5	11.5	13.2	14.2	16.0	14.7
Low Controls	11.0	10.3	11.1	11.0	12.2	15.1	16.3

[1] David E. Drew, Science Development: An Evaluation Study (National Academy of Sciences, Washington, D.C. 20418, 1975), p. 155.

[2] High Controls are nongrantee departments receiving a high rating in the Cartter assessment of quality in graduate education (e.g., Harvard, Wisconsin, Cal Tech). Medium Controls were considered to be most comparable with the USDP grantees.

> . . .it appeared that departments receiving above a given amount in the initial Science Development grant were much more likely to perform well, while those below that amount tended to do poorly. The amount varied from field to field (an initial award of $700,000 for mathematics and $800,000 for physics and chemistry). As a follow-up on this notion, the USD recipients in each field were dichotomized at the threshold, and the trends on the criteria were analyzed separately for the two new groups. In Figures C-1, C-2, and C-3 publication data for those two groups, as well as for the medium control groups are plotted. Note that the "above threshold" USD recipients perform brilliantly. For example, in mathematics these schools seem to be moving into a category of excellence: they catch the high controls, a finding that is rarely matched elsewhere in this volume. In chemistry, the USD schools show a definite effect on publication rates, where before there was virtually none. Of the two experimental fields, chemistry had a larger portion of recipients with below threshold funding, suggesting one possible explanation for the poorer performance in this field reported earlier.[16]

The statements of goals shown in Volume II[3] suggest one explanation of these observations: although the budgets show funds as being allocated to disciplines, in actuality the funds could have gone to a department, one element of a department, or a multi- or inter-disciplinary center. In physics, the grant to Duke University (physics: $523 thousand initially) went only to high energy physics. At the Polytechnic Institute of New York (PINY) (physics; $454 thousand initially; mathematics: $177 thousand total), funds were used to build up only those areas related to chemistry or electronics. At the University of Texas (chemistry: $431 thousand total), all activities were organized around four interdisciplinary activities rather than departments.

Thus, while the observation of the "threshold" effect in funding suggests that large sums are more effective than small, it raises a question about the validity of the composition of the sample groups used by NRC/NBGE, *i.e.*, whether departments should be included in the sample group if only a segment of their activities received grant support. The same question will come up with respect to Departmental SDG grants for multi-disciplinary activities (*e.g.*, biochemistry, chemical physics, surface studies). The choice made by NRC/NBGE was the most conservative one.

Summary. There are several areas of disagreement between the present report and the NRC/NBGE reports. The most important of these are:

- the NRC/NBGE reports do not give a documented exposition of the SDP goals, and seem not to have recognized all of these goals;
- questions are raised about the validity of the control procedures; and,
- the average starting salary is shown to be invalid as an indicator. One conclusion (6b in the "Highlights" above) is based solely on this indicator and hence is also invalid.

FOOTNOTES, Chapter IV

[1] Ford Foundation, "Toward Greatness in Higher Education: A First Report on the Ford Foundation Special Program in Education," (Ford Foundation, New York, N.Y. 10022, 1964).

[2] Parts of this discussion follow closely discussion in: U.S. Congress: House Committee on Science and Astronautics, Subcommittee on Science, Research, and Development. Hearings, 91st Congress, 1st Session, 1970 National Science Foundation Authorization, Volume II (U.S. Government Printing Office, Washington, D.C. 20402, 1969) pp. 526ff.

[3] U.S. National Science Foundation, "The NSF Science Development Programs, Volume II: Budgets, Statements of Goals for Each Grant, and Grantees' Summaries of Grant Impact," (Fred E. Stafford, ed.) (NSF 77-17) (National Science Foundation, Washington, D.C. 20550, 1977)

[4] David E. Drew, "Science Development: An Evaluation Study," (National Academy of Sciences, Washington, D.C. 20418, 1975) p. 45

[5] U.S. Congress. House Committee on Science and Astronautics, Subcommittee on Science, Research, and Development. Hearings, 92nd Congress, 1st Session, 1972 National Science Foundation Authorization (U.S. Government Printing Office, Washington, D.C. 20402, 1971) p. 843

[6] National Board on Graduate Education, "Science Development, University Development, and the Federal Government," (National Board on Graduate Education, Washington, D.C. 20418, 1975)

[7] George Bugliarello, President, Polytechnic Institute of New York, letter to NSF of October 8, 1975.

[8] George Bugliarello, Henry Urrows, and Harold Margolin, "Planning and Evaluating an Academic Merger and Making it Work: Final Report to the Carnegie Corporation of New York," (Polytechnic Institute of New York, New York, N.Y. 11201, 1976). See *e.g.* p. 11 of this report.

[9] U.S. President's Science Advisory Committee, "Scientific Progress, the Universities, and the Federal Government," (U.S. Government Printing Office, Washington, D.C. 20402, 1960).

[10] Howard E. Page, "The Science Development Program," in *Science Policy and the University*. Harold Orlans, ed., (The Brookings Institution, Washington, D.C. 20036, 1968) pp. 101-119.

[11] National Board on Graduate Education, Reference 6, above, p. 41.

[12] David E. Drew, Reference 4, above, pp. 19f.

[13] National Board on Graduate Education, Reference 6, above, pp. 7f.

[14] David E. Drew, Reference 4, above, p. 155.

[15] Allan M. Cartter, "An Assessment of Quality in Graduate Education," (American Council on Education, Washington, D.C. 20036, 1966).

[16] David E. Drew, Reference 4, above, pp. 180ff.

CHAPTER V

Conclusion

Science has been likened to an orchard. In times of need during the 1940's, the Nation shook the trees and gathered the fruit. During the 1950's and 1960's, the Nation moved to sustain the vigor of academe, and of academic science in particular. It saw the need for technologically trained personnel increase while the need for the unskilled diminished. For this and other reasons, it moved to put first quality education within the reach of every person in every region of the country.

Many Federal and private sector programs provided facilities, instruments, formula grants, traineeships, and research project support. Among these programs, the Science Development Programs (SDP) prompted the entire academic community to think about quality in education and to strive for excellence in the sciences. The SDP, along with certain of the other programs, identified science development as an institutional problem. The SDP motivated the universities to identify and plan for achieving their most cherished long-range goals, and to take the first steps toward them. They said, if you start to help yourselves, we will provide those resources that are essential but otherwise most difficult to obtain. Three hundred proposals were submitted. The nature of the proposal review process provided a mechanism for the exchange of ideas and set precedents for establishing external review committees. Because goals and needs were clearly defined, fund raising from other sources was facilitated. In these ways, the SDP benefited all institutions.

Although the Science Development grants were small compared to institutional budgets and of the same magnitude as departmental or activity budgets, they were large compared to most grants that any department could aspire to and could be used over an extended period of time. As such, they offered the departments exceptional flexibility as well as urgently needed resources otherwise unobtainable by the particular grantee. Money, however, is like fertilizer. Applied in the wrong way or in the wrong places, it can cause unproductive growth, it can burn, or it can kill. Applied at the wrong time, it can stimulate growth that is easily killed by frost or drought. Almost all involved agree that the university administrators and NSF program managers successfully avoided the first of these problems.

The current economic recession in the academic world is uneven in the different regions of the Nation and may still be increasing in severity. Whether the growth stimulated by the SDP has made the institutions more vulnerable to the effects of that recession is not clear. In a very few instances, this may have been the case. In most instances the opposite is true. Nonetheless, clearly outstanding activities that enhance the overall strength of their institutions face cutbacks in spite of their value. At present, however, the major fraction, and perhaps nearly all of the 261 departments or activities involved, have made and are making substantial improvements in the entire spectrum of services offered to their several clienteles. The results include improved education of premedical, engineering, and science students, better courses for nonscientists, better offerings in the K-12 system and in the colleges, increased research output, direct assistance to regional industries and communities, and contributions to solving long-range and current national problems.

Most of the grantees are among the outstanding departments or institutions in their particular regions, some of these solely because of the Science Development Grant. And some, at least in part of their activities, perform research and offer educational services that match the very best that this country has to offer.

APPENDIX A-1.

Numbers and Amounts of Awards Made Under the NASA Sustaining University Program for Training, Research, and Facilities, 1962-1971[1]

State Institution	Number of Grants and Contracts	Cumulative Obligations ($1000)
Alabama		
Alabama A&M Univ	3	77
Auburn Univ—Auburn	5	1,572
Oakwood College	1	25
Talladega College	1	34
Tuskegee Institute	2	64
Univ Ala—Huntsville	1	250
Univ Ala—Tuscaloosa	4	3,769
State Totals	17	5,791
Alaska		
Univ of Alaska	1	200
State Totals	1	200
Arizona		
Arizona State Univ	1	517
Univ of Arizona	3	2,633
State Totals	4	3,150
Arkansas		
Univ Arkansas—Fayetv	1	725
State Totals	1	725
California		
Calif Inst of Tech	4	2,635
Stanford University	13	6,029
Univ Calif—Berkeley	5	6,675
Univ Calif—L Angeles	8	7,041
Univ Calif—Riverside	1	228
Univ Calif—San Diego	2	615
Univ Calif—S Barbara	2	217
Univ of Southern Cal	8	2,996
State Totals	43	26,436
Colorado		
Colorado Sch of Mine	2	505
Colorado State Univ	2	837
Univ Colorado—Bouldr	2	1,722
Univ of Denver	6	2,633
State Totals	12	5,697
Connecticut		
Univ of Connecticut	1	622
Wesleyan University	1	29
Yale University	4	1,506
State Totals	6	2,157
Delaware		
Delaware State Col	1	9
Univ of Delaware	1	578
State Totals	2	587
District of Columbia		
Catholic University	2	1,046
D C Teachers College	1	2
Federal City College	2	53
George Washington U	3	2,158
Georgetown Univ	1	454
Howard University	3	498
State Totals	12	4,211
Florida		
Florida State Univ	1	682
Univ of Florida	3	3,852
Univ of Miami	10	2,204
State Totals	14	6,738
Georgia		
Emory University	1	197
Georgia Inst of Tech	5	4,347
Univ of Georgia	1	653
State Totals	7	5,197
Hawaii		
Univ of Hawaii	1	215
State Totals	1	215
Idaho		
Univ of Idaho	1	170
State Totals	1	170
Illinois		
Ill Inst of Tech	1	977
Northwestern U—Evans	3	1,570
So Ill Univ—Carbondl	1	93
Univ of Chicago	2	3,336
Univ of Illinois—Urbana	2	2,363
State Totals	9	8,339
Indiana		
Indiana U—Bloomington	3	933
Purdue University	6	4,148
Univ of Notre Dame	1	760
State Totals	10	5,841

Iowa

Iowa State Univ	1	1,037
Univ of Iowa	2	1,736
State Totals	3	2,773

Kansas

Kansas State Univ	2	1,037
Univ of Kansas	5	3,871
State Totals	7	4,908

Kentucky

Univ of Kentucky	1	538
Univ of Louisville	2	567
State Totals	3	1,105

Louisiana

La State U—Bat Rouge	2	1,285
Tulane University	1	795
State Totals	3	2,080

Maine

Univ of Maine—Orono	2	725
State Totals	2	725

Maryland

Bowie State College	1	12
Johns Hopkins Univ	2	900
Morgan State College	3	36
Univ Maryland—Col Pk	6	5,612
State Totals	12	6,560

Massachusetts

Boston College	1	224
Boston University	1	383
Brandeis University	1	375
Clark University	1	163
Harvard University	1	276
Lowell Tech Inst	1	61
Mass Inst of Tech	4	10,989
Northeastern Univ	2	435
Tufts University	1	229
Univ of Massachusetts	1	293
Worcester Poly Inst	1	185
State Totals	15	13,613

Michigan

Michigan State Univ	2	895
Michigan Tech Univ	1	95
Univ of Michigan	4	2,825
Wayne State Univ	1	310
State Totals	8	4,125

Minnesota

U Minn—Minnp-St Paul	6	6,134
State Totals	6	6,134

Mississippi

Mississippi State U	2	529
Univ Miss—University	1	263
Univ So Mississippi	1	101
State Totals	4	893

Missouri

St. Louis University	1	755
Univ Mo—Columbia	2	1,495
Univ Mo—Rolla	1	466
Washington University	5	3,411
State Totals	9	6,127

Montana

Montana State Univ	2	909
Univ of Montana	1	247
State Totals	3	1,156

Nebraska

Univ Nebraska—Lincoln	1	366
State Totals	1	366

Nevada

Univ of Nevada—Reno	1	234
State Totals	1	234

New Hampshire

Dartmouth College	1	403
Univ New Hampshire	1	345
State Totals	2	748

New Jersey

Princeton University	3	1,383
Rutgers U—N Brunswk	2	614
Stevens Inst of Tech	1	540
State Totals	6	2,537

New Mexico

New Mex St U—Las Cr	2	1,053
Univ of New Mexico	2	1,058
State Totals	4	2,111

New York

Adelphi University	3	778
Alfred University	1	90
City College of NY	2	198
City U NY—Grad Cntr	1	383
Clarkson Coll of Tech	1	269
Columbia University	11	3,008
Cornell University	5	3,117
Fordham University	1	230
New York University	10	2,948
Poly Inst Brooklyn	2	1,866
Rensselaer Poly—NY	3	3,145
State Univ NY—Buffalo	1	177
State U NY—Stony Brk	7	498
Syracuse University	3	1,932
Univ of Rochester	2	1,935
Woodstock College	1	30
Yeshiva University	4	672
State Totals	58	21,276

North Carolina

Duke University	2	1,359
No Car A&T State U	4	61
No Carolina State U	2	1,024
Univ N Car—Chapel Hill	3	1,362
State Totals	11	3,806

North Dakota

No Dakota State Univ	1	172
Univ of North Dakota	1	77
State Totals	2	249

Ohio

Case Western Reserve	6	4,569
Kent State Univ	1	284
Miami University	1	42
Ohio State Univ	2	1,022
Ohio University	1	190
Univ of Cincinnati	2	1,296
Univ of Toledo	1	234
State Totals	14	7,637

Oklahoma

Oklahoma State Univ	2	1,139
Univ Oklahoma—Norman	2	1,234
State Totals	4	2,373

Oregon

Oregon State Univ	1	759
State Totals	1	759

Pennsylvania

Carnegie Mellon Univ	1	1,136
Drexel University	3	920
Duquesne University	1	98
Lehigh University	1	767
Pennsylvania State U	4	2,702
Temple University	1	177
Univ of Pennsylvania	2	1,974
Univ of Pittsburgh	5	4,869
Villanova University	1	35
State Totals	19	12,678

Rhode Island

Brown University	2	1,192
Univ of Rhode Island	1	337
State Totals	3	1,529

South Carolina

Clemson Univ—Clemson	1	458
Univ of So Carolina	1	390
State Totals	2	848

South Dakota

So Dakota Schl Mines	1	100
So Dakota State Univ	1	150
Univ of South Dakota	1	191
State Totals	3	441

Tennessee

Univ Tennessee—Knoxv	2	1,975
Vanderbilt University	1	830
State Totals	3	2,805

Texas

Baylor University	1	48
Bishop College	2	36
Prairie View A&M Col	6	97
Rice University	4	4,010
Southern Methodist U	2	848
Texas A&M University	3	3,194
Texas Christian Univ	1	278
Texas Southern Univ	2	26
Texas Tech Univ	1	525
Univ of Houston	7	2,394
Univ Texas—Austin	1	901
Univ Texas—Dallas	1	3,549
State Totals	31	15,906

Utah

Brigham Young Univ	1	200
Univ of Utah	1	706
Utah State Univ	1	430
State Totals	3	1,336

Vermont

Univ of Vermont	2	1,097
State Totals	2	1,097

Virginia

College of Wm & Mary	3	1,127
Hampton Institute	1	11
Old Dominion Univ	4	663
Univ of Virginia	3	1,660
Virginia Poly Inst	4	1,429
State Totals	15	4,890

Washington

Univ of Washington	3	2,623
Washington State U	1	426
State Totals	4	3,049

West Virginia

West Virginia	4	1,397
State Totals	4	1,397

Wisconsin

Marquette University	1	53
Univ Wisc—Madison	6	7,515
State Totals	7	7,568

Wyoming

Univ of Wyoming	1	177
State Totals	1	177
GRAND TOTAL	416	221,470

SOURCE Office of University Affairs National Aeronautics and Space Administration Washington D C 20546

APPENDIX A-2.

Awards Made By The Department of Defense Under Project THEMIS (1967-1971)

State & Institution	Program Topics	Department	Award Amount ($ Thousands)
Alabama			
Auburn University	Information Processing	Math	679
University of Alabama	Structural Mechanics	Engr Mech	605
Alaska			
University of Alaska	Human Ecology	Inst of Arctic Res	611
Arizona			
Arizona State	Human Performance in Isolation	Psychol	570
Arizona State	Detection Devices, Techniques & Theory	Engr	801
University of Arizona	Precision Optical Systems	Optical Sci Cntr	808
University of Arizona at Tucson	X-Ray and XUV Radiation Physics	Physics	582
California			
Univ Cal San Diego	Transport Phenomena in Flow Systems	Engr Physics	823
Univ Cal Riverside	Solar Radiation Effects	Physics	800
Colorado			
Colorado State	Tropical Weather Disturbances, Surface Effects	Atmos Sci	985
Colorado State	Predictability of Low-Altitude/Winds	Fluid Mech	755
Colorado State at Fort Collins	Effects of Environment on Sensors	Elec Engr	800
Connecticut			
Un of Connecticut	Structural Fatigue	Metallurgy & Physics	814
Delaware			
Un of Delaware	Fluid Mechanics & Heat Transfer	Mech & Aero Engr	1119
Un of Delaware at Newark	Oceanography	Civil Engr	960
District of Columbia			
Georgetown Univ	Laser Technology	Physics	808
Catholic Univ	Vitreous State Structure and Dynamics	Physics	744
Catholic Univ	Dynamics of Cable Systems	Mech Engr	783
Catholic Univ	Underwater Acoustics	Mech Engr	1000
Florida			
Univ of Florida	Solid State Materials	Materials	600
Univ of Florida	Logistics & Information Processing	Ind & Syst Engr	733
Florida State	Geophysical Fluid Dynamics	Geophys Fluid Dyn	1550
Florida State	Prediction of Tropical Weather Phenomena	Meteorology	878
Florida State	Computer Aided Instruction	Math	865
Georgia			
Georgia Tech	Low Speed Aerodynamics	Aerospace Engr	701
Georgia Tech	Interface Phenomena	Phys Sci	740
Univ of Georgia at Athens	Statistical Analysis and Information Retrieval	Math	433

Hawaii

Un. of Hawaii	Astronomy Research	Instit of Astron	945
Un. of Hawaii	On-Line Computer Systems	Engr	814
Un. of Hawaii at Honolulu	Vector-borne Tropical Diseases	Med Microbiol & Trop Med	828

Illinois

Ill Inst Tech	V-STOL Aerodynamics	Mech & Aero Engr	820
Ill Inst Tech at Chicago	Degradation of Structural Materials	Metallurgical Engr	774

Indiana

Indiana University	Environmental Hazards	Anatomy & Physiology	796
Notre Dame Univ	Deep Sea Engineering	Ocean Engr	925

Iowa

Iowa State	Automatic Navigation & Control	Elect Engr	840
Iowa State	Ceramic & Composite Materials	Ceramic Engr	898
Univ of Iowa	Vibration & Stability of Military Vehicles	Mech & Hydraulics	875
Univ of Iowa	Application & Theory of Automata	Math	700

Kansas

Univ of Kansas	Remote Sensing Instrumentation	Center for Research	793
Univ of Kansas	Analysis of Changing Systems	Anthropology	600
Kansas State	Performance in Altered Environment	Environ Res	800
Kansas State	Nuclear Radiation Effects on Electronic Components	Nuclear Engr	1068

Kentucky

Un of Kentucky	Metal Deformation Processing	Metallurgical Engr	812
Kentucky Univ at Lexington	Research in Electrochemical Processes	Chem	776
Kentucky Univ at Lexington	Environmental Stress Physiology	Physiology	800
Un of Louisville	Performance Assessment and Enhancement	Perform Res Lab	681

Louisiana

Louisiana State	Infectious & Communicable Diseases	Trop Med & Med Paras	683
Louisiana State	Digital Automata	Elect Engr	1023

Massachusetts

Univ of Mass	Deep Sea Structures	Ocean Engr	840
Boston College	Elementary Chemical Kinetics	Chem	880

Michigan

Michigan State U at E Lansing	Behavioral Studies	Psychology	400

Minnesota

Un of Minnesota	Infra-Red Detector & Laser Technology	Physics	892
Un of Minnesota	Gas Turbine Technology	Mech Engr	965
Un of Minnesota	Organization Performance and Human Effectiveness	Psychology	773

Mississippi

Mississippi State	Rotor & Propeller Aerodynamics	Engr	612
Un of Mississippi	Biocontrol Systems	Psychology	509

Missouri

Un of Missouri at Columbia	Fluid Transport Properties	Chem Engr	769
Un of Missouri at Rolla	Aqueous Aerosols in Atmospheric Processes	Physics	650
Un of Missouri at Rolla	Basic Studies on Electronic Materials	Materials Res	600
Un of Missouri at Rolla	Terrestrial Science Research	Rock Mech & Exp Res Cntr	820

Washington Univ at St. Louis	Control, Guidance and Information Studies	Systems Sci & Engr	807
Washington Univ at St Louis	Optimum Detection Systems	Physics	807
Nevada			
Univ of Nevada	Cloud Physics	Physics	848
New Hampshire			
Dartmouth College	Time Shared Computing Systems	Computer Sci	804
New Jersey			
Rutgers Univ	Fluid Flow Aerodynamics	Mech & Aero Engr	600
Stevens Institute	Non-Linear Physics of Polymers	Chem	748
Stevens Institute	Cryogenic Sciences & Engineering	Elect Engr	683
Stevens Institute	Evaluation of Terrain Vehicle Systems	Transportation Res Gp	660
New Mexico			
New Mex Inst M&T	Environmental Sciences	No Specific Dept	1112
Un of New Mexico	Radiation Effects on Electronics	Physics	852
New York			
SUNY-Albany	Modification of Environment	Earth & Atmos Sci	797
SUNY-Buffalo	Environmental Physiology	Physiology	1525
Rensselaer Poly	Electrochemical Power Sources	Chem Engr	844
Rensselaer Poly	Radiation Effects	Chem	812
Rensselaer Poly	Optimum Digital Signal Processing	Elect Engr	841
Yeshiva Univ NYC	Research on Thin Film Materials	Physics	780
North Carolina			
No Carolina State	Materials Response Phenomena	Engr Mech	900
No Carolina State	Digital Encoding Systems	Elect Engr	789
North Dakota			
No Dakota State	Control of Vectors of Diseases of Military Importance	Entomology	728
Un of No Dakota	High Pressure Physiology	Physiology	1051
Ohio			
Case-Western Resv	Research in R&D Management	Operations Res	600
Ohio University	Low Level Navigation	Research Institute	882
Kent State Univ	Liquid Crystal Detectors	Chem	814
Un of Cincinnati	Internal Aerodynamics in Air-Breathing Engines	Aerospace Engr	653
Oklahoma			
Oklahoma State	Electronic Description of the Environment	Elect Engr	959
Univ of Oklahoma	Mechanism & Theory of Shock	Physiology	768
Oregon			
Oregon State	On-Line Computer Environmental Research	Computer Cntr	1435
Pennsylvania			
Drexel Inst Tech	Powder Metallurgy	Metallurgical Engr	801
Drexel Inst Tech	Forecasting by Satellite Observations	Physics	788
Jefferson Med Col	Pathogenesis of Acute Diarrheal Disease	Microbiology	645
Lehigh University	Non-Linear Wave Propagation	Math	698
Lehigh University	Low-Cycle Fatigue in Joined Structures	Civ Engr	760
Lehigh University	Fluid Amplification	Mech Engr	760
Hahnemann Med Col	Bioamines in Stress	Phys Biophys	1040
Rhode Island			
R I University—at Kingston	Photo Electronic Imaging Devices	Electr Engr	760
South Carolina			
Med Col of So Car	Resuscitation & Treatment of Wounded	Surgery	546

South Dakota			
S. Dak. Sch. of Mines	Modification of Convective Clouds	Atmos Sci	490
Tennessee			
Un. of Tennessee—Knoxville	Dynamic Sealing	Mech & Aero Engr	728
Un. of Tennessee—Knoxville	Remote Sensor Research	Civil Engr	812
Un. of Tennessee—Tullahoma	MHD Power Generation	Physics	800
Vanderbilt Univ	Coating Science & Technology	Mat Sci & Metallurgical Engr	902
Texas			
Texas A&M	Optimization Research	Math	925
Texas A&M	Meteorology Research	Res Foundation	858
Texas A&M	Aircraft Dynamics Subsonic Flight	Aerospace Engr	673
Texas Christian	Human Pattern Perception	Psychology	535
Un. of Houston	Information Processing	Math	910
Rice University	Coherent & Incoherent EM Radiation	Elect Engr	647
Rice University	Remote Sensing of Gamma Ray Signatures	Geology	772
So Methodist	Automatic Navigation	Elect Engr	800
So Methodist	Statistics in Calibration Methods	Math	1008
Texas Tech	Performance & Man-Machine Effectiveness	Ind Engr	732
Utah			
University of Utah	Chemistry of Combustion	Engr	808
Vermont			
Univ of Vermont	Isolation & Sensory Communication	Psychology	864
Virginia			
Univ of Virginia	Learning Control Systems	Mech Engr	683
Univ of Virginia	Atomic Interactions in Gases	Aerospace Engr	806
Univ of Virginia	Cryogenic Instrumentation	Physics	880
Virginia Polytech/Blacksburg	Vehicle Engineering & Control	Engr Mech	643
West Virginia			
W Virginia Univ	V/STOL Aerodynamics	Aerospace Engr	809
TOTAL			$94.49 million

APPENDIX A-3

Goals and Descriptions of Health Science Advancement Awards (NIH), 1966-1974[1]

HEALTH SCIENCES ADVANCEMENT AWARD PROGRAM

In response to the recognized need to increase the number of institutions of first-rank capability for biomedical research and research training, the NIH inaugurated the Health Sciences Advancement Award (HSAA) program in 1966. The program goal is to expand the national capability for research in the health sciences by increasing the number of distinguished biomedical research and research training institutions within the Nation. The program is designed to assist academic institutions to strengthen significantly their activities in health sciences by: (1) supporting the advancement of new and existing health research and training endeavors where an appropriate institutional base for such advancement exists; and (2) encouraging the development of health science activities in institutions that presently possess considerable strength in related fields of science.

The HSAA program provides funds annually to a grantee, usually for a project period of 5 years. Awards are competitive on the basis that applicant institutions must identify and describe in detail a unifying research theme or scientific focus within the specific institutional proposal for which funds are requested. The NIH investment in a Health Sciences Advancement Award requires a commitment by the grantee to the long-term investment required by, and characteristic of, any major institutional change related to accelerated or redirected growth.

The program was launched in FY 1966 with pilot grants to the University of Virginia and to Cornell University. In 1967, grants were awarded to the University of Colorado, the University of Oregon, Purdue University, Vanderbilt University, and Washington University. In 1968 and 1969, only two new grants were made each year because of the fiscal restraints imposed upon the NIH. The 1968 awards were to Rice University and the University of California at Davis. The 1969 awards went to Duke University and the University of Kansas (Kansas City and Lawrence).

A description of the primary areas of research emphasis at each grantee institution follows:

University of Virginia

The HSAA program is related to the University effort to strengthen six basic medical sciences, with the major challenge being the advancement of the Departments of Anatomy, Biochemistry, Physiology, Pathology, Microbiology, and Pharmacology.

In addition, all the basic science departments are to join in an effort to provide a coherent cell biology course for implementing research and research training activities.

To complement the programs of the basic medical sciences, the University plans to strengthen and advance its capabilities in biostatistics and biomathematics, biophysics, and bioengineering. The program in bioengineering is unique in that the faculty is derived from the Schools of Engineering, Graduate Arts and Sciences, and Medicine.

Cornell University

The HSAA program was initiated to help the University concentrate on the development of biochemistry as the keystone for an integrated biology effort involving 45 biologically oriented faculty who had been dispersed in separate colleges on the Ithaca campus, plus at least 20 more faculty to be recruited. An integral goal of the HSAA plan was to formulate a unified teaching and research training effort to serve the entire University.

The above effort involves five sections (Biochemistry and Molecular Biology; Microbiology; Genetics, Development, and Physiology; Neurobiology and Behavior; and Ecology and Systematics) and two units (Wiegard Herbarium, and the Laboratory of Cell Physiology, Growth, and Development).

Impetus for the total effort in which the HSAA is involved was provided by the near simultaneous

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[1] Excerpt from the "Annual Report of the Division of Research Resources for Fiscal Year 1969," (National Institutes of Health, Bethesda, MD 20014) pp 81-88

assignment of two professorships (interest on $3 million) by the University and the substantial amounts of money awarded by the Ford Foundation and the National Science Foundation.

University of Colorado

The program involves strengthening the biomedical research activities of the eight basic medical science departments in the Medical School at the Denver campus, establishing the research components of a new Department of Cellular and Molecular Biology at the Boulder Campus, and establishing a two-way closed-circuit television and data link between the Denver Medical Center and the Boulder campus.

In strengthening the medical science departments of the Denver Medical Center, six areas of research interest are involved: mechanistic and physical biochemistry, chemistry of macromolecules, ultrastructure and function, developmental biology, molecular genetics, and biomathematics.

The new Department of Cellular and Molecular Biology is a continuation of recent efforts to bring modern biology to the Boulder campus. These efforts were initiated by the recent (1966-67) creation of the Institute for Developmental Biology and the Institute for Behavioral Genetics. The Department complements the Institute for Developmental Biology, and offers instruction at both the graduate and the undergraduate level. Faculty members for the Department have broad interests in many aspects of cellular and molecular biology, particularly in research areas not already represented in the two existing Institutes.

The establishment of the Department is regarded as a key part of the HSAA program in that it is to be central in coordinating the teaching and research activities between the two campuses. The Departments of Chemistry, Physics and Astrophysics, Anthropology, Psychology, and the two Institutes mentioned above are to be heavily dependent upon its development of strength in the area of cellular and molecular biology.

The third component of the HSAA program, the two-way closed-circuit television and data link, is an effort to facilitate the intellectual contact between the biomedical scientists in Denver and their counterparts in Boulder. The link provides the two campuses with both immediate camera-monitor communication and video tape playback of conferences, discussion, seminars, and classes.

University of Oregon

This award is to support to major overlapping programs, one in developmental biology and one in neurobiology, which interact with a third program in macromolecular chemistry. The program provides for the expansion of existing research (neurobiology and macromolecular chemistry) and the encouragement of an incipient program (developmental biology) by projecting ten key appointments.

The program strengthens the existing multidisciplinary approach to behavior by integrating efforts in neurobiology. Five new appointments are planned for the Biology and Psychology Departments, applying the following broad criteria for selection: (1) the research of appointees would focus upon fundamental neural or psychological phenomena; (2) experimental techniques would include sophisticated quantitative approaches in biochemistry, physiology, and psychology; and (3) the appointees would serve as communication links between psychology, neurophysiology, and developmental biology. In addition, new opportunities for interaction involve: (1) a research training course in neurobiology which channels students into an interdisciplinary approach to neurobiology early in their careers; and (2) a new Marine Station Laboratory at Charleston, Oregon, which provides simple marine invertebrates for the study of neurobiological problems.

As part of the curriculum reform in the Department of Biology, a major 1-year graduate level course in developmental biology is underway. The HSAA provides some of the more sophisticated equipment currently employed in developmental biology for this research training course.

In order to expand the program in developmental biology, three faculty appointments should enhance the molecular aspects of the existing program, which now has strength at the cell-organ levels. These appointments form bridges between Departments such as Biology, Chemistry, or Psychology, and the Institute of Molecular Biology.

Finally, the initiation of a Visiting Fellow Program has several elements, one of which is to have a group of outstanding individuals serve as an advisory consulting group to review ongoing programs and to advise on future programs. The Visiting Fellow Program also sponsors seminar symposia and workshop programs which focus on important controversial areas of research interests.

Purdue University

Purdue University has a program to advance knowledge of and provide research training in neurobiology, including the study of the means by which external stimuli are perceived, recognized, stored, assembled and translated into immediate or delayed responses, and the processes by which nervous activity is regulated and integrated into behavior. A broad spectrum of studies is underway: the transfer of energy; the chemistry, structure, and function of membranes; the nature of receptor sites; the development of neuronal connections, etc.; behavioral studies involving the nature of imprinting, learning, motivation, etc.; and the manner in which biological units interact with each other in the physical environment.

The program provides for the coordinated efforts of the Departments of Entomology, Psychology, Electrical Engineering, and Biological Sciences. The latter Department, with a total faculty and staff of almost 400 persons, is responsible for teaching and research in biochemistry, biophysics, botany, genetics, microbiology, physiology, and zoology.

The insights of investigators with different backgrounds are being brought to bear on the nature of mental processes and biological and environmental interactions. To complement the existing faculty and staff, the HSAA is to support two distinguished senior investigators in neurobiology among 15 new appointments over the 5-year period. The effort is to examine the extent to which insights gained in fields such as molecular genetics, molecular aspects of growth regulations, etc., can be applied to neurobiology. By a more intimate association with biologically oriented engineers and mathematicians, biological interactions will be increased. Finally, the program involves about 10 specific research areas such as photochemistry, including visual and photosynthetic pigments; resonance phenomena in complex molecules, visual receptors, and other sensory mechanisms; neuron physiology-membrane phenomena, synapses, etc.

The activities of the Department of Biological Sciences ranges from the physical sciences and mathematics on one hand, to the behavioral sciences on the other. Purdue expects to establish a major educational and research center in neurobiology by 1973, graduating 25-50 Ph.D.'s per year, and training 12-24 postdoctoral scientists per year.

Vanderbilt University

The major purpose of the program is to accomplish a strengthening of the research and training programs of the Medical School by establishing new faculty positions for outstanding leaders in specific areas of research interests. The participants of the program are organized into three areas of research interest that are interdisciplinary in nature but limited to the faculty of the Medical School. The three areas are those of biomolecular structure, cell structure and function, and genetics and cell differentiation.

In the area of molecular structure, research efforts are being improved and facilitated by the addition of investigators competent in the fields of physical chemistry of macromolecules, kinetics of fast reactions, X-ray diffraction, and chemical synthesis of biologically interesting compounds. The area of cell structure is being strengthened by the addition of competence in the fields of high-resolution electron microscopy, physical chemistry of membranes, and neurophysiology. The area of genetics and cell differentiation is being enhanced by the addition of expertise in experimental embryology, human genetics, microbial genetics, and modern methods of cell and virus culture.

To facilitate the immediate impact of the program upon the Medical School, five visiting professorships have been established. These visiting professors are selected because of the contribution they can make to the research in progress on one of the areas indicated above. Such individuals are expected to contribute to seminars, graduate teaching and, if appropriate, to supervise postdoctoral fellows.

Washington University

The program is broad and comprehensive, and coordinates applied and basic science activities in three interrelated areas—neurobiology, cellular and molecular biology, and biomedical engineering. Research and research training activities involve the preclinical departments of the School of Medicine, the two life science departments of the Graduate School of Arts and Sciences, and the Chemical and Electrical Engineering departments of the School of Engineering and Applied Science. The entire effort is complemented by the biomedical computer research activities of the School of Engineering and Applied Science.

Although HSAA support was not requested for the neurobiology component, the plan is to interweave these ongoing research activities into a core program for the development of molecular biology in the basic medical sciences. The effort and purpose of the program is not only to advance the science base but also to provide support for the interactions and intellectual interrelationships that are developing across disciplinary lines.

In addition, the program calls for the creation of a new Department of Genetics, pointed toward biochemical genetics, which would attempt to capitalize on the present strengths of the Medical School and would increase the total research potential of existing departments, particularly the preclinical departments, the Department of Biological Chemistry, and the Department of Microbiology. The latter department intends to develop a significant program in virology, directed toward viral genetics and the biology of cultured human cells

The program plan is to build on existing strengths, each of which displays a strong biochemical-ultrastructural approach, and, with this increase in research and research training potential, to take full advantage of the biomathematical and bioengineering sciences to achieve results which would otherwise be unobtainable without effective interchange between biologists, clinicians, engineers, and mathematicians. Thus, there are dual goals in the HSAA proposal—that there be excellence in the disciplines involved and that multidisciplinary studies be encouraged and supported.

Rice University

The Rice University HSAA program focuses the institution's effort in three fields. The Biology Department is building on strength in developmental and regulatory biology, parasitism, and symbiology. The biochemistry group is making a major effort in research on the chemistry and physics of molecular processes, as well as in the structural and synthetic studies of natural products. The biomedical engineering group, in association with Baylor University medical scientists, is studying prosthetic systems for replacing or supplementing human organ systems. Bio-instrumentation and material development are part of the program.

University of California (Davis)

The theme of the HSAA program at Davis is comparative medicine. The program is an interdisciplinary study involving more than 35 professional scientists from five schools and colleges of the University. The University resources are being focused on developmental biology (the effects of a variety of chemical, microbiological, and nutritional agents on embryogenesis, fetal development, and congenital anomalies). Comparative immunologic reactions in the fetal state are also being examined. The above studies are being correlated to the functional and structural observations of the effects of exogenous chemical and toxicological agents on the respiratory and hepatic systems.

The entire effort is to utilize the unusual animal facilities available at Davis (more than ten different species of animals are being used for comparative studies) to learn more about human disease.

Duke University (1969 New Award)

Duke University received an initial award for a program designed to establish excellence in research on membrane components of cells and tissues. Knowledge of membrane structure and function is essential to the understanding of diseases such as cancer, atherosclerosis, viral infections, muscular dystrophy, rheumatoid arthritis, hyaline membrane diseases, and a host of other illnesses. Scientists will use their HSAA grant to investigate such areas as the role of membranes in early development, cell membrane changes induced by viruses, and the chemistry of bacterial, fungal, and animal cell walls. Medical School faculty will participate from the Departments of Anatomy, Microbiology, Immunology, Pathology, Medicine, Biochemistry, and Physiology-Pharmacology.

University of Kansas (1969 New Award)

The University of Kansas received an initial award for a program that stresses the chemical basis of drug action. Knowledge of the basic mechanisms of drug action are vital to perceive the effect of certain antibiotics on protein synthesis, the influence of certain drugs on the metabolic parameters of brain tissue, and other basic molecular processes. University of Kansas researchers will extend their study of basic mechanisms of drug action ranging from theoretical chemistry, through chemical synthesis of "tailor-made" compounds, to biological assay and clinical testing. Key participants in the program will be faculty from the Departments of Medicine, Pathology, and Pharmacology in the Medical School, and from the Departments of Chemistry, Medicinal Chemistry, Pharmaceutics, Biochemistry, and Pharmacology at the Lawrence Campus.

APPENDIX B-1

NSF Personnel Associated With the Science Development Programs, 1964-1972

Allen, Mildred C.
Baker, George W.
Boroughs, Howard J.
Bregida, Albert P.
Brosseau, George E., Jr.
Carrabino, Joseph F.
Carrigan, Richard A.
Cheatham, Paul G.
Chern, Bernard
Clark, David T.
Consolazio, William V.[1]
Daen, Jerome S.
Dale, Wesley J.
Danek, Joseph G.
DeBell, Jean T.
Denton, Jesse C.
Dugan, Caldwell N.
England, J. Merton
Hall, Richard H.
Havens, Elmer G.
Heider, S. A.
Herwig, Lloyd O.
Horowitz, Harold
Johnson, Robert M.
Kadesh, Robert R.
Kidd, F. Furman
Kotch, Alex
Lance, John F.
Leise, Joshua M.[1]
Leonard, Frederic A.
Levin, Louis[2]
Linnell, Robert H.
Livingston, George A.
Long, Ralph H., Jr.
Major, John K.
Mayer, J. Richard
McMahon, Joan C. (now Joan Jordan)
Nicely, Patricia E.
Page, Howard E.[3]
Robertson, Randal M.[2]
Rosen, William G.
Smith, Denzel D.[1]
Spuhler, Harold A.
Stratton, Lena R.

[1] Served as Division Director, Deputy Division Director, or Section Head
[2] Served as Associate or Assistant Director
[3] Served as Deputy Assistant Director, or Head of Office

APPENDIX B-2

Science Development Grants Listed Alphabetically by Institution[1]

Type[2]	Institution	Area[3]	Starting Date
	Alaska, U of	Solid Earth Sciences	4/70
	Arizona State U	Solid State Sciences	9/69
U	Arizona, U of	Astron, Chem, Math, Phys	7/65
	Boston U	Biological Sciences	3/70
	Bowling Green State U	Psychology	9/69
S	Brandeis U	Chem, Phys	7/70
	Brooklyn Polytechnic Inst	See Polytechnic Inst of N Y	
	Bryn Mawr College	Biochemistry	7/69
	California, U of at San Diego	Economics	9/70
	California, U of at Santa Barbara	Electrical Eng	9/70
	California, U of at Santa Cruz	Astronomy	9/69
U	Carnegie-Mellon U	Bio, Chem, Math, Phys	5/67
U	Case Western Reserve U	Chem, Life Sci, Mat Sci, Phys	5/65
	Claremont Graduate Sch	Mathematics	9/68
	Claremont Graduate Sch	Psychology	4/71
	Clark U	Geography	6/67
	Clark U	Psychology	9/69
	Clarkson College of Tech	Chemical Eng	9/69
	Clemson U	Eng/Hybrid Computer	3/70
	Colorado Sch of Mines	Geoscience & Min Res	4/70
	Colorado State U	Civil Eng	3/70
U	Colorado U of	Astrophys, Chem, Eng, Math, Phys, Psych	6/65
S	Connecticut U of	Environmental Sciences	3/70
	CUNY, City College	Physics	9/68
	CUNY, Hunter College	Biology	9/68
	Delaware, U of	Physics	7/68
	Denver, U of	Mathematics	9/68
	Drexel Inst of Tech	Metallurgical Eng	6/67
U	Duke U	Chem, Eng, Gen, Phys, Stat/Comp	12/66
	Emory U	Chemistry	9/70
U	Florida State U	Chem, Phys, Psychbiol, Stat	7/68
U	Florida, U of	Astron, Chem, Eng, Math, Phys	7/65
	Georgetown U	Languages & Linguistics	9/70
U	Georgia, U of	Dev Biol, Gen, Molec Biol	8/67
	Hawaii, U of at Manoa	Chemistry	7/70
	Houston, U of	Chemical Eng	9/67
	Illinois Inst Tech	Biology	9/69
	Illinois, U of at Chicago Circle	Chemistry	9/68
U	Indiana U	Chem, Comp Sci, Phys	7/67
U	Iowa, U of	Endocrin, Gen, Neurobiol	8/67
S	Kansas State U	Biology	9/69
	Kent State U	Psychology	3/70
S	Kentucky, U of	Mathematics	7/68
	Lehigh U	Mat Sci & Metallurgy	9/67
	Lehigh U	Mechanical Eng & Mechanics	9/69
U	Louisiana State U at B R	Chem, Geol, Math, Phys	11/65
	Louisiana State U at N O	See New Orleans, U of	
	Louisville, U of	Psychology	9/68
	Marquette U	Biology	9/67
U	Maryland, U of	Atmospheric, Computer, & Physical Sci	5/67
	Massachusetts, U of Amherst	Psychology	4/71
U	Michigan State U	Chem, Math, Phys	9/68
	Michigan Tech U	Engineering	9/69
	Mississippi, U of	Electrical Eng	12/69
	Missouri, U of at Rolla	Physics	9/67
	Montana, U of	Geology	4/71

	Nebraska, U of at Lincoln	Physics	9/69
S	Nebraska, U of at Lincoln	Chemistry	8/67
	New Hampshire, U of	Psychology	3/70
S	New Mexico, State	Mathematics	4/66
	New Mexico, U of	Mathematics	6/67
	New Orleans, U of	Chemistry	9/68
	New York, See also CUNY, SUNY, and Polytechnic Institute of New York		
U	New York U	Phys, Psych	6/69
U	North Carolina State U at Raleigh	Biomath, Eng	5/66
U	North Carolina, U of at C H	Chem, Phys, Social Sci	5/67
S	Northwestern U	Comp Cent Systems, Eng	9/70
U	Notre Dame, U of	Biol, Chem, Phys	5/67
	Oakland U	Systems Engineering	9/68
	Ohio U (Athens)	Physics	7/68
	Oklahoma State U	Systems Science	9/69
	Oregon, State U	Chemistry	3/70
U	Oregon, U of	Comp Ctr, Physical & Biol Sci	5/65
U	Pittsburgh, U of	Chem, Cryst, Phys	9/69
U	Polytech Inst of N Y	Chem, Electronics	11/65
U	Purdue U	Biol, Phys	5/66
	Rensselaer Poly Inst	Chemistry	9/69
	Rensselaer Poly Inst	Mathematics	7/68
U	Rice U	Eng, Math, Systems Rsch	6/65
	Rochester, U of	Fundamental Studies	4/71
U	Rochester, U of	Biol, Chem	6/65
U	Rutgers, The State U	Math, Phys	5/66
	South Carolina, U of	Chemistry	9/69
U	Southern California, U of	Physical & Eng Science, Solid St	11/65
	Southern Methodist U	Anthropology	4/71
	Southern Methodist U	Electrical Eng	7/68
	Southern Methodist U	Economics	3/70
	SUNY, Albany	Biological Sci	9/70
	SUNY, Albany	Mathematics	9/69
	SUNY, Binghamton	Geology	9/68
	SUNY, Binghamton	Economics	3/70
S	SUNY, Stony Brook	Astro & Astrophys, Chem, Phys, Psych, Sol State	7/70
	Stevens Institute of Tech	Physics	9/69
	Tennessee Tech	Mechanical, Eng	6/67
S	Tennessee, U of	Eng, Phys	7/68
	Texas A&M U	Chemistry	7/69
	Texas A&M U	Economics	9/70
	Texas Tech	Electrical Eng	9/70
U	Texas, U of at Austin	Physical, Social, & Life Sci Cntrs	12/66
U	Tulane U of Louisiana	Bio, Math, Psych	5/66
	Utah State U	Ecology	9/68
	Utah, U of	Physics	9/69
	Utah, U of	Chemistry	9/70
U	Vanderbilt U	Astron, Chem, Molec Biol, Phys	5/67
	Virginia Polytech Inst & State U	Geological Sciences	9/69
U	Virginia, U of	Biol, Physical Sciences	7/65
	Washington State U	Chemical Physics	9/68
	Washington State U	Sociology	9/70
U	Washington U (St Louis)	Biol, Chem, Eng, Phys	5/65
U	Washington, U of (Seattle)	Env Sci, Geol, Phys, Quat Rsch	9/68
S	Wayne State U	Chemistry	5/67
	Wesleyan U	Physics	9/68
S	West Virginia U	Engineering	3/67
	William and Mary, College of	Physics	3/70
	Wisconsin, U of at Milwaukee	Surface Sci	7/68
	Wyoming, U of	Geology	7/68
	Yale U	Social and Policy Studies	5/71
	Yeshiva U	Physics	12/69

Grant numbers are given in Table 11 Science Development Program Grants Listed by States

U University Science Development Grant (31 grants) S Special Science Development Grant (11 grants) All others are Departmental Science Development Grant (73 grants) because of their similarity grants made under the Departmental SDP and the 1970 Science Development Program are listed in one category

Approximate descriptions For details and explanations of abbreviations please see Appendix B 5

APPENDIX B-3

Science Development Grantees Listed by Type of Grant.

(a) University Science Development

Arizona, U of
Carnegie-Mellon U
Case Western Reserve U
Colorado, U of
Duke U
Florida, U of
Flordia State U
Georgia, U of
Indiana U
Iowa, U of
Louisiana State U at B R
Maryland, U of, College Park Campus
Michigan State U
New York U
North Carolina State U at Raleigh
North Carolina, U of at Chapel Hill
Notre Dame, U of
Oregon, U of
Pittsburgh, U of
Polytechnic Institute of N Y
Purdue U
Rice U
Rochester, U of
Rutgers, The State U
Southern California, U of
Texas, U of at Austin
Tulane U
Vanderbilt U
Virginia, U of
Washington, U of (Seattle)
Washington U (St Louis)

(b) Special Science Development

Brandeis U
Connecticut, U of, Main Campus
Kansas State U
Kentucky, U of
Nebraska, U of at Lincoln
New Mexico State U
Northwestern U
SUNY-Stony Brook
Tennessee, U of
Wayne State U
West Virginia U

(c) Departmental Science Development

Alaska, U of
Arizona State U
Boston U
Bowling Green State U
Bryn Mawr College
California, U of at San Diego
California, U of at Santa Barbara
California, U of at Santa Cruz
Claremont Graduate School (2)
Clark U (2)
Clarkson College of Technology
Clemson U
Colorado School of Mines
Colorado State U
CUNY, City College
CUNY, Hunter College
Delaware, U of
Denver, U of
Drexel University
Emory U
Georgetown U
Hawaii, U of at Manoa
Houston, U of
Illinois, U of at Chicago Circle
Illinois Institute of Technology
Kent State U
Lehigh U (2)
Louisville, U of
Marquette U
Massachusetts, U of at Amherst
Michigan Tech, U
Mississippi, U of
Missouri, U of at Rolla
Montana, U of
Nebraska, U of at Lincoln
New Hampshire, U of
New Mexico, U of
New Orleans, U of
Oakland U
Ohio U (Athens)
Oklahoma State U
Oregon State U
Rensselaer Polytechnic Institute (2)
Rochester, U of
South Carolina, U of
Southern Methodist U (3)
Stevens Institute of Technology
SUNY, Albany (2)
SUNY, Binghamton (2)
Tennessee Tech U
Texas A&M (2)
Texas Tech U
Utah State U
Utah, U of (2)
Virginia Polytechnic Inst and State U
Washington State U (2)
Wesleyan U (Connecticut)
William and Mary, College of
Wisconsin, U of at Milwaukee
Wyoming, U of
Yale U
Yeshiva U

APPENDIX B-4

Science Development Programs: Summary of Numbers of Grantee Departments or Activities and Funds by Discipline

	Univ SDP		Dept'l & Spec'l SDP		Total	
	No	Amount (Thousands)	No	Amount (Thousands)	No	Amount (Thousands)
Biological and Medical Sciences[1]						
Anatomy	1	$ 274	0		1	$ 274
Bacteriology	1	566	0		1	566
Biology	10	14,703	6	$3,952	16	18,655
Biomathematics	1	1,445	0		1	1,445
Biopsychology	1	713	0		1	713
Botany	4	2,109	0		4	2,109
Ecology	0		1	550	1	550
Entomology	1	656	0		1	656
Genetics	2	422	0		2	422
Microbiology	3	1,425	0		3	1,425
Molecular Biology	1	1,342	0		1	1,342
Pharmacology	1	450	0		1	450
Physiology	1	945	0		1	945
Psychobiology	1	1,366	1	500	2	1,866
Zoology	3	4,508	0		3	4,508
Subtotal	31	30,924	8	5,002	39	35,926
Computer Research						
Computer Science and Computer Centers	5	5,550	1	525	6	6,075
Subtotal	5	5,550	1	525	6	6,075
Engineering[2]						
Aerospace	4		0		4	
Chemical	4		3		4	
Civil	2		1		7	
Electrical	8		4		3	
Electrophysics	1		0		12	
Mechanical	6		2		8	
Metallurgy and Materials	3		3		6	
Mineral	1		0		1	
Nuclear	1		0		1	
Systems Eng/Sci	1		2		3	
Urban Systems	0		1		1	
General	1		2		3	
Subtotal	32	15,689	18	9,832	50	25,521
Environmental Science						
Atmospheric Science	1	413	0		1	413
Environmental Science	0		1	145	1	145
Geology, Geophysics, Earth Science, Mineral Resources	5	5,177	6	3,397	11	8,574
Oceanography	1	710	0		1	710
Quaternary Research	1	237	0		1	237
Fluid Dynamics	1	434	0		1	434
Subtotal	9	6,971	7	3,542	16	10,513
Materials Research[2]						
Materials Science	3	3,742	1	550	4	4,292
Solid State and Crystallography	2	2,416	2	1,450	4	3,866
Subtotal	5	6,158	3	2,000	8	8,158

Mathematical and Physical Sciences[2]						
Astronomy[2]	5	4,438	2	876	7	5,314
Biochemistry	2	1,522	1	403	3	1,925
Chemistry, Chemical Physics	23	32,630	14	8,389	37	41,019
Mathematics	15	11,025	7	4,264	22	15,289
Physics	25	49,373	13	8,629	38	58,002
Statistics	3	1,240	0		3	1,240
Surface Studies	0		1	555	1	555
Subtotal	73	100,228	38	23,116	111	123,344
Social Sciences						
Anthropology	1	523	1	600	2	1,123
City and Regional Planning	1	677	0		1	677
Economics	1	531	4	1,969	5	2,500
Fundamental Studies	0		1	848	1	848
Geography	0		1	564	1	564
Linguistics	1	712	1	460	2	1,172
Philosophy	1	17	0		1	17
Political Science	1	560	0		1	560
Psychology	7	7,152	7	3,505	14	10,657
Social Science	3	1,384	1	1,500	4	2,884
Sociology	1	497	1	530	2	1,027
Subtotal	17	12,053	17	9,976	34	22,029
Library Scientific	2	1,395	0		2	1,395
Subtotal	2	1,395			2	1,395
TOTAL	176	178,968	95	53,993	271	232,961

See also the list of NIH Health Science Advancement Awards

[2] Please see Appendix B-5 for further detail. Funds for certain areas were not always separately identified in the budgets. Thus funds for astronomy awarded to Departments of Physics and Astronomy were listed under "Physics," hence the combined listing in this table. Similarly funds for Materials Research are included under the headings for Chemistry, Engineering, and Physics.

APPENDIX B-5

Science Development Grants Listed by Discipline, Showing Funds (in Thousands of Dollars) Allotted to Each Grantee Department or Activity

Discipline	Institution	Code	Amount to Discipline	Date	Subdiscipline(); Other Disciplines Other SD Grant/Discipline'
Anatomy	Iowa, U of	U	274	8/67	Biochem, Botn, Microbiol, Pharm, Physiol, Psych, Zoo
Anthropology	Southern Methodist U	D	600	4/71	DSDG/Econ, Eng
	Texas, U of	U	523	1/67	Astron, Botn, Chem, Comp Sci, Eng, Gen, Ling, Microbiol, Phys, Psych, Zoo
Astronomy (7 entries, 5U, 2D)	(Grants to physics departments sometimes included astronomy and/or astrophysics)				
	Arizona, U of	U	2512	7/65	Chem, Math, Phys
	California (SC), U of	D	600	9/69	
	Colorado, U of	U	See Phys	6/65	Chem, Eng, Math, Phys, Psych
	Florida, U of	U	464	7/65	Chem, Eng, Math, Phys
	SUNY at Stony Brook	S	276	/70	Molec Dyn, Phys, Psychobiol, Solid St
	Texas, U of	U	610	1/67	Anthro, Botn, Chem, Comp Sci, Eng, Gen, Ling, Microbiol, Phys, Psych, Zoo
	Vanderbilt U	U	192	5/67	Chem, Library Sci, Molec Biol, Phys
	Virginia U of	U	660	6/65	Biol, Chem, Mat Sci, Math, Phys
Atmospheric Science	Maryland, U of	U	See Fluid Dyn	5/67	(Fluid Dyn), Chem, Comp Sci, Math, Phys
	Washington, U of at Seattle	U	413	9/68	Botn, Geol, Geophys, Oceanog, Phys, Quaternary Research
Bacteriology	Georgia, U of	U	566	8/67	Biochem, Biol, Biopsych, Botn, Ent, Microbiol, Zoo
Biochemistry	Bryn Mawr College	D	403	7/69	
	Georgia, U of	U	1066	8/67	Bact, Biochem, Biol, Biopsych, Botn, Entm, Microbiol, Zoo
	Iowa, U of	U	456	8/67	Anat, Botn, Microbiol, Pharm, Physiol, Psych, Zoo
Biology (17 entries 11U, 6D)	(See also Anatomy, Biochemistry, Life Sciences, Molecular Biology)				
	Boston U	D	650	3/70	
	Carnegie-Mellon U	U	247	5/67	Chem, Math, Phys
	Case-Western Reserve U	U	1728	5/65	(Living State Ctr), Chem, Phys, Mat Sci
	CUNY, Hunter College	D	618	9/68	
	Georgia, U of	U	1010	8/67	Bact, Biochem, Biopsych, Botn, Entm, Microbiol, Zoo
	Ill Inst of Tech	D	[illegible]	9/69	
	Kansas State U	S	[illegible]	9/69	
	Marquette U	D	[illegible]	9/67	
	Notre Dame, U of	U	2400	5/67	(Microbiol), Chem, Math, Phys
	Oregon, U of	U	1062	5/65	(Biol, Molec Biol), Chem, Comp Sci, Geol, Math, Phys, Psych, Soc Sci
	Purdue U	U	2000	5/66	Phys
	Rochester, U of	U	1950	6/65	Chem
	SUNY-Albany	D	625	9/70	DSDG/Math
	Tulane U	U	[illegible]	7/66	Math, Psych
	Virginia, U of	U	1165	6/65	Astron, Chem, Mat Sci, Math, Phys
	Washington U (St Louis)	U	914	4/65	Chem, Eng, Phys
Biomathematics	North Carolina State at Raleigh	U	1445	5/66	Eng
Biopsychology	Georgia, U of	U	713	8/67	Bact, Biochem, Biol, Botn, Entm, Microbiol, Zoo

Botany	Georgia, U of	U	972	8/76	Bact, Biochem, Biol, Biopsych Entm, Microbiol, Zoo
	Iowa, U of	U	672	8/67	Anat, Biochem, Microbiol, Pharm, Physiol, Psych, Zoo
	Texas, U of	U	294	1/67	Anthro, Astron, Chem, Comp Sci, Eng, Ling, Microbiol, Phys, Psych, Zoo
	Washington, U of at Seattle	U	171	9/68	Atmos Sci, Geol, Geophys, Oceanog, Phys, Quaternary Research Center
Chemical Physics	Indiana U	U	See Chem	7/67	Chem, Comp Sci, Phys
	Washington State U	D	550	9/68	DSDG/Sociology
Chemistry (35 entries 22U, 13D)	(See also Biochemistry, Chemical Physics, Molecular Dynamics, Surface Studies)				
	Arizona, U of	U	1930	7/65	Astron, Math, Phys
	Brandeis, U	S	800	7/70	Phys
	Carnegie-Mellon U	U	902	5/67	Biol, Math, Phys
	Case-Western Reserve U	U	1740	5/65	Biol, Mat Sci, Phys
	Colorado, U of	U	774	6/65	Eng, Math, Phys, Psych
	Duke U	U	595	12/66	Eng, Gen, Phys, Stat
	Emory U	D	562	9/70	
	Florida St U	U	1890	3/68	Phys, Psychobiol, Stat
	Florida, U of	U	2052	7/65	Astron, Eng, Math, Phys
	Hawaii, U of	D	606	7/70	
	Illinois, U of at CC	D	545	9/68	
	Indiana U	U	1847	12/66	(Chem-Phys), Comp Sci, Phys
	Louisiana St U at B R	U	1634	11/65	Geol, Math, Phys
	Louisiana St U at N O	See New Orleans, U of			
	Maryland, U of	U	1195	5/67	Comp Sci, Fluid Dyn, Math, Phys
	Michigan, St U	U	1387	5/68	Math, Phys
	Nebraska, U of	S	830	8/67	DSDG/Phys
	New Orleans, U of	D	478	9/68	
	North Carolina, U of	U	1302	5/67	City Reg Planning, Comp Sci, Econ, Phys, Pol Sci, Psych, Soc Sci, Sociology, Stat
	Notre Dame, U of	U	1327	5/57	Biol, Math, Microbiol, Phys
	Oregon St U	D	600	3/70	
	Oregon, U of	U	1164	5/65	Biol, Chem, Comp Sci, Math, Molec Biol, Phys, Psych, Soc Sci
	Pittsburgh, U of	U	2012	6/69	Crystallography, Phys
	Polytech Inst N Y Brooklyn	U	1152	11/65	Eng, Math, Phys
	Rensselaer Poly Inst	D	490	9/69	DSDG/Math
	Rochester, U of	U	3755	6/65	Biol, DSDG/Fund Studies
	SUNY-Stony Brook	S	254	7/70	(Molec Dyn), Astron, Phys, Psychobiol, Solid St
	So California, U of	U	568	11/65	Eng, Geol, Library Sci, Mat Sci, Math, Phys, Solid St
	South Carolina, U of	D	500	9/69	Psychobiol, Solid St
	Texas A&M U	D	560	7/69	DSDG/Econ
	Texas, U of	U	431	12/66	Anthro, Astro, Comp Sci, Botn, Eng, Gen, Ling, Microbiol, Phys, Psych, Zoo
	Utah, U of	D	695	9/70	DSDG/Phys
	Vanderbilt U	U	1817	5/67	Astron, Library Sci, Molec Biol, Phys
	Virginia, U of	U	1192	7/65	Astron, Biol, Mat Sci, Math, Phys
	Washington U (St Louis)	U	1964	4/65	Biol, Eng, Phys
	Wayne State U	S	919	5/67	
City Reg Planning	North Carolina, U of at C H	U	677	5/65	Chem, Comp Sci, Econ, Phys, Pol Sci, Psych, Soc Sci, Sociology, Stat
Computer Science/Center	Clemson U		(See Engineering)	3/70	(Hybrid computer factor Eng)
	Duke U (See Statistics)				
	Indiana U	U	1311	12/66	Chem, Phys
	Maryland, U of	U	1316	5/67	Chem, Fluid Dyn, Math, Phys
	North Carolina, U of at C H	U	366	5/67	Chem, City Reg Planning, Econ, Comp Sci, Phys, Pol Sci, Psych, Soc Sci, Sociology, Stat
	Northwestern U	S	525	9/70	Urban Systems Eng
	Oregon, U of	U	2525	5/67	(Stat Lab & Comp Cntr), Biol, Chem, Comp Sci, Geol, Math, Phys, Psych, Soc Sci
	Texas, U of	U	32	12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng

Earth Sciences	(See also Geological Science)				
Ecology	Utah State U	D	550	9/68	
Economics (5 entries 1U, 4D)	California (SD), U of	D	571	9/70	
	North Carolina, U of at C H	U	531	5/67	Chem, City Reg Planning, Comp Sci, Phys, Pol Sci, Psych, Soc Sci, Sociology, Stat
	Southern Methodist U	D	550	3/70	DSDG/Anthro, Eng
	SUNY-Binghamton	D	390	3/70	DSDG/Geology
	Texas A&M U	D	458	9/70	DSDG/Chem
Engineering (26 entries including 50 Engineering departments 18U, 32D	California (SB), U of	D	480	9/70	(Elec Eng)
	Clemson U	D	773	3/70	(Hybrid Computer Facility)
	Clarkson Col of Tech	D	590	9/69	(Chem Eng)
	Colorado State U	D	600	3/70	Civ Eng
	Colorado, U of	U	1103	6/65	(Aerospace, Elec, Mech Eng'g), Chem, Math, Phys, Psych
	Drexel Inst of Tech	D	528	6/68	(Met Eng)
	Duke U	U	1257	12/66	(Civ, Elec, Mech Eng), Chem, Gen, Phys, Stat
	Florida, U of	U	1936	7/65	(Chem Eng, Elec Eng, Eng Sci & Mechanics, Materials Eng), Math, Phys
	Houston, U of	D	420	9/67	(Chem Eng)
	Lehigh U	D	670	9/67	(Mech Eng & Mechanics); DSDG/Mat Sci
	Michigan Tech U	D	385	9/69	(Met Eng)
	Mississippi, U of	D	400	12/69	(Elec Eng)
	North Carolina St U at Raleigh	U	3110	5/66	(Aerospace, Chem, Civ, Elec, Mat, Mech, Min, Nucl Eng), Biomath
	Northwestern U	S	975	9/70	(Urban Systems Eng), Comp Sci
	Oakland U	D	570	9/68	(Systems Sci/Eng)
	Oklahoma St U	D	665	9/69	(Systems Sci/Eng) (Aerospace, Chem, Elec, Mech.)
	Polytechnic Inst N Y / Brooklyn	U	2759	11/65	(Met Eng, Electrophysics), Chem, Math, Phys
	Rice U	U	967	6/65	(Chem, Elec, Mech, Systems Eng'g), Math, Philos, Soc Sci
	So California, U of	U	1397	11/65	(Aerospace, Elec Eng'g), Chem, Geol, Library Sci, Mat Sci, Math, Phys, Solid St
	Southern Methodist U	D	600	7/68	(Elec Eng), DSDG/Anthro, Econ
	Tennessee Tech U	D	300	6/67	(Mech Eng)
	Tennessee, U of	S	700	7/68	(Chem, Met Eng'g), Phys
	Texas, Tech U	D	476	9/70	(Elec Eng)
	Texas, U of	U	264	12/66	(Elec Eng); Anthro, Astron, Botn, Chem, Comp Sci, Gen, Ling, Microbiol, Phys, Psych, Zoo
	Washington U (St Louis)	U	2896	4/65	(Eng, Appl Sci), Biol, Chem, Psych
	West Virginia U	D	700	3/67	(Interdisciplinary)
Entomology	Georgia, U of	U	656	8/67	Bact, Biochem, Biol, Biophys, Botn, Entm, Microbiol, Zoo
Environmental Sciences	Connecticut, U of	D	145	3/70	
Fluid Dynamics	Maryland, U of	U	434	5/67	Chem, Comp Sci, Math, Phys
Fundamental Studies	Rochester, U of	D	848	4/71	(Interdisciplinary Center includes Physics, Math, Social Sciences, Biological Sciences), USDG/Biol, Chem
Genetics	Duke U	U	422	12/66	Chem, Eng, Phys, Stat
	Texas, U of	U		12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng, Ling, Microbiol, Phys, Psych, Zoo
Geography	Clark U	D	564	6/67	DSDG/Psych
Geological Science (10 entries 4D, 6D)	Alaska, U of	D	720	4/70	
	Colorado Sch of Mines	D	700	4/70	Mineral Resources
	Louisiana State U at B R	U	1811	11/65	Chem, Math, Phys
	Montana, U of	D	500	4/71	
	Oregon, U of	U	182	5/65	Biol, Chem, Comp Sci, Geol, Math, Phys, Psych, Soc Sci
	So California, U of	U	377		Chem, Eng, Library Sci, Mat Sci, Math, Phys, Solid St

	SUNY-Binghamton	D	500	9/68	DSDG/Econ
	Virginia Polytech Inst	D	500	9/69	
	Washington, U of at Seattle	U	2314	9/68	Atmos Sci, Botn, Geophys, Oceanog, Phys, Quaternary Research
	Wyoming, U of	D	477	7/68	
Geophysics	Washington, U of at Seattle	U	493	5/68	Atmos Sci, Botn, Geol, Oceanog, Phys, Quaternary Research
Library, Scientific	Vanderbilt U	U	436	5/67	Astron, Chem, Molec Biol, Phys
	So California, U of	U	959	11/65	Chem, Eng, Geol, Mat Sci, Math, Phys
Life Sciences	(See Anatomy, Biochemistry, Biopsychology, Biology, Biomathematics, Botany, Ecology, Entomology, Fundamental Studies, Genetics, Microbiology, Molecular Biology, Pharmacology, Physiology, Psychobiology, Zoology See also list of NIH's HSAA)				
Linguistics	Georgetown U	U	460	4/70	(Sociolinguistics)
	Texas, U of	U	712	12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng, Gen, Microbiol, Phys, Psych, Zoo
Materials Science	(Electrical engineering, physics, and solid state may include materials science components)				
	Case Western Reserve U	U	1958	5/65	Biol, Chem, Phys
	Lehigh	D	550	9/67	(Met and Mat Sci); DSDG/Eng
	So California, U of	U	803	11/65	Chem, Eng, Geol, Library Sci, Math, Phys, Solid St
	Virginia, U of	U	981	6/65	Astron, Biol, Chem, Math, Phys
Mathematics	(See also Statistics)				
(22 entries 15U, 7D)	Arizona, U of	U	945	7/65	Astron, Chem, Phys
	Carnegie-Mellon U	U	1253	5/67	Biol, Chem, Phys
	Claremont Grad School	D	491	9/68	DSDG/Psych
	Colorado, U of	U	225	6/65	Chem, Eng, Math, Phys, Psych
	Denver, U of	D	500	9/68	
	Florida, U of	U	302	7/65	Astron, Chem, Phys
	Kentucky, U of	S	974	7/68	
	Louisiana State U at B R	U	1192	11/65	Chem, Geol, Phys
	Maryland, U of	U	940	5/67	Chem, Comp Sci, Fluid Dyn, Phys
	Michigan St U	U	1472	5/68	Chem, Phys
	New Mexico State U	S	700	4/66	
	New Mexico, U of	D	550	6/67	
	Notre Dame, U of	U	631	5/67	Biol, Chem, Microbiol, Phys
	Oregon, U of	U	585	5/65	Biol, Chem, Comp Sci, Geol, Phys Psych, Soc Sci, Stat
	Polytechnic Inst N Y / Brooklyn	U	177	11/65	Chem, Eng, Phys
	Rensselaer Poly Inst	D	569	7/68	DSDG/Chem
	Rice U	U	726	6/65	Eng, Philos, Soc Sci
	Rutgers U	U	1224	5/66	Phys
	So California, U of	U	536	11/65	Chem, Eng, Geol, Library Sci, Mat Sci, Phys, Solid St
	SUNY-Albany	D	480	9/69	DSDG/Biol
	Tulane U	U	463	5/66	Biol, Psych
	Vanderbilt U		(Only Univ funds were used)	5/67	Astron, Biol, Chem, Library Sci, Phys
	Virginia, U of	U	354	7/65	Astron, Biol, Chem, Mat Sci, Phys
Microbiology	Georgia, U of	U	146	8/67	Bact, Biochem, Biol, Biopsych, Botn, Entm, Zoo
	Iowa, U of	U	973	8/67	Antm, Biochem, Botn, Pharm, Physiol, Psych, Zoo
	Notre Dame, U of	U	See Biol	5/67	Biol, Chem, Math, Phys
	Texas, U of	U	306	12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng, Gen, Ling, Phys, Psych, Zoo
Mineral Resources	Colorado Sch of Mines	D	See Geo Sci		
Molecular Biology	Vanderbilt U	U	1342	5/67	Astron, Chem, Library Sci, Phys
Molecular Dynamics	SUNY-Stony Brook	S	See Chem	7/70	Astron, Phys, Psychobiol, Solid St
Oceanography	Washington, U of (Seattle)	U	710	5/68	Atmos Sci, Botn, Geol, Geophys, Phys, Quaternary Research
Pharmacology	Iowa, U of	U	450	8/67	Anat, Biochem, Botn, Microbiol, Physiol, Psych, Zoo
Philosophy	Rice U	U	17	6/65	Eng, Math, Soc Sci

Physics	**(See also Solid State, Surface Studies)**				
(38 entries: 25U, 13D)	**Arizona U of**	**U**	**1840**	**7/65**	**Astron, Chem, Math**
	Brandeis U	**S**	**1100**	**7/70**	**Chem**
	Carnegie-Mellon U	**U**	**2387**	**5/67**	**Biol, Chem, Math**
	Case-Western Reserve U	**U**	**3734**	**5/65**	**Biol, Chem, Mat Sci**
	Colorado, U of	**U**	**2695**	**6/65**	**(Astron and Phys); Chem, Eng, Math, Psych**
	CUNY-City College	D	765	9/68	
	Delaware, U of	D	556	7/68	
	Duke U	U	744	12/66	Chem, Eng, Gen, Stat
	Florida State U	U	2430	3/68	Chem, Psychobiol, Stat
	Florida, U of	U	1175	7/65	Astron, Chem, Eng, Math
	Indiana U	U	6198	12/66	Chem, Comp Sci
	Louisiana State U at B R	U	1579	11/65	Chem, Geol, Math
	Maryland, U of	U	818	5/67	Chem, Comp Sci, Fluid Dyn, Math
	Michigan State U	U	2629	5/58	Chem, Math
	Missouri, U of at Rolla	D	550	9/67	
	Nebraska, U of	D	715	9/69	(Phys, Astrophys); SSDG/Chem
	New York U	U	3684	6/69	Psych
	North Carolina, U of at C H	U	658	5/67	Chem, City Reg Planning, Comp Sci, Econ, Pol Sci, Psych, Sociology, Soc Sci, Stat
	Notre Dame, U of	U	1307	5/67	Biol, Chem, Math, Microbiol
	Ohio U (Athens)	D	563	7/68	
	Oregon, of	U	988	5/65	Biol, Chem, Comp Sci, Math, Soc Sci
	Pittsburgh, U of	U	1747	6/69	Chem, Crystallography
	Polytechnic Inst N.Y./ Brooklyn	U	454	11/65	Chem, Eng, Math
	Purdue U	U	1900	5/66	Biol
	Rutgers U	U	3484	5/66	Math
	So California, U of	U	1108	11/65	Chem, Eng, Geol, Library Sci, Mat Sci, Math, Solid St
	Stevens Inst of Tech	D	670	9/69	
	SUNY-Stony Brook	S	170	7/70	Astron, Chem, Molec Dyn, Psychobiol, Solid St
	Tennessee, U of	S	750	7/68	Eng
	Texas, U of	U	1470	12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng, Gen, Ling, Microbiol, Psych, Zoo
	Utah, U of	D	720	9/69	DSDG/Chem
	Vanderbilt U	U	1616	5/67	Astron, Chem, Library Sci, Molec Biol, Phys
	Virginia, U of	U	1332	7/65	Astron, Biol, Chem, Mat Sci, Math
	Washington U (St. Louis)	U	1235	4/65	Biol, Chem, Eng
	Washington U of (Seattle)	U	2161	5/68	Atmos Sci, Botn, Geol, Geophys, Oceanog, Quaternary Research
	Wesleyan U	D	560	9/68	
	William & Mary, College of	D	610	2/69	
	Yeshiva U	D	900	12/69	
Physiology	Iowa, U of	U	945	8/67	Anat, Biochem, Botn, Microbiol, Pharm, Psych, Zoo
Political Science	North Carolina, U of at C H	U	560	5/67	Chem, City Reg Planning, Econ, Comp Sci, Phys, Psych, Sociology, Soc Sci, Stat
Psychobiology	Florida State U	U	1366	3/68	Chem, Phys, Stat
	SUNY-Stony Brook	S	500	7/70	Astron, Molec Dyn, Phys, Solid St
Psychology	Bowling Green State U	D	532	9/69	
(14 entries: 7U, 7D)	Claremont Graduate Sch	D	466	4/71	DSDG/Math
	Clark U	D	545	9/69	DSDG/Geog
	Colorado, U of	U	634	6/65	Chem, Eng, Math, Phys
	Iowa, U of	U	189	8/67	Anat, Biochem, Botn, Microbiol, Pharm, Physiol, Zoo
	Kent State U	D	400	3/70	
	Louisville, U of	D	500	9/68	
	Massachusetts, U of	D	582	4/71	
	New Hampshire, U of	D	480	3/70	

	New York U	U	2476	6/69	Phys
	North Carolina, U of at C.H.	U	511	5/67	Chem, City Reg Planning, Comp Sci, Econ, Phys, Pol Sci, Sociology, Soc Sci, Stat
	Oregon, U of	U	227	5/65	Biol, Chem, Comp Sci, Geol, Math, Phys, Soc Sci
	Texas, U of	U	1085	12/66	Anthro, Astron, Botn, Chem, Comp Sci, Eng, Gen, Ling, Microbiol, Phys, Zoo
	Tulane U	U	2030	7/66	Biol, Math
Quaternary Research	Washington, U of (Seattle)	U	237	9/68	Atmos Sci, Botn, Geol, Geophys, Oceanog, Phys
Social Sciences	(See under Anthropology, City and Regional Planning, Economics, Fundamental Studies, Geography, Linguistics, Philosophy, Political Science, Psychology, Sociology)				
	North Carolina, U of at C H	U	688	5/67	Chem, City Reg Planning, Comp Sci, Econ, Phys, Pol Sci, Psych, Sociology, Stat
	Oregon, U of	U	15	5/65	Biol, Chem, Comp Sci, Geol, Math, Phys, Psych
	Rice U	U	681	6/65	(Behavioral & Soc Sci), Eng, Math
	Yale U	D	1500	6/71	(Inst Soc & Policy Studies)
Sociology	North Carolina, U of at C H	U	497	5/67	Chem, City-Reg Planning, Comp Sci, Econ, Phys, Pol Sci, Psych, Sociology, Stat
	Washington State U	D	530	9/70	DSDG/Chemical Physics
Solid-State	(See also Materials Science and Physics)				
	Arizona State U	D	650	9/69	(Interdisciplinary Center)
	Pittsburgh, U of	U	691	6/69	(Crystallography), Chem, Phys
	Southern California, U of	U	1725	11/65	(Interdisciplinary Program), Chem, Eng, Geol, Library Sci, Mat Sci, Math, Phys
	SUNY-Stony Brook	S	800	7/70	Astron, Molec Dyn, Phys, Psychobiol
Statistics	Duke U	U	159	12/66	(Comp Sci, Stat), Chem, Eng, Gen, Phys
	Florida State U	U	334	3/68	Chem, Phys, Psychobiol
	North Carolina, U of at C H	U	747	5/67	Chem, City Reg Planning, Comp Sci, Econ, Phys, Pol Sci, Psych, Sociology, Soc Sci
Surface Studies	Wisconsin, U of at Milwaukee	D	555	7/68	
Zoology	Georgia, U of	U	867	8/67	Bact, Biochem, Biol, Biopsych, Botn, Entm, Microbiol
	Iowa, U of	U	2768	8/67	Anat, Biochem, Botn, Microbiol, Pharm, Physiol, Psych
	Texas, U of	U	873	1/67	Anthro, Astron, Botn, Chem, Eng, Gen, Ling, Microbiol, Phys, Psych

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In the last column to the right any subdisciplines involved are listed in parentheses Other disciplines if any funded by the grant are listed in alphabetical order The comment DSDG Econ Eng under Anthropology for SMU means that SMU received additional Departmental SD Grants in Economics and Engineering The abbreviations used follow

List of Abbreviations

ANATomy
ANTHROpology
ASTRONomy
ATMOSpheric SCIences

BACTeriology
BIOCHEMistry
BIOLogy
BIOMATHematics
BIOPSYCHology
BOTany

CHEMistry
CHEMical PHYSics
CITY and REGional Planning
COMPuter SCIence
CRYSTALLOGRAPHY

EARTH SCIENCES CenTeR
ECOLOGY
ECONomics
ENGineering AEROSPACE, CHEMical, CIVil, ELECtrical, MECHanical, METallurgical, MINeral, NUCLear, URBAN SYSTEMS
ENTOMology
ENVIRONmental SCIence

FLUID DYNamics
FUNDamental STUDIES

GENetics
GEOGraphy
GEOLogy
GEOPHYSics

LIBRARY, SCIentific
LIFE SCIences
LINGuistics

MATerials SCIence
MATHematics
MICROBIOLogy
MINERAL RESOURCES
MOLECular DYNamics

OCEANOGraphy

PHARMacology
PHILOSophy
PHYSics
PHYSIOLogy
POLitical SCIence

QUATERNARY RESEARCH

SOCial SCIences
SOCIOLOGY
SOLID STate
STATistics
SYSTEMS SCIence

URBAN SYSTEMS ENGineering

ZOOlogy

APPENDIX B-6

Interdisciplinary Centers and Activities Funded by the Science Development Programs

In Universities with several strong science departments, there will normally be strong interactions across department lines by individual faculty members and through service facilities such as shops or analytical laboratories. The following list provides, on the other hand, examples of formalized interdisciplinary activities that resulted from or were strengthened by science development grants.

Alaska Univ of	Solid Earth Sciences, Geophysical Institute
Arizona State U	Solid State Sciences (Chem, Geochem, Phys)
Bryn Mawr College	Biochemistry
Case Western Reserve	Materials Science
Colorado School of Mines	Geoscience and Mineral Research
Colorado U of	Institute for Behavioral Science
Iowa U of	Three interdisciplinary programs in endocrinology, genetics, and neurobiology
University of Maryland	Center for Theoretical Physics, Institute for Fluid Dynamics and Applied Mathematics
North Carolina U of at CH	Institute for Research in Social Science
North Carolina State U at Raleigh	Biomathematics
Northwestern U	Urban Affairs Engineering Center
Oklahoma State U	Systems Engineering (Mechanical & Electric Engineering)
Oregon Univ of	Center for Volcanology Theoretical Science Institute
Rice U	Systems Science
Rochester U of	Institute for Fundamental Studies (Biol, Chem, Phys, Math, Social Sciences)
SUNY-Binghamton	Economic Growth Institute, Social Policy Institute
Texas U of at Austin	Behavioral Genetics, Linguistics and Behavior, Molecular Science Center, RAAP Center (Relativity, Astrophysics, Astronomy and Plasma Studies)
Utah State U	Ecology
Virginia U of	Center for Advanced Studies (Included the sciences when started under grant, extended to the humanities)
Washington State U	Chemical Physics
Washington U of (Seattle)	Institute for Quaternary Studies, Linking Physical, Biological, & Geological Sciences. Geophysics Program, Glaciology Program
Wisconsin U of Milwaukee	Surface Studies (Chem, Eng, and Phys)
Yale U	Institution for Social and Policy Studies, School of Organization and Management