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ABSTRACT

This report, the third in a biennial series, provides a picture of the current situation and recent trends concerning the availability, cost, and condition of research space, capital spending, and sources of support for research facilities at universities and colleges. The survey data are based on both quantitative and qualitative assessments provided by 253 academic research institutions, including 29 historically black colleges and universities. Following an executive summary and an introduction, chapters discuss: (1) trends in the overall amount of research space available in science and engineering disciplines and differences between institutional types and among science/engineering disciplines; (2) costs and square footage associated with repair/renovation and new construction of research facilities for projects initiated in 1986-89 and for planned projects; (3) sources of funds for these projects, emphasizing the differences between public and private institutions; (4) qualitative information, including institution assessments of the condition of their research facilities, the adequacy of the amount of research space, the adequacy of selected infrastructure aspects of facilities, and the amount of deferred repair/renovation; and (5) findings for historically black colleges and universities. Twenty-five tables, 7 charts, and 13 figures graphically support the text. Appendices contain technical notes, a list of sampled institutions, the survey questionnaire, and detailed statistical tables. (JDD)

HIGHLIGHTS

AMOUNT OF SPACE: There are an estimated 116 million net assignable square feet (NASF) of science/engineering (S/E) research space at the nation's research-performing institutions in 1990. Seventy percent of this space is located at the 100 largest research performing institutions, which account for 84 percent of total academic research expenditures. Over 85 percent of 1990 research space is concentrated in 5 disciplines: the biological (22 percent), agricultural (18 percent), and medical (17 percent) sciences, engineering (15 percent), and the physical sciences (14 percent). There were no statistically significant changes from 1988 to 1990 either in the overall amount of academic research space or in the distribution of this space among institution types or S/E disciplines.

NEW CONSTRUCTION: Institutions reported new construction projects totalling about $4.5 billion over the 1986-89 period. About $2.0 billion was reported for projects initiated in 1986-87 and $2.5 billion in 1988-89. When completed, these projects will produce over 20 million NASF of new research space. Much of the new construction is replacing outdated or inadequate space rather than enlarging the total amount of research space. Institutions plan substantial construction activity in 1990-91. Almost $3.5 billion in new projects are planned to begin during the coming two years, roughly the same amount as had been projected for the two years following the prior survey (1988-89).

DEFERRED CONSTRUCTION: For every dollar of new facilities construction planned for 1990-91, an estimated additional $3.11 in needed construction spending will be deferred, up from a $2.48 deferral rate at the time of the 1988 survey. The current (1990) level of deferred construction is estimated to be $8.0 billion, up 38 percent from $5.8 billion in 1988

REPAIR/RENOVATION. Expenditures for facilities repair and renovation (R/R) increased from $840 million in 1986-87 to $1.04 billion in 1988-89, in contrast to projections that had envisioned decreased spending. The total space affected by these repairs, however, decreased somewhat, resulting in higher average unit costs than had been anticipated.

DEFERRED REPAIR/RENOVATION. Based on costs of reported R/R projects, it is estimated that about $4.25 in needed R/R is being deferred for every $1.00 in R/R that is planned for 1990-91, up from a $3.60 deferral rate in 1988. The total amount of deferred R/R will rise to more than $4.0 billion by the end of 1991, a 40-percent increase from the level found in the 1988 survey.

AVERAGE UNIT COSTS: The average unit cost of new construction grew from $207/square foot in 1986-87 to $231/square foot in 1988-89, costs are estimated at $311/square foot for 1990-91 projects. This represents a 50-percent increase over the 1986-91 period. Comparable unit costs for R/R activities nearly doubled during that time, growing from $62/square foot in 1986-87 to an estimated $111/square foot in 1990-91.

ADEQUACY OF AMOUNT OF SPACE: In each of the 5 largest S/E fields, 40 to 60 percent of the institutions that perform research in the discipline report needs for more research space. However, in most fields and institution types, the need for increased amounts of research space does not appear to have grown from 1988 to 1990.

CONDITION OF SPACE: The proportion of R&D space reported by institutions to be in need of limited or major repair or renovation was 39 percent both in 1988 and 1990. There was a modest increase from 1988 to 1990 in the proportion of space assessed as being "suitable for use in the most highly developed and scientifically sophisticated research in its field" (up from 24 to 26 percent of total).

SOURCES OF FUNDS: In both 1986-87 and 1988-89, public institutions acquired about half of their funding for new construction projects from state/local governments, while private institutions depended mainly on private donations. Both public and private institutions depended primarily upon institutional funding for R/R projects. Other major sources of funding included debt financing and private donations. The total institutional debt incurred from projects initiated in 1988-89 is expected to be about $1.4 billion.

HBCUs: While historically black colleges and universities (HBCUs) reported a 30-percent overall increase in the total amount of research space available in 1990, they continued to account for about 1 percent of total academic research space.

SCIENTIFIC AND ENGINEERING RESEARCH FACILITIES AT UNIVERSITIES AND COLLEGES: 1990

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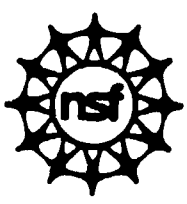

National Science Foundation

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FOREWORD

The environment in which academic research is conducted is becoming more complex, and the financial resources that support research are being spread more thinly as more programs compete for the available support.

The cost of supporting research has risen substantially. This cost includes the research facilities--the bricks, mortar, and support systems--that house the research enterprise. The status of these facilities in terms of amount and sufficiency can impact the quantity and quality of the research and education that is performed in the academic setting. In order to renew, expand, or establish new research capacity, academic research facilities must be present in adequate amounts and must be of suitable quality to allow science and engineering research and education at the highest levels of excellence.

This report, the third in a biennial series, provides a comprehensive picture of the current situation and recent trends concerning the availability, cost, and condition of research space, as well as capital spending and sources of support for research facilities. It is designed to provide important information to the Congress, the Administration, and others involved with the U.S. science and engineering research enterprise.

Erich Bloch
Director
National Science Foundation

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The 1990 Survey of Research Facilities at Universities and Colleges was developed and guided by Judith F. Coakley, Senior Science Resources Analyst, Division of Science Resources Studies, Universities and Colleges Studies Group (UCSG), National Science Foundation (NSF), under the overall direction of James B. Hoehn, Study Director, UCSG. Guidance and review were provided by Daniel Melnick, Director, Division of Science Resources Studies, and F. Karl Willenbrock, Assistant Director for Scientific, Technological, and International Affairs (STIA), NSF. The report also benefited from the comments provided by Richard Green, William Cole, and Altie Metcalf of the Research Facilities Office, NSF.

The National Institutes of Health also provided significant financial and other support for the survey, under the direction of Paul Seder, NIH Office of Science Policy and Legislation.

An expert Advisory Panel contributed to the survey design, the analysis plan, and the review of this report:

- Dennis Barnes, Associate Vice President for Governmental Relations, University of Virginia
- Richard Blatchly, Professor of Chemistry, Williams College
- Joanne Cate, Principal Administrative Analyst, Capital Improvements Planning, University of California
- Harvey Kaiser, Senior Vice President, Facilities Administration, Syracuse University
- Julie Norris, Assistant Vice President and Director of Sponsored Programs, University of Houston
- Kenneth Shine, Dean of the Medical School, University of California-Los Angeles
- David Satcher, President, Meharry Medical School
- Allen Sinisgalli, Associate Provost for Research Administration, Princeton University

In addition, several higher education association and university representatives advised NSF on the development of the survey. The contributing associations included:

- The American Association of State Colleges and Universities
- The American Council on Education
- The American Society for Engineering Education
- The Association of American Medical Colleges
- The Association of American Universities
- The Council of Graduate Schools in the United States
- The Council on Governmental Relations
- The National Association of Independent Colleges and Universities
- The National Association of State Universities and Land Grant Colleges
- The National Council of University Research Administrators

The 1990 survey was conducted by Westat, Inc., of Rockville, Maryland, under contract to NSF (Contract Number SRS-8913122). Westat staff who played significant roles in the project were:

- Kenneth Burgdorf, Project Director
- Paul Newman, Project Manager
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- Terrie Squadere, Survey Operations Director
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- Michael Brick, Project Statistician
- Annell Bond, Project Systems Analyst
- William Renfrew, Project Programmer
- Susan Hein, Report Graphics
- Sylvie Warren, Project Secretary

DATA CONSIDERATIONS

- This report provides da on the amount, condition, and sources of funding for repair/renovation and new construction of **research and development (R&D)** facilities in science and engineering disciplines for all research-performing academic institutions. To define research and development in this survey, the definition of "organized research," as specified in OMB Circular A-21, was used. **Organized research** includes research and development activities of an institution that are separately budgeted and accounted for, including sponsored research and university research. "Sponsored research means all research and development activities that are sponsored by Federal and non-Federal agencies and organizations...University research means all research and development activities that are separately budgeted by the institution under an internal application of institutional funds." The definition **excludes** departmental research that is not separately budgeted and accounted for, as that is classified as part of the instruction function in OMB Circular A-21.

- R&D facilities refers to the physical plant (bricks and mortar) in which research activities take place, including building infrastructure, fixed equipment, and non-fixed equipment costing over $1 million. The definition excludes instrumentation, i.e., movable equipment costing less than $1 million. Facilities that have been designated as academically administered Federally Funded Research and Development Centers (FFRDCs) are excluded.

- R&D space includes the net assignable square footage (NASF) of space in research facilities where organized R&D activities take place. Multipurpose space such as offices is prorated to reflect the proportion of use devoted to organized research.

- "Repair/renovation" and "new construction" capital projects are limited to projects with estimated total costs at completion of $100,000 or more for R&D related space. Costs include both structural costs and the cost of the associated infrastructure such as utilities, data communications, etc. For multipurpose space, institutions prorated the cost to reflect the proportion of R&D space involved in the project.

- The survey data on new and deferred construction, new and deferred repair/ renovation, and the condition and adequacy of existing research facilities are based on both quantitative and qualitative assessments provided by academic research institutions. Although some of these data are by their very nature subjective, they do capture an overall picture of the current status of facilities. However, this report does not, nor was it intended to, assess the impact of facilities on the quality of research being conducted at academic institutions.

- This report provides national estimates for all research-performing academic institutions. A stratified probability sample of 253 institutions was selected with probability proportional to size, as measured by total science/engineering R&D expenditures. The survey universe includes approximately 525 institutions. Estimates are provided by type of institution (doctorate, non-doctorate, largest 100 R&D performers, and historically black colleges and universities) and control (public versus private). The sample was not drawn in a manner that will allow generation of geographic, i.e., state or regional level, estimates.

- The institutional response rate to the survey was 94 percent for all academic institutions and 90 percent or greater for all institution types. The overall item nonresponse rate was less than 1 percent.

- The findings in this report are based on a sample and are therefore subject to sampling variability. Estimated standard errors for 1988 and 1990 selected statistics and the difference between the years are shown in Table A-2 in the Technical Notes.

- Data followup for the 1990 study included cross-year review, which was intended to verify inconsistencies between the current year and 1988. Where appropriate, 1988 data were revised in consultation with institutional respondents. For this reason, the 1988 totals shown in this report may differ slightly from those in the 1988 final report. References to 1988 data should be restricted to this document.

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EXECUTIVE SUMMARY

In order to sustain a strong academic research capability and to enable the expansion of the nation's research capacity, the facilities that house the research enterprise must be maintained and replenished. The size, condition, and adequacy of these research facilities impact on the quantity and quality of the research conducted at our nation's universities and colleges. In recognition of the need for objective and systematic information on the status of academic research facilities, Congress directed the National Science Foundation (NSF), in the Authorization Act (P.L. 99-159, section 108):

> *...to design, establish, and maintain a data collection and analysis capability... for the purpose of identifying and assessing the research facilities needs of universities and colleges... The Foundation, in conjunction with other appropriate Federal agencies, shall conduct the necessary surveys every 2 years and report the results to the Congress.*

This report is the third in this biennial series, due to Congress in September 1990. It is based on NSF's 1990 Survey of Scientific and Engineering Research Facilities at Universities and Colleges. This is the second full-scale study involving research space by science/engineering field and type of institution.

The survey data on new and deferred construction, new and deferred repair/ renovation, and the condition and adequacy of existing research facilities are based on both quantitative and qualitative assessments provided by academic research institutions. Although some of these data are by their very nature subjective, they do capture an overall picture of the current status of facilities. However, this report does not, nor was it intended to, assess the impact of facilities on the quality of research being conducted at academic institutions.

Amount, Condition, and Adequacy of Research Space

Amount of Research Space

- There are an estimated 116 million net assignable square feet (NASF) of research space available at the nation's research-performing institutions in 1990. There was very little overall change from 1988 to 1990, either in the total amount of space assigned to science and engineering (S/E) disciplines or in the total amount of space used for organized research.

- As in 1988, the 100 largest R&D performers accounted for the majority of all academic R&D space in 1990 (70 percent); they accounted for 84 percent of total R&D expenditures.

- More than 85 percent of the current academic research space is concentrated in five S/E fields; the biological (22 percent), agricultural (18 percent), and medical (17 percent) sciences, engineering (15 percent) and physical sciences (14 percent).

Of a total 276 million net assignable square feet of space in science and engineering fields at American universities and colleges, 116 million square feet (about 40 percent) is allocated to research.[1] This is not appreciably different from the amount of R&D space reported in 1988. The vast majority of the research space was located in doctorate-granting institutions (96 percent). Three-fourths of all academic research space was in public institutions, somewhat higher than the share of total R&D spending (65 percent) that occurs in these institutions.

Seventy percent of this R&D space (81.7 million NASF) is housed in the 100 largest research-performing institutions, based on total R&D spending in science and engineering fields (Chart 1).[2] They have a mean of 800,000 square feet of research space per institution. Other doctorate-granting institutions account for 25 percent of total R&D space, with an institutional mean of 150,000 square feet. Non-doctorate granting institutions continue to account for less than 5 percent of all academic research space (5.2 million NASF), with an average of 22,000 square feet per institution.

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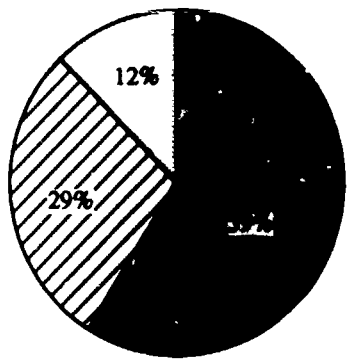
[1] All estimates of research space are based on net assignable square feet (NASF) assigned to organized research. See Appendix pages A-6 and C-2 for definitions.

[2] The "largest 100 R&D performers" (based on total research expenditures in science and engineering) were selected as an analytical grouping because they represent significant proportions of R&D expenditures (83 percent) and space (70 percent). They are also referred to as the "top 100 research institutions" throughout this report.

Chart 1
Distribution of space assigned to science/engineering (S/E) disciplines by institution type: 1990



All assigned S/E space (276 million square feet)

R&D space (116 million square feet)

Top 100 R&D | Other doctorate-granting | Non-doctorate-granting

Source National Science Foundation, SRS

Adequacy of the Current Amount of Research Space

- In each of the five largest S/E disciplines, 40 to 60 percent of the institutions that perform research in the discipline reported need for more research space.

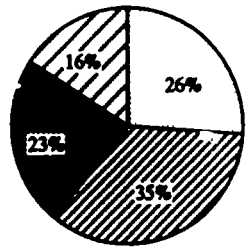
- In most fields and in most institution types, however, the reported need for increased amounts of research space does not appear to have grown from 1988 to 1990.

In each of the major S/E disciplines, upwards of 40 percent of the institutions that perform research in the discipline reported in the 1990 survey that they need more research space. Reports of inadequate amounts of research space were most prevalent among medical schools (for both biological and medical sciences), and such reports were more widespread in 1990 than in 1988. In most disciplines, however, the need for more research space does not appear to have grown since 1988. By discipline, ratings of "generally adequate" or better in relation to the **amount** of space ranged from a low of 48 percent of institutions with programs in medical sciences to a high of 68 percent of those with programs in psychology. In a few fields (e.g., the physical sciences and engineering), the number of schools reporting a need for more space has declined slightly since the 1988 survey.

Condition of Current Research Space

- The proportion of total R&D space that institutions reported to be in need of limited or major repair/renovation in 1990 was 39 percent, the same percentage as reported in 1988 (Chart 2).

Chart 2
Institution-assessed quality/condition of academic research facilities: 1990



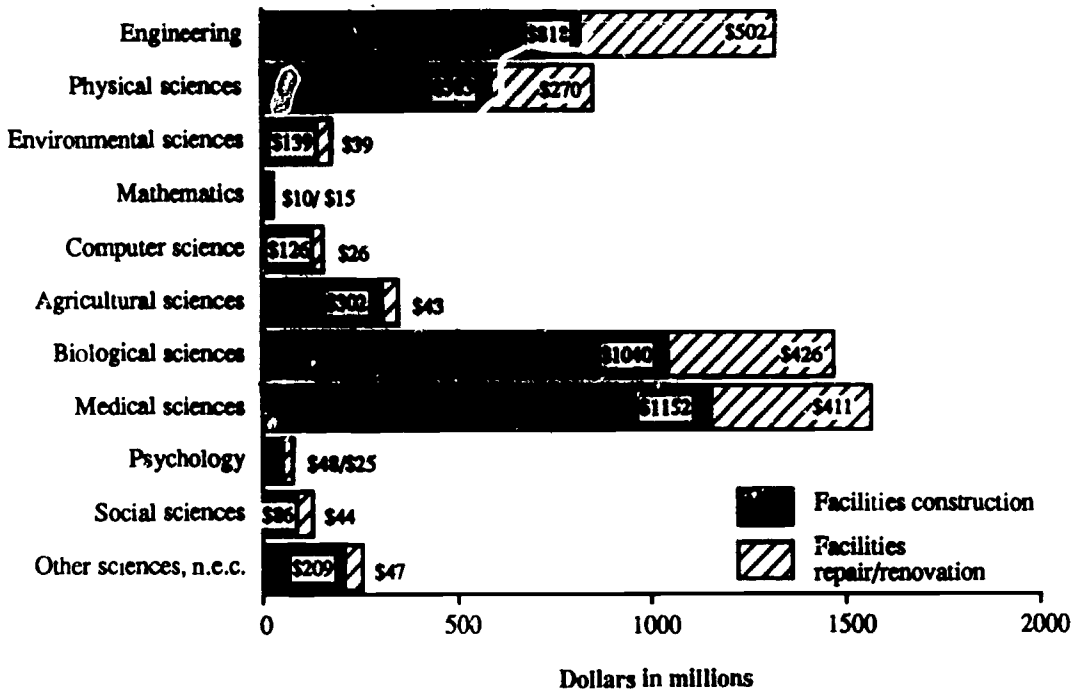
(base = 116.3 million sq. ft.)

Suitable for use in most sophisticated research
Effective for most uses
Needs limited repair/renovation
Needs major repair/renovation

Source. National Science Foundation, SRS

- At the other end of the quality/condition spectrum, there may have been a slight overall increase in the amount of space that institutions reported as being suitable for

Chart 3
Total spending for construction and repair/renovation of academic research facilities by discipline: 1986-89



Source. National Science Foundation, SRS

the "most highly developed and scientifically sophisticated research"; the estimates increased from 24 percent of R&D space in 1988 to 26 percent in 1990. In absolute terms, the total amount of research space rated in this category rose about 12 percent. Absolute increases were seen across almost all institution types and all S/E fields.

- Institutions in the top 100 reported a larger proportion of their research space as "suitable for the most highly developed research" (27 percent) than was found at other doctorate (24 percent) or non-doctorate institutions (19 percent).

Capital Projects To Maintain, Improve, or Expand Research Space

- Institutions spent a total of $6.4 billion for construction and repair/renovation of S/E research facilities over the four-year period 1986-89. This estimate excludes all construction, repair, or renovation projects that cost less than $100,000.

- New facilities construction accounted for over 70 percent of these capital project expenditures ($4.5 billion).

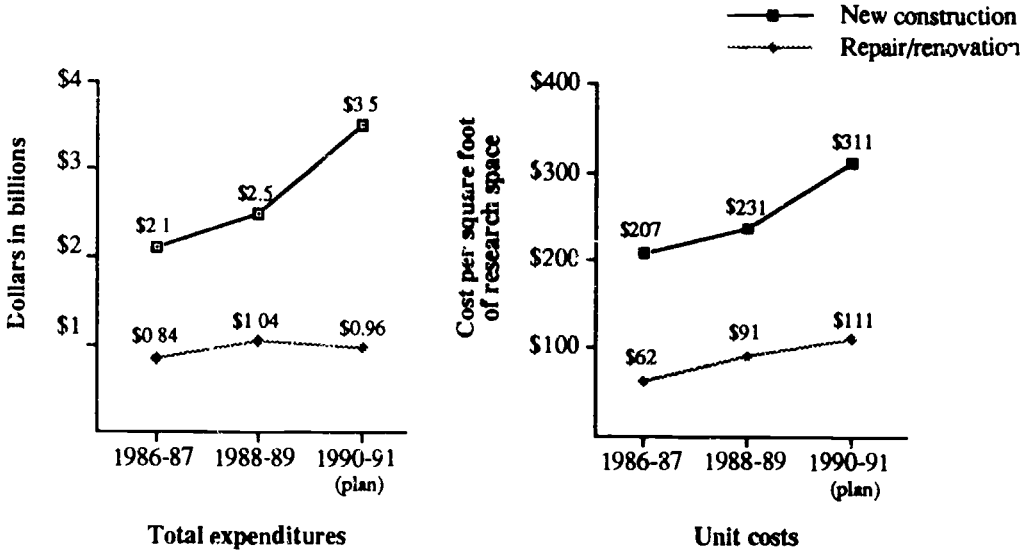
- These capital projects were heavily concentrated in four disciplines, the medical, biological, and physical sciences and engineering, which collectively accounted for 80 percent of all construction expenditures and 87 percent of all repair/renovation expenditures (Chart 3).

Construction of New Research Facilities

- Institutions reported groundbreaking for new construction projects totalling about $4.5 billion over the 1986-89 period. About $2.0 billion was reported for projects begun in 1986-87 and $2.5 billion in 1988-89. When completed, these projects will produce over 20 million square feet of new R&D space.

- The actual construction activity in 1988-89 as reported in the 1990 survey was not as extensive as institutions had planned for

Chart 4
Total expenditures and unit costs for recent and planned capital projects: 1986-91



Source National Science Foundation, SRS

1988-89 as reported on the 1988 survey. The shortfall was greater for level of expenditures (27 percent less than planned) than for amount of space (10 percent less than planned). Approximately $1.0 billion in planned new construction for 1988-89 did not take place, mainly due to funding constraints.

- The unit cost (the average cost per square foot) of the R&D components of the construction projects actually undertaken in 1988-89 ($231/square foot) was 12 percent higher than the average unit cost of the projects initiated in 1986-87 ($207/square foot). Costs are estimated to rise an additional 35 percent for 1990-91 projects, to $311/square foot (Chart 4).

- Although high levels of construction activity occurred over the 1986-89 period, comparable increases were not seen either in the total amount of R&D space or in the proportion of top quality R&D space. This suggests that much of the new construction is used to replace obsolete or inadequate facilities rather than to increase institutions' total amounts of research space.

- Spending for new construction in 1990-91 is projected by institutions to grow by over 40 percent, to a total of almost $3.5 billion.

About 43 percent of all academic research institutions broke ground for new R&D related construction projects in 1988-89, up from 37 percent in 1986-87.[3] Construction activity was most prevalent among the largest 100 research performers, 71 percent of which initiated projects in 1988-89. New construction begun during 1988-89 will produce a total of 10.6 million NASF of new

[3] All data on construction and repair/renovation projects are based on the institutions' fiscal years in which the projects were, or will be, initiated. For simplicity, references to the periods in which construction or repair/renovation begins omit the notation "FY", it is understood that all such dates refer to the institutions' fiscal years

research space when completed.[4] This represents a 7-percent increase in research NASF when compared to projects initiated in 1986-87, but falls short of the 11.8 million NASF that had been planned as reported by institutions on the 1988 survey. Costs for the 1988-89 projects totalled $2.5 billion, considerably less than the $3.4 billion that had been projected two years earlier. Inability to obtain sufficient funding was the principal reason given by respondents for postponing or scaling back planned construction projects.

Institutions projected in the 1990 survey that they plan to spend approximately $3.5 billion on new construction projects in 1990-91. This represents a 40-percent increase in expenditures over the 1988-89 level for construction of 11.2 million NASF of new research space, the equivalent of 10 percent of existing research space.

The rising construction expenditures can be attributed to two factors: (1) the steady annual growth in the amount of research space under construction, and (2) the rapid growth in the unit cost of research space. Costs per square foot for new construction grew from $207/square foot in 1986-87 to $231/square foot in 1988-89; costs are estimated at $311/square foot for 1990-91 projects (Chart 4).[5]

Institutions have consistently reported that construction costs are driven not only by the need for more research space, but by the need for upgrading the quality of the space. Costs are driven by Federal, state, and local government safety and regulatory requirements as well as by the need for high-tech facilities. Institutions repeatedly mentioned the need to upgrade animal care facilities, toxic and hazardous waste storage and disposal facilities, and telecommunication capabilities as contributing to rising construction costs. Geographic and local differences in regulatory and safety codes--e.g., seismic safety codes--often result in regional average unit costs that are markedly higher than those seen elsewhere.

Repair/Renovation of Existing Research Facilities

- Spending for facilities repair/renovation grew from $840 million in 1986-87 to $1.04 billion in 1988-89, in contrast to institution projections that had envisioned decreased spending (Chart 4).

- The total space affected by these repairs, however, decreased somewhat, resulting in higher average unit costs for the R/R projects actually undertaken in 1988-89 than had been projected two years earlier--$91/square foot versus $80/square foot.

Expenditures for R/R activities in 1988-89 were higher than projected by institutions in the 1988 survey--$1.04 billion versus a projection of $754 million. The total space affected by these repairs increased somewhat, from 9.4 million NASF to 11.5 million NASF. This suggests that institutions may underestimate the extent to which future R/R projects are needed in response to technical, regulatory, or emergency requirements.

Similar to the 1988 survey, institutions report that plans for R/R in 1990-91 will decline by 9 percent over 1988-89 levels. Unit costs for R/R activities, however, are projected to increase substantially.

Deferred Capital Projects

- An estimated $15.6 billion would be required to address institutions' currently reported needs for additional research space and for repair/renovation of existing research space. Since institutions plan to spend a total of $3.6 billion for research-related capital projects in 1990-91, this leaves an estimated $12.0 billion backlog of needed but unfunded capital projects (Chart 5).

[4] This does not necessarily imply a direct increase in the total amount of space available for research purposes, as much of this new space will be used to replace other aging or inadequate space, or space that will be converted to other uses.

[5] It should be noted that these unit costs are presented as analytic constructs only, and are used to make descriptive comparisons. They should not be construed to represent actual unit costs for any specific construction project, but are useful in tracking broad cost trends over time. Unit costs for capital projects are highly variable, depending on the specific requirements of the particular project and on S/E field and geographic region of the country.

Chart 5
Trends in deferral of needed research facilities capital projects: 1988 to 1990

Type of capital project	Survey year 1988	1990
	(Dollars in billions)	
New construction		
Needed at time of survey	$8.1	$10.6
Planned for two years following the survey *	- $2.3	- $2.6
Deferred	$5.8	$8.0
Repair/renovation		
Needed at time of survey	$3.5	$5.0
Planned for two years following the survey	- $0.8	- $1.0
Deferred	$2.8	$4.0
Capital projects, total		
Needed at time of survey	$11.6	$15.6
Planned for two years following the survey	- $3.0	- $3.6
Deferred	$8.6	$12.0

* For those institutions that reported they need additional research space and plan new construction projects

Source: National Science Foundation, SRS

- The current $12 billion level of deferred capital projects represents a 40-percent increase over the level found in 1988 ($8.6 billion).

- As in 1988, about two-thirds of the current capital project backlog is in the area of deferred construction ($8 billion of $12 billion).

Deferred New Construction

- If all institutions were able to construct additional research space in the S/E disciplines that report an inadequate current amount of space, at the same average cost as for the construction projects that are being planned for 1990-91, the estimated total would be $10.6 billion. Of this, $2.6 billion of needed expansion is being planned for 1990-91; the rest, $8.0 billion, is being deferred into the indefinite future.

- The current level of deferred construction ($8 billion) is 38 percent above the level found in 1988 ($5.8 billion).

- The current overall level of deferred construction means that, for every dollar of planned new construction in 1990-91, $3.11 of needed construction will be deferred (up from $2.48 in 1988).

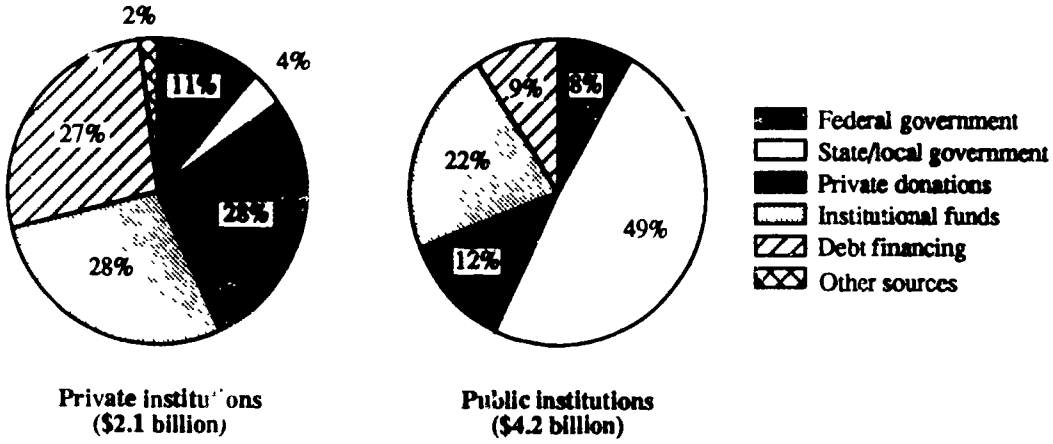
Although the numbers of institutions reporting inadequate amounts of research space did not change much from 1988 to 1990 in most S/E disciplines, actual and planned construction costs have increased significantly. Consequently, the estimated cost of addressing unmet needs for facilities expansion has also increased, and this is reflected in the deferred construction figures given above.

Deferred Repair/Renovation

Institutions have consistently expressed concern over the backlog of needed repair and renovation activities for research facilities.

- In the 1988 survey, the anticipated deferred R/R in 1988-89 (i.e., the difference between the projected total cost of all needed R/R and the anticipated cost of all planned R/R) was $2.78 billion. According to 1990 survey

Chart 6
Relative sources of funds for research facilities capital projects begun in 1986-89



Source National Science Foundation, SRS

data, the amount of deferred R/R will rise to more than $4.0 billion by the end of 1991.

- The amount of R&D space needing R/R is slightly larger in 1990 than it was in 1988. Also, the anticipated unit cost of R/R for 1990-91 is higher than it was two years ago for 1988-89 ($111/square foot versus $91/square foot).

The amount of R/R now planned for 1990-91 is lower than was planned in 1988 for 1988-89 (8.6 million NASF versus 9.4 million NASF). The result is that the estimated cost of the backlog--the R/R that will be deferred in 1990-91--has risen to $4.06 billion. Thus, if all research space needing R/R in 1990 (39 percent of existing research space) were to receive it, at the same cost per square foot as was found in institutions actually planning such projects, the cost would be $5.0 billion, roughly 5 times the amount institutions plan to spend. Therefore, it is estimated that institutions will defer about $4.25 in needed R/R for every $1.00 that will be spent.

Sources of Funds

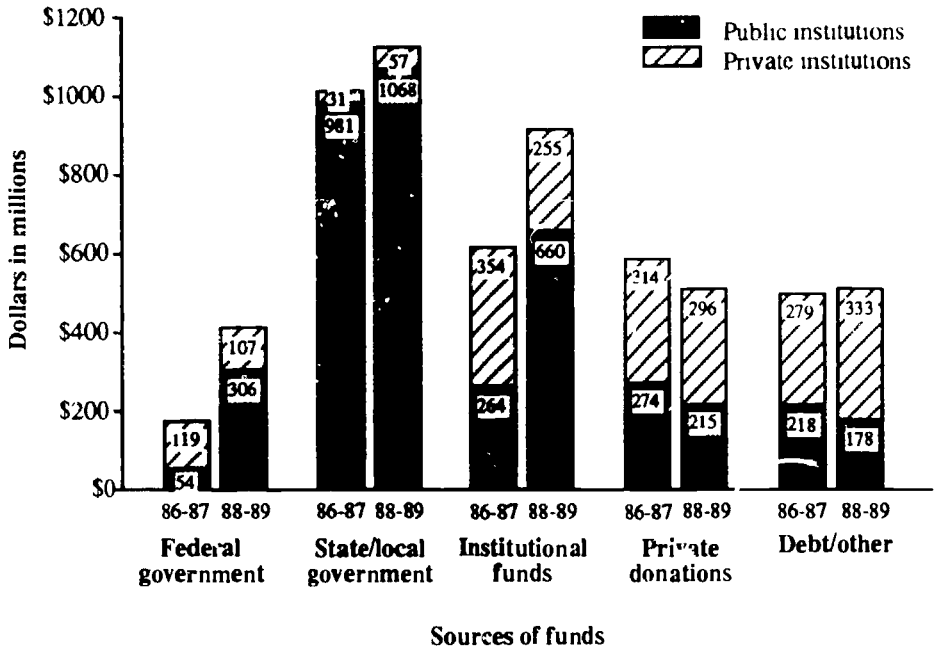
- Similar to the findings in the 1988 study, major sources of funds for new construction projects in 1988-89 came primarily from three sources: state/local governments, private donations, and debt financing. Public institutions acquired nearly half of their funding from state/local governments, while private institutions depended mainly on private donations (Chart 6).

- Both public and private institutions depended primarily upon institutional funding for R/R projects.

- The Federal government provided a comparatively small share of total direct funding for both new construction and R/R projects in 1988-89, about 14 and 6 percent, respectively.[6] Still, in absolute terms, Federal funds for new construction of research facilities more than doubled over

[6] This report includes data on the direct costs of construction and repair/renovation and the sources of funds for these direct costs. No attempt was made to quantify future indirect cost pressures resulting from current or planned projects.

Chart 7
Sources of funds for research facility capital projects begun in 1986-87 and in 1988-89 by control of institution*



* Data include expected total project costs of R&D components of new construction and repair/renovation projects begun in the specified two-year periods.

Source National Science Foundation, SRS

the 1986-89 period. The increase was seen mainly at public institutions (Chart 7).

- Private institutions' use of tax-exempt bonds and other debt financing for new construction projects doubled from $124 million in 1986-87 to $254 million in 1988-89. Much of this increase ($87 million) involved non-tax-exempt debt.

- The increasing use of taxable bonds and other debt may be related to the fact that, of the 30 private institutions that are among the 100 largest research performers in the nation, nearly two-thirds had reached the $150 million statutory limit on tax-exempt bonds in 1990.

Private institutions expended $738 million for new construction projects in 1988-89 while public institutions invested $1.7 billion. Substantially different patterns of funding support were reported.

Private institutions depended mainly on private donations (36 percent) and debt financing (34 percent) to support new construction in 1988-89. This funding pattern is consistent with findings for 1986-87 projects with two exceptions: institutional funding dropped somewhat, and the use of debt financing other than tax-exempt bonds grew from less than 1 percent in 1986-87 to 12 percent in 1988-89.

Public institutions, in contrast to private institutions, acquired almost half of all new construction funding from state/local governments. The Federal government provided the second largest portion in 1988-89, growing from a 3-percent share in 1986-87 to 16 percent. Only 9 percent of construction costs were secured from debt financing.

Expenditures for repair/renovation of research facilities for both private and public institutions totalled $1 billion in 1988-89. Both types of institutions obtained over half of their R/R funding from institutional funds. The second largest source for private schools was debt financing (24 percent), while public institutions depended more upon state/local governments (33 percent). The Federal share of costs for R/R activity, 6 percent, doubled in absolute terms over 1986-87 levels, with most of the increase going to private institutions.

Private institutions reported that they plan to float $350 million in tax-exempt bonds for new construction projects in 1990-91, more than twice

the value of bonds issued during 1988-89. For private institutions only, recent legislation has placed a $150 million limit on outstanding tax-exempt bonds. Among the 30 private institutions in the top 100, 16 had reached the cap by 1988; 19, by 1990; and another 3 expect to do so in the next two years.

Research Facilities at Historically Black Colleges and Universities

- While historically black colleges and universities (HBCUs) reported a 30-percent overall increase in the total amount of research space available in 1990, they continued to account for just over 1 percent of total research space for all academic research institutions.

- In 1988-89, HBCUs obtained about 80 percent of their research facilities construction and R/R funding from either Federal or state/local government sources, similar to levels reported for 1986-87 projects.

Historically black colleges and universities reported high levels of research facility construction activity over the 1986-89 period, resulting in a 30-percent overall increase in the total amount of research space available in 1990. The 1.4 million NASF used for research represents just over 1 percent of total NASF for all academic institutions, similar to the HBCU share of total academic R&D spending. These proportions have not changed significantly since the 1988 survey.

HBCUs obtained more than 80 percent of total research facilities funding from government sources. The Federal government accounted for 53 percent of total funding over the 1986-89 period, while state/local government sources provided 29 percent.

Facility condition ratings were generally more positive for HBCUs than were seen in most other institution categories. However, the proportion of R&D space rated as being "suitable for the most highly developed and scientifically sophisticated research" declined somewhat, from 36 percent in 1988 to 31 percent in 1990. The amount of space requiring limited or major R/R remained constant at 25 percent.

Methodology

The Survey of Scientific and Engineering Research Facilities at Universities and Colleges is conducted every two years. The first full-scale baseline study was conducted in 1988 and a report was submitted to Congress in September of that year. The 1990 study was conducted during the fall and winter of 1989-90 with a report due to Congress in September 1990.

Prior to the 1988 survey, NSF developed the research facilities survey questionnaire in cooperation with several higher education associations, university representatives, and an expert advisory panel. The survey universe includes doctorate- and non-doctorate-granting institutions as well as historically black colleges and universities (HBCUs) that perform research in science and engineering.

The 1990 survey collected quantitative as well as qualitative data for individual science and engineering fields. This provided a detailed picture of the amount and condition of available research space, recent and planned repair/renovation and construction activities, and sources of funds for these capital projects for the years 1988 through 1991. There was little difference between the 1988 and 1990 survey questionnaires. Additional detail was added to the "sources of funds" questions to gather needed information of specific private sources. Also, the data for main institutions and associated medical schools, which were collected on separate questionnaires in 1988, were combined into one questionnaire for the 1990 survey.

The data in this report were obtained from a stratified probability sample of 253 universities and colleges in a universe of 525 institutions. The universe datafile included all universities and colleges that offered a master's or doctoral degree in the sciences and/or engineering, all others that had separately budgeted S/E research and development (R&D) expenditures of $50,000 or more, and all historically black colleges and universities (HBCUs) reporting any R&D expenditures. Within strata, institutions were sampled with probability proportionate to the size, based on R&D expenditures in science and engineering. The institution sample for the 1990 survey was essentially the same as for the 1988 study. All of the schools ranked in the top 50 and 98 of the top 100 were sampled. The 253

institutions in the sample accounted for more than 75 percent of total academic R&D expenditures and at least 70 percent of spending in each S/E discipline. The 1990 study included the same 29 HBCUs that were surveyed in the 1988 study.

Findings from the 1990 study are statistically weighted to provide national estimates for all schools that perform R&D activities. The response rate was 94 percent for all universities and colleges. The overall item nonresponse rate was less than 1 percent.

1. INTRODUCTION

Background

Academic research facilities in science and engineering are an important national resource. Extensive hearings were held during the 99th Congress in both the House and Senate committees on science and technology to examine the research facilities needs of universities and colleges. Both committees found "sufficient evidence to suggest the presence of a serious and growing problem..." and expressed concern that the Federal government did not have in place an ongoing analytical system to document the current status of and needs for research facilities by major field of science and engineering. Such systematic information was needed to understand current and future facilities pressures and to formulate sound solutions over time.

Higher education officials have also expressed growing concern about the increasing backlog of deferred repair and renovation projects, driven to a large extent by the need to upgrade the quality of their facilities to meet new technical and health and safety requirements. Additional concerns have been raised regarding the sources of financing of facilities. For example, the limitation on tax-exempt bonds that private institutions may have outstanding and the decreasing tax advantages of private gifts may impact on institutions' abilities to secure funding for necessary repair/renovation or construction activities.

In recognition of the need for objective information in the area of research facilities, Congress directed the National Science Foundation (NSF), in the Authorization Act of November 22, 1985 (P.L. 99-159, section 108):

> ...to design, establish, and maintain a data collection and analysis capability... for the purpose of identifying and assessing the research facilities needs of universities and colleges....The Foundation, in conjunction with other appropriate Federal agencies, shall conduct the necessary surveys every 2 years and report the results to the Congress.

Three surveys have now been conducted and the results reported to the Congress. It was expected by Congress that this continuous assessment would provide baseline data necessary to formulate appropriate solutions to documented needs, as well as trend data necessary to evaluate outcomes of approaches that might be implemented. To this end, the information from these surveys serves the need of the NSF's Research Facilities Office (RFO) for data on the quantity and quality of academic research space, facilities-related expenditures and the sources of funding for capital projects. The RFO was established in December 1988, after Congress authorized the Academic Research Facilities Modernization Program (NSF Authorization Act of 1988, 102 Stat. 2873, 42 U.S.C. 1862a-1862d) to assist in modernizing and revitalizing the nation's research facilities at institutions of higher education (see NSF 89-127).

The survey data on new and deferred construction, new and deferred repair/ renovation, and the condition and adequacy of existing research facilities are based on both quantitative and qualitative assessments provided by academic research institutions. Although some of these data are by their very nature subjective, they do capture an overall picture of the current status of facilities. However, this report does not, nor was it intended to, assess the impact of facilities on the quality of research being conducted at academic institutions.

The 1986 NSF Academic Research Facilities Survey

The first report to Congress in response to the mandate was September 1, 1986. In order to meet the schedule, NSF used an existing "quick response" survey mechanism, the Higher Education Surveys (HES) system, to collect data during the spring of 1986. These surveys collected quantitative data on the amount of R&D space and facilities-related expenditures and qualitative information on university officials' assessment of their research facilities needs and problems. The surveys were restricted to a limited set of doctorate-granting institutions and did not collect quantitative data by individual science/engineering field. The resulting report was submitted to Congress in October 1986.

The 1988 NSF Academic Research Facilities Survey

While the 1986 NSF "quick response" survey was being conducted, the Foundation began the development of an expanded survey to be conducted in 1988, and every two years thereafter. The National Institutes of Health (NIH) joined NSF in sponsoring the expanded survey. Development of the survey benefited from the assistance of higher education

associations, university representatives, and an expert advisory panel representing five research universities. A group of higher education associations sponsored a workshop in the spring of 1987 for the purpose of advising NSF and NIH on the content of the survey questionnaire. During the summer of 1987, NSF, NIH, and contractor staff conducted site visits at 22 colleges and universities to discuss data collection issues, definitions, and questionnaire items. The findings were presented in another association-sponsored workshop in the early fall, where general agreement was reached about the details of the survey design and questionnaire.

The sample for the 1988 survey represented a universe of approximately 525 institutions, which included all those that awarded doctoral or master's degrees in the sciences or engineering, all others that had separately budgeted research expenditures of $50,000 or more, and all historically black colleges and universities (HBCUs) with any research expenditures. A sample of 247 institutions was selected with probability proportional to size, as measured by total science and engineering R&D expenditures.[1] The sample included all of the 50 largest research universities, and 98 of the top 100, based on total R&D expenditures. In order to provide reliable estimates for HBCUs, all 29 of those that had reported any separately budgeted research expenditures were included in the sample.

The survey questionnaire collected data on research square footage and capital projects for construction or for repair/renovation of research facilities by major science and engineering discipline. Capital projects data were collected separately for each of the institution's previous two fiscal years (1986 and 1987) and for work planned for FY 1988 and 1989. Finally, items concerning the condition and adequacy of research facilities were also included in the survey.

The survey was conducted by mail during the fall and winter of the 1987-88 academic year, with extensive telephone followup to maximize the response rate. The final response rate to the survey was 90 percent, overall, with little variation by type or control of institution.[2]

The 1990 NSF Academic Research Facilities Survey

The current survey was conducted two years after the 1988 survey and closely replicates the earlier study in order to maximize the comparability of the findings. Except for very minor expansions of the institution sample (to better represent current patterns of R&D activity) and questionnaire (to obtain more differentiated information about private sources of funds for capital projects), the design and questionnaire for the 1990 study were essentially the same as in the previous survey. To assist institutions in identifying and reporting facilities-related changes since the previous study, institutions were given computer-generated facsimiles of their responses to the 1988 survey.

As with the previous study, the 1990 survey was conducted by mail, with telephone followup for nonresponse. The processing of returned questionnaires entailed extensive computer checking for logical inconsistencies within the 1990 questionnaire and between the 1988 and 1990 questionnaires. Respondents were contacted by telephone to resolve any such inconsistencies that were discovered.[3]

The 1990 survey had an overall response rate of 94 percent, and response rates of over 90 percent were obtained in all institution type categories.

Following the completion of data collection, additional site visits were conducted to discuss the findings with responding institutions and obtain insights that would assist in the analysis and interpretation of the data. (See **Appendix A, Technical Notes**, for additional detail on the study methodology.)

Presentation of the Data and Organization of the Report

The 1988 and 1990 Surveys of Scientific and Engineering Research Facilities provide the most

[1] The universe file from which the sample was drawn was the 1983 survey of R&D expenditures, which represented the most recent universe survey of R&D spending at universities and colleges

[2] For additional information about the methodology and findings of the 1988 survey, see Scientific and Engineering Research Facilities at Universities and Colleges: 1988, National Science Foundation, NSF 88-320, September 1988.

[3] Some revisions were made to prior-year data as a result of these inquiries. Consequently, to obtain accurate historical data, only the latest statistical tables should be used, not those published earlier.

comprehensive national database available on the status of these facilities. This report uses the data from these surveys to describe current facilities status and to identify changes over the time periods represented in the two studies.[4]

All of the findings discussed in this analysis are derived from a larger and more detailed series of statistical tabulations, which are presented in Appendix D. Although most of the results mentioned in the text of this report are shown in association with text tables or graphics based on data from Appendix D, occasional references are also made directly to Appendix D tables.

The first three findings chapters provide quantitative information. Chapter 2 concerns trends in the overall amount of research space available in science and engineering disciplines at the nation's research-performing academic institutions. Differences between institutional types and between science/engineering disciplines are described. Chapter 3 discusses the costs and square footage associated with repair/renovation and new construction of research facilities for projects initiated in 1986-89 and for projects planned to begin in 1990 or 1991. The sources of funds for these projects are discussed in Chapter 4, with particular emphasis on the differences between public and private institutions. The status of private institutions relative to the limitation on outstanding tax-exempt bonds is also discussed in Chapter 4.

Chapter 5 presents the qualitative information collected in the survey, including institution assessments of the condition of their research facilities, the adequacy of the amount of research space available, and the adequacy of selected infrastructure aspects of facilities. The findings concerning facilities condition are compared to repair/renovation information provided in Chapter 3 to assess trends in the amount of *deferred* repair/renovation.

Finally, Chapter 6 provides a summary of findings for historically black colleges and universities.

Appended to this report are technical notes presenting additional information about the design and methodology of the 1988 and 1990 studies (Appendix A); a list of sampled institutions (Appendix B); the survey questionnaire (Appendix C); and detailed statistical tables (Appendix D).

[4] A companion to this NSF report is being prepared by the National Institutes of Health to provide additional information about biomedical research facilities in medical schools, in other academic settings, in hospitals, and in private, nonprofit research organizations. Findings from the 1988 survey for these groups are presented in The Status of Biomedical Research Facilities, 1988, National Institutes of Health, January 1989

2. CURRENT AMOUNT OF RESEARCH SPACE

Highlights

- A total of 116.3 million net assignable square feet (NASF) of science/engineering (S/E) research space was reported in use in American universities and colleges in 1990; there was no statistically significant change from 1988 to 1990 in the overall amount of academic S/E research space.
- Likewise, from 1988 to 1990 there were no statistically significant changes in the distribution of research space among institutions and disciplines.
- Seventy percent of all academic S/E research space is concentrated in the 100 largest research-performing institutions, which have an average of over 800,000 square feet of research space per institution.
- Other doctorate-granting institutions (those not in the top 100) account for 25 percent of the nation's R&D space and have a mean of about 150,000 square feet of research space per institution. Non-doctorate-granting institutions contain less than 5 percent of all academic research space, and average about 20,000 square feet of research space per institution.
- Among the 100 top R&D performers, half of all space assigned to S/E disciplines is allocated to sponsored research, while other doctorate-granting institutions allocate 37 percent for such research, and non-doctorate-granting institutions allocate 16 percent.
- Three-fourths (75 percent) of all academic research space (86.9 million NASF) is located in public institutions; private institutions contain 29.4 million NASF.
- Over 85 percent of all S/E research space is concentrated in five disciplines: the biological (22 percent), agricultural (18 percent), and medical (17 percent) sciences; engineering (15 percent); and physical sciences (14 percent).

Distribution of Research Space Among Institutions

The 525 research-performing universities and colleges represented in this study contain an estimated 276 million NASF of space in science and engineering disciplines in 1990, 42 percent (116 million square feet) of which is allocated to separately budgeted organized research.[5] Neither the total amount of S/E space nor the amount assigned to organized research is significantly different from the amount reported in 1988 (Figure 1).

Seventy percent of all 1990 R&D space (81.7 million NASF) is housed in the 100 largest research-performing institutions, as defined by 1988 total S/E research expenditures.[6] This group, on average, allocates half of its science/engineering space to organized research (Table 1).

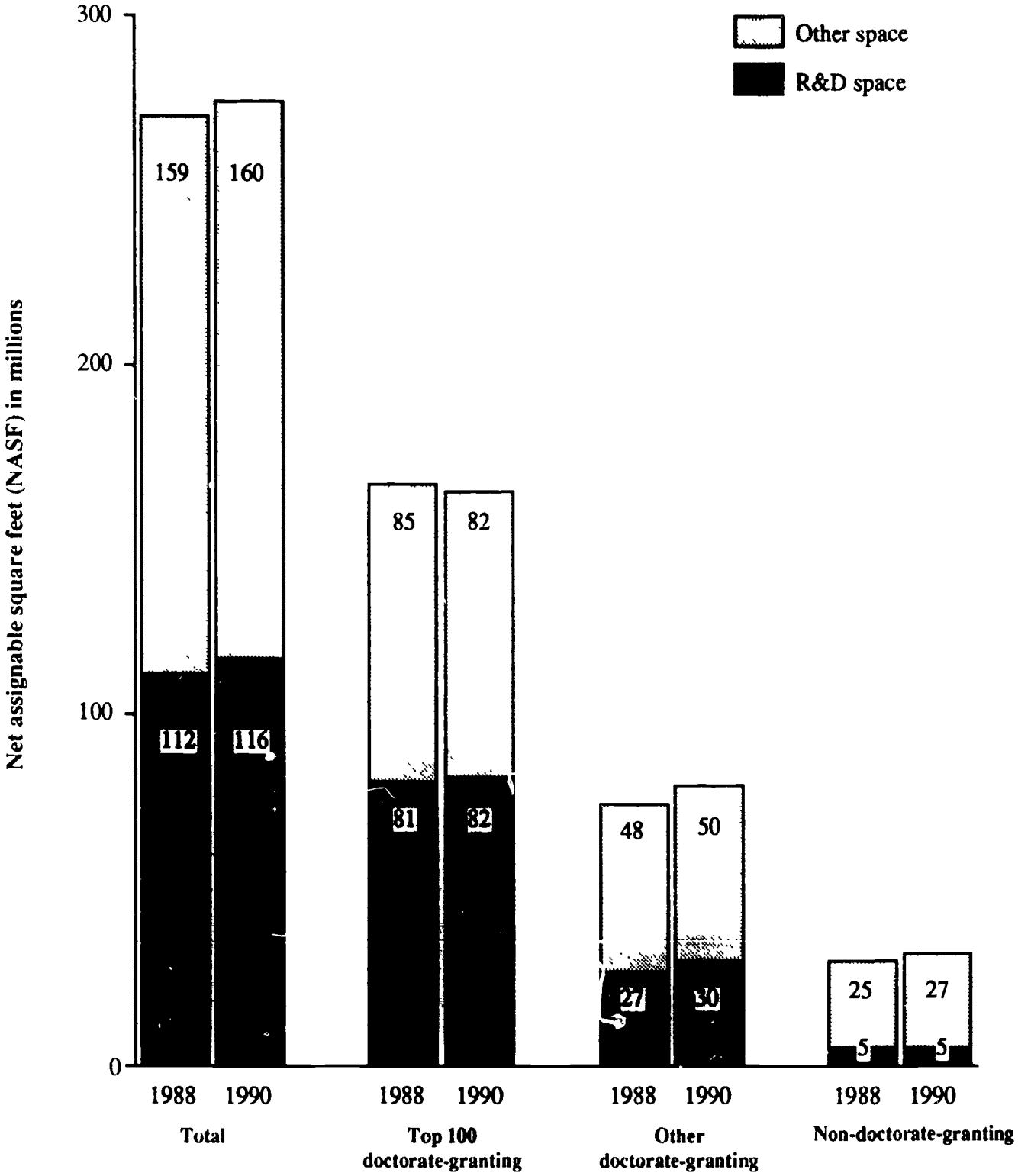
Doctorate-granting institutions that are not in the top 100 contain 30 million NASF of S/E research space, representing 25 percent of all academic research space in universities and colleges. Institutions in this category allocate just over one-third (37 percent) of their total S/E space to organized research, a somewhat lower proportion than for the top 100. Non-doctorate-granting institutions allocate an even lower 16 percent of their S/E space to organized research, and they account for a total of 5 percent of all academic research space.

Particularly for non-doctorate-granting institutions, these figures should be considered conservative estimates of the actual amount of research space in use today. Many respondents at small, predominantly undergraduate institutions have indicated that organized research, as defined by OMB, understates the extent of research activity at

[5] The terms "separately budgeted" and "organized research" are defined in OMB circular A-21, which is used by larger institutions to calculate indirect cost recovery rates for Federally funded activities. This definition appears in the technical notes, Appendix A.

[6] The "100 largest R&D performers" was selected as an analytical grouping because those institutions collectively represent significant proportions of all academic R&D expenditures (83 percent). They are also referred to as the "Top 100 in R&D" throughout this report.

Figure 1
Distribution of space assigned to science/engineering disciplines by institution type: 1988 and 1990



Reference: Appendix Tables 2-5 and 2-6
Source: National Science Foundation, SRS

Table 1 Number of institutions and amount of R&D space by institution type and control: 1988 and 1990

Institution type and control	Number of institutions		Amount of R&D space					
			Total (square feet in millions)		Mean per institution (in thousands)		As a percent of total S/E space	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	525	525	112 1	116 3	213	222	41	42
Doctorate-granting	293	293	107 4	111.2	367	380	45	46
Top 100 in R&D	100	100	80 6	81.7	806	817	49	50
Other	193	193	26 8	29.5	139	153	36	37
Non-doctorate-granting	232	232	4 6	5.2	20	22	15	16
Public	320	319	82 4	86 9	258	272	40	41
Doctorate-granting	191	190	79 3	83 6	415	440	43	44
In top 100 in R&D	70	70	59 3	61.3	847	876	46	48
Other	121	120	20	22.3	165	186	36	37
Non-doctorate-granting	129	129	3 1	3 3	24	26	15	14
Private	205	206	29 7	29 4	145	143	45	46
Doctorate-granting	102	103	28 2	27.6	276	268	49	50
In top 100 in R&D	30	30	21 3	20.4	710	680	57	58
Other	73	73	6 9	7 2	95	99	35	36
Non-doctorate-granting	103	103	1 5	1 8	15	17	16	19

Note: Details may not sum to totals because of rounding

Reference: Appendix Table 2-1

Source: National Science Foundation, SRS

their institutions, since it does not include undergraduate research or department-funded faculty research, especially research that is conducted in multipurpose offices and laboratories that are not assigned exclusively for research use.[7] Consequently, small institutions that reported to the study using the A-21 definition may have understated their research space by a considerable amount. On the other hand, many of the smaller research providers are not required to maintain records based on A-21 definitions, and several are known to have reported the total amount of space they use for research, including multi-use "departmental research" space. It should also be noted that, even if non-doctorate-granting institutions excluded as much as half of their total research space in order to comply with the study definitions (which seems highly unlikely), institutions in this category would still collectively account for less than 10 percent of all academic research space.

Public institutions, which make up 60 percent of the population of research-performing institutions, tend to be somewhat larger than the private institutions in this population: they house three-quarters of all academic S/E research space. The average amount of research space in public institutions is larger than that at private institutions, overall (272,000 NASF versus 143 000 NASF) and in each of the three institution type categories (Table 1). As a group, though, private institutions allocate a greater share of their S/E space to research (46 percent) than do their public counterparts (41 percent).

These 1990 findings concerning the amounts and distributions of total S/E space and of S/E research space, by type and control of institution, are entirely consistent with those from the 1988 survey. Thus, although estimates from the two surveys are not always exactly the same, none of the differences are statistically significant.

[7] The same problem would also exist at the larger research institutions, but respondents from several such institutions have estimated that the A-21 definition encompasses most of their research space, on the order of 90 percent or more.

Table 2 Percent of institutions with any assigned R&D space in science/engineering disciplines by discipline and institution type: 1988 and 1990

Discipline	Percent of institutions with any R&D space in the discipline		Amount of R&D space			
			Total (square feet (in millions)		As a percent of total S/E space in the discipline	
	1988	1990	1988	1990	1988	1990
Total	--	--	112	116	41	42
Engineering ..	54	56	16	17	40	43
Physical sciences	85	86	16	16	45	43
Environmental sciences	57	54	6	6	51	50
Mathematics. . .	61	56	1	1	15	15
Computer science	63	54	1	1	29	31
Agricultural sciences	18	18	18	21	59	61
Biological sciences	91	92	24	26	53	53
Medical sciences	51	51	19	20	29	31
Psychology	77	77	3	3	34	33
Social sciences	69	66	3	3	20	22
Other sciences, n e c	18	13	4	2	72	51

Reference Appendix Table 2-3

Source National Science Foundation, SRS

R&D Space by Discipline

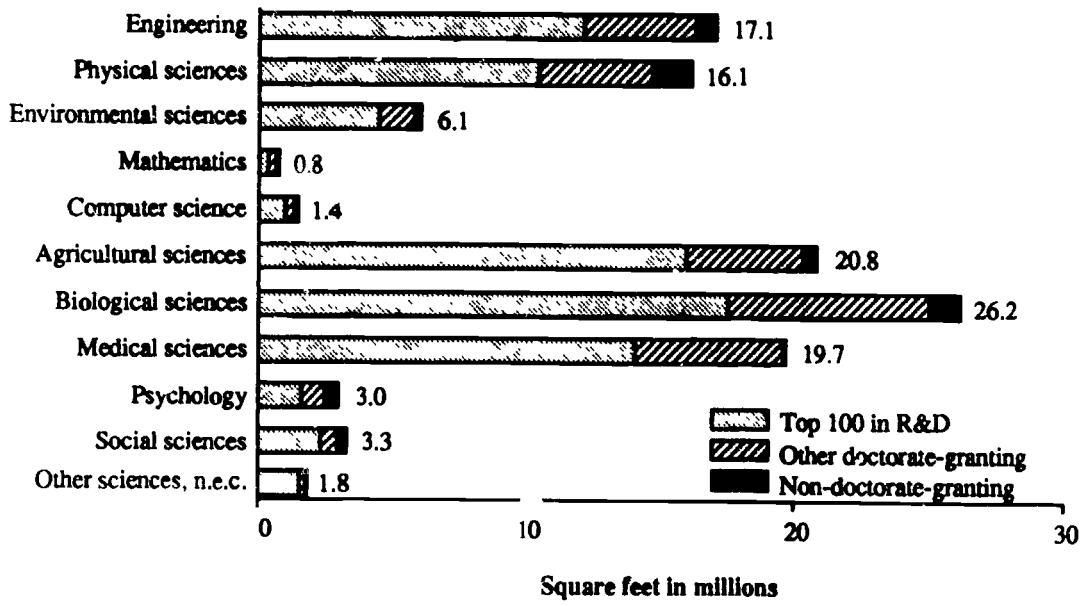
Few academic institutions conduct organized research in every science/engineering discipline. Most widespread are the biological sciences, which are represented at 92 percent of all institutions (Table 2). This is followed by the physical sciences (found at 86 percent of all institutions) psychology (77 percent), and the social sciences (66 percent). Engineering, mathematics, computer science, and environmental and medical sciences each occupy research space at about half of all institutions. Agricultural sciences research is limited to less than 20 percent of all institutions, almost all of which are public (Appendix Table 2-4). In addition, 13 percent of the institutions reported research space under the category "other sciences, not elsewhere classified (n.e.c.)." This category was used for non-departmental and interdisciplinary facilities that could not be readily allocated to one or more specific disciplines.

Disciplines that are the most widely represented across institutions do not necessarily have the largest amount of research space. The four smallest disciplines in terms of total research space (mathematics, computer science, psychology, and the social sciences) are all widely represented.

The majority of the academic research space is concentrated in the biological (22 percent), agricultural (18 percent), and medical sciences (17 percent), followed closely by engineering (15 percent) and physical sciences (14 percent) (Figure 2). Together, these five disciplines account for 86 percent of all research space in use at American universities and colleges. These patterns have remained stable over time, with only minor variations in this allocation of space between 1988 and 1990.

The ratio of research space to total space also varies by discipline. Thus, over 60 percent of all space assigned to the agricultural sciences is used for research (Table 2). Similarly, over half of all academic space in the biological and environmental sciences is used for R&D, as is 51 percent of the space designated as "other sciences." Again, there is little change in this profile from the results of the 1988 survey.

Figure 2
Distribution of S/E research facilities by discipline and institution type: 1990



Reference. Appendix Table 2-6
Source National Science Foundation, SRS

Table 3 Distribution of R&D space by discipline and institution type 1988 and 1990

Discipline	Total		Doctorate-granting				Non-doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
	(Percent of research space)							
Total	100	100	100	100	100	100	100	100
Engineering	14	15	14	15	15	14	11	14
Physical sciences	14	14	13	13	16	14	29	28
Environmental sciences	6	5	6	6	5	4	5	4
Mathematics ...	1	1	0	1	1	1	1	1
Computer sciences	1	1	1	1	2	1	4	2
Agricultural sciences	16	18	18	20	11	14	8	11
Biological sciences	21	22	21	21	23	25	22	22
Medical sciences.	17	17	16	17	17	19	2	2
Psychology ...	3	3	2	2	3	3	9	8
Social sciences ..	3	3	3	3	2	2	7	6
Other sciences, n e c	4	2	4	2	5	1	2	2

Note: Details may not sum to totals because of rounding
Reference: Appendix Table 2-6
Source National Science Foundation, SRS

The allocation of research space among disciplines was essentially the same in 1990 as it was in 1988, and the allocation was also generally similar across the different types of institutions (Table 3). There are some noteworthy differences between doctorate-granting and non-doctorate-granting institutions, however. Thus, non-doctorate-granting institutions allocate larger shares of their research space to the physical sciences, psychology, and the social sciences than do doctorate-granting institutions. The reverse is true for agricultural and medical sciences, which are considerably more prominent at doctorate-granting institutions than at non-doctorate-granting institutions.

Leased and Temporary Space

Trends in institutions' use of leased and/or temporary research space might be an indication of short-term fluctuations in need for expanded research facilities. In the 1988-90 period, little change was observed in this indicator. Only 3 percent of all S/E R&D space at universities and colleges is in leased rather than institution-owned facilities (Table 4).

Table 4 Percentage of academic research space that is leased or housed in temporary facilities 1988 and 1990

Institution type and control	Leased space		Temporary space	
	1988	1990	1988	1990
	(Percent of total R&D NASF)			
Total	3 4	3 1	1 8	1 5
Doctorate-granting	3 5	3 2	1 8	1 5
Top 100 in R&D	3 5	3 2	1 9	1 7
Other	3 4	3 2	1 3	1 0
Non-doctorate-granting	0 2	0 3	1 2	0 7
Public	2 8	2 5	2 1	1 7
Private	4 9	4 8	1 0	0 9

Reference Appendix Table 2-8

Source National Science Foundation, SRS

Doctorate-granting institutions use leased research space relatively more often than non-doctorate-granting institutions (3.2 percent versus 0.3 percent), and private institutions have relatively more leased space than public institutions (4.8 percent versus 2.5 percent).

Temporary space, such as trailers and quonset huts, is used for less than 2 percent of all R&D space. Again, doctorate-granting institutions use temporary facilities for a greater share of their R&D space needs (1.5 percent) than do non-doctorate-granting institutions (0.7 percent), and public institutions rely more on temporary quarters (1.7 percent) somewhat more than do private institutions (0.9 percent).

3. NEW CONSTRUCTION AND REPAIR/RENOVATION OF RESEARCH FACILITIES

Highlights

New Construction

- A great deal of new construction activity has been undertaken in recent years, with institutions breaking ground for over $2 billion in R&D-related new construction in 1986-87 and over $2.5 billion in 1988-89. When completed, these projects will produce over 20 million net assignable square feet of new R&D space.

- In spite of this substantial level of new construction, there was little or no net increase in research space from 1988 to 1990, suggesting that much of the new construction is replacing outdated or inadequate space rather than enlarging the total amount of research space.

- Construction unit costs (the cost per square foot of research space created) increased at an average annual rate of 12.5 percent from 1986-87 to 1990-91, well above the level of inflation over this period. Apparently, growing technological and regulatory requirements are becoming major factors driving construction costs for academic research facilities.

- There was an increase in construction activity from 1986-87 to 1988-89, but it was not nearly as great as that which had been planned at the start of the 1988-89 period, as reported in the prior survey. Approximately $1 billion in new construction planned for 1988-89 was abandoned or delayed, often due to funding shortfalls.

- There was some evidence that high-tech, high-unit-cost projects and project components were especially vulnerable to deferral.

- Facilities planners anticipate substantial construction activity in 1990 and 1991. Almost $3.5 billion in new construction projects are planned to begin during the coming two years, roughly the same amount as had been projected for the two years following the prior survey (1988-89).

- In comparison to the 1988 survey, construction starts are down among engineering departments (from 28 percent of the relevant institutions in 1986-87 to 18 percent in 1988-89), and up among biological sciences programs (from 12 percent in 1986-87 to 22 percent in 1988-89).

Repair/Renovation

- Expenditures for facilities repair and renovation increased from $840 million in 1986-87 to $1.04 billion in 1988-89, in contrast to projections that had envisioned decreased spending. The total space affected by these repairs, however, decreased somewhat, resulting in much higher average unit costs than had been anticipated.

- As also happened in the 1988 survey, institutions now project less repair/renovation activity for the upcoming two-year period than occurred in the past two years.

Introduction

Institutions were asked to report all new construction project starts and major repair/renovation projects begun during the two-year period 1988-89 and planned for the years 1990-91. Project start was defined as the year in which they actually broke ground for new construction. The 1988 survey had asked about projects started during 1986-87 and planned for 1988-89, providing four sets of data spanning a six-year window of actual and planned construction and repair/renovation activities.

The survey was limited to major projects, which were defined as those with R&D-related costs of $100,000 or more. All cost figures are total project costs (defined as cost to complete), including planning, construction, and fixed equipment. In the case of multiyear projects, total project costs were allocated to the year in which the project actually began. Multipurpose projects that served both research and non-research purposes were prorated to reflect only the R&D-related portion of the cost.

This chapter describes new construction and repair/renovation projects started during the period 1986-89, and planned for 1990-91. The chapter

begins with a discussion of new construction projects, net assignable square footage affected, and project costs. Repair and renovation projects are then discussed in the latter half of the chapter. Deferred capital projects are discussed in Chapter 5.

Construction of New R&D Space, 1986-91

Extent of Construction Activity

Over 40 percent (43 percent) of all academic institutions broke ground for new R&D-related construction projects during 1988 and 1989, up somewhat from 37 percent during the prior two-year period (Table 5). This overall prevalence of facilities construction in 1988-89, as reported retrospectively in 1990, was the same as the institutions had projected for this period in the 1988 survey, although the particular institutions involved in actual construction projects were not always the same ones that had planned projects for this period. The number of institutions planning any R&D facilities construction for 1990-91 is slightly lower (35 percent overall) than for the previous years.

Actual construction activity in 1988-89 was most prevalent among the 100 largest R&D performers (71 percent), lower among other doctorate-granting institutions (43 percent), and least prevalent among non-doctorate-granting institutions (31 percent). These differences are generally consistent with the relative amounts of research activity (e.g., aggregate R&D expenditures) at institutions in these three categories, and the differences are also consistent across time periods, for both actual and planned construction. The differences are especially pronounced for 1990-91 planned construction, during which time 82 of the top 100 institutions in R&D expenditures plan new construction starts, as compared to only 9 percent of those in the non-doctorate-granting group.

New construction starts in 1988-89 were more common among public institutions (50 percent) than among private institutions (33 percent), as was also the case in the 1986-87 period (44 percent versus 25 percent). Nonetheless, both public and private institutions reported increased construction activity over 1986-87.

Table 5 Percent of institutions starting any projects to construct new science/engineering R&D space by institution type and control and year of project start: 1986-91*

Institution type and control	Year of construction project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	37	43	43	35
Doctorate-granting	46	61	53	55
Top 100 in R&D	72	79	71	82
Other	33	51	43	41
Non-doctorate-granting	25	21	31	9
Public	44	56	50	44
Doctorate-granting	54	70	56	64
In top 100 in R&D	79	86	74	86
Other	40	60	45	50
Non-doctorate-granting	29	36	40	14
Private	25	23	33	21
Doctorate-granting	31	44	47	39
In top 100 in R&D	57	67	63	73
Other	21	36	40	25
Non-doctorate-granting	18	2	20	4

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space.

Reference Appendix Table 3-1

Source National Science Foundation, SRS

Consistently over the three two-year periods encompassed in this study, the largest S/E disciplines in terms of existing amounts of research space also tended to be the ones with the most widespread new construction. Thus, 34 percent of all institutions with research space in the agricultural sciences reported new construction starts in 1988-89, consistent with the findings of the prior survey (Table 6). Construction activity was also relatively prevalent among the biological (22 percent) and medical sciences (18 percent), as well as in engineering (18 percent) and in interdisciplinary programs that could not be classified into any of the other disciplines (19 percent). Very few institutions reported any new construction starts in mathematics, psychology, or the environmental, social or computer sciences. Fewer

than 10 percent of the institutions with research space in these disciplines reported new construction starts for these areas.

Table 6 Percent of institutions with any recent or planned projects to construct new R&D space by discipline. 1986-91*

Discipline	Year of construction project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	37	44	44	35
Engineering	28	20	18	20
Physical sciences	9	15	15	11
Environmental sciences	9	11	6	8
Mathematics	1	3	2	3
Computer sciences	8	7	7	6
Agricultural sciences	38	38	34	33
Biological sciences	12	23	22	16
Medical sciences	20	29	18	26
Psychology	5	2	3	2
Social sciences	5	4	4	3
Other sciences, n e c	15	16	19	4

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space The base of the percentage is the estimated number of institutions with any R&D space in the discipline in 1988

Reference Appendix Table 3-3

Source National Science Foundation, SRS

In comparison to the 1986-87 period as reported in the 1988 survey, actual construction starts in 1988-89 were down among engineering departments (from 28 percent of the relevant institutions in 1986-87 to 18 percent in 1988-89), and up among biological sciences programs (from 12 percent in 1986-87 to 22 percent in 1988-89). Both of these trends appear to be consistent with projections that had been reported in the 1988 survey.

Overall Trends in Amounts and Costs of New Construction

New construction begun during 1988-89 will produce an estimated total of 10.6 million net assignable square feet (NASF) of new research space when completed (Figure 3).[8] This is a 7-percent increase over the 9.9 million NASF in new construction started in 1986-87. However, it is 1.2 million square feet *less* than had been planned in early 1988.

A similar pattern is seen when construction activity is measured in dollar terms. The research components of construction projects for which ground was broken in 1988-89 are estimated to have a total cost at completion of $2.5 billion, which is up slightly from the comparable figure for projects begun in 1986-87 ($2.1 billion). However, it is nearly a billion dollars *below* institutions' planned committments for 1988-89, as reported in the 1988 survey ($3.4 billion).

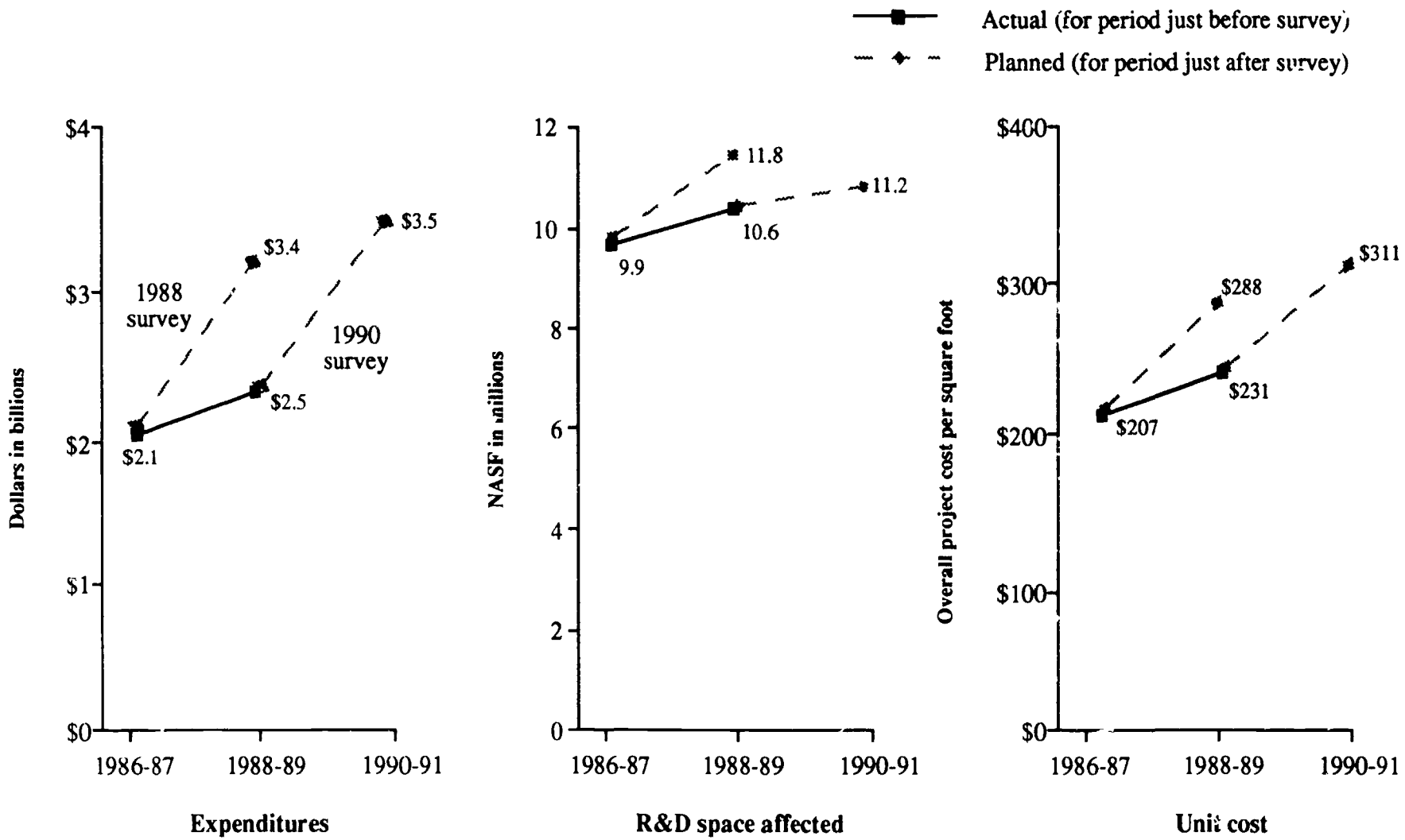
These findings indicate that, while there was a slight increase in facilities construction activity from 1986-87 to 1988-89, there was also a substantial amount of eleventh-hour downscaling or abandonment of construction work that had not only been identified as needed, but had been planned, reviewed, approved, budgeted, and actually scheduled for groundbreaking.

For most affected institutions, this cutback in construction involved a reduction in the scale of the projects undertaken in 1988-89 rather than a complete postponement of construction activity during this period (i.e., most institutions that planned 1988-89 construction projects in a given discipline actually did break ground for new construction, but the projects were often scaled back significantly from what had been planned). Asked the reasons their projects did not materialize as planned, several institutions cited difficulties in fundraising as being the main problem.

From the data provided, institutions apparently hope to have greater success in raising funds for 1990 and 1991 facilities construction projects than they did in the previous two-year period: the estimated total cost of construction projects planned to begin in 1990-91 is $3.5 billion. If realized, these plans would require a 40 percent ($1 billion) increase over the $2.5 billion spending level reported for 1988-89.

[8] This does not necessarily imply that there will be a corresponding increase in the total amount of space available for research purposes, as much of this new space will be used to replace other aging or outdated space, or space that will be converted to other uses. Indeed, as noted in Chapter 2, the total stock of research space has not increased substantially in the two years since the previous study, even though a great deal of construction activity has taken place.

Figure 3
R&D - related total cost, net assignable square footage, and cost per square foot of actual and planned new construction projects: 1986-1991*



* Findings are limited to projects with R&D - related cost of $100,000 or more.
Reference: Appendix Table 3-2
Source: National Science Foundation, SRS

The study did not collect cost-per-square foot data, as such. However, it is possible to obtain a rough estimate of the overall average unit cost of new construction simply by dividing the aggregate total cost for all projects by the aggregate amount of research space to be produced. As shown in Figure 3, these average unit costs have increased from $207/NASF in 1986-87 to $231/NASF in 1988-89, and they are anticipated to increase further to $311/NASF in 1990-91. This constitutes a 50-percent increase in construction costs over this 4-year period.

Such unit cost increases, which are well above the level of inflation over this period, are apparently being driven by other factors. By far, the two major factors most often cited by respondents in explaining the growing costs of new construction were the concurrent demands of providing state-of-the-art scientific research facilities (which entail ever-growing power, air handling, data communications, and other requirements), along with the increasing burden of conforming to state and Federal health and safety requirements. Indeed, some respondents hypothesized that these two "add-on" factors account for a greater portion of the total costs of research facilities construction than does the basic bricks and mortar itself. Typical respondent comments in relation to this issue include the following:

- *Simply put: meeting regulations costs money, lots of money. This includes both bringing existing facilities up to current requirements and meeting standards in new construction. (Public, doctorate-granting institution)*

- *Major factors in recent years have been safety and health regulations, including and principally asbestos removal and containment, but also improving air quality in chemical labs. Any changes in national, state or local standards have an immediate effect on the campus because of the highly sophisticated research done here. Project costs have certainly increased as a result of regulatory changes... (Public, doctorate-granting institutions)*

- *The costs driven by regulatory changes are major in nature and particularly critical because they are often beyond the planning and budgeting capacity of the University. We strongly support health and safety and regulatory reform but the fiscal impact of such mandated programs overwhelms the research budget. Costs associated with these changes impact not only research budgets of the University but the overall institutional budget and consequently have a direct effect on the instructional mission of the University as well. (Public, doctorate-granting institution)*

Among the most costly projects reported by institutions are bio-hazard and toxic materials control facilities, clean rooms, and animal quarters that conform to the new Federal standards. Such facilities require costly environmental and air circulation control, plumbing, waste storage and removal, and other features that are subject to strict regulatory controls. Typical respondent comments in relation to this issue include the following:

- *Changes in legislation regulating the care of animals and the handling/disposal of hazardous materials will be a major expense for the medical center in the near future. We anticipate legislation significantly improving the quality of life to be provided animals used in medical research that will require substantial modifications to the existing facility. Both the increase in the amount of space required for each animal...and the quality of the space...will be expensive to provide. (Private, doctorate-granting institution)*

- *Animal care and accreditation requirements have caused substantial costs which might otherwise not be required in the absence of the regulations. Approximately $2 million is designated for remodeling of animal care facilities. (Public, doctorate-granting institution)*

- *(Private, doctorate-granting institution) is incurring major expenses for chemical waste and radioactive waste handling....Regulatory changes are driving major projects for chemical and radiation safety and for animal care.*

- *Many of the animal units constructed a few years ago are now obsolete. Unless the obsolete animal facilities are updated, the research personnel will not be able to conduct many of tomorrow's research projects. (Public, doctorate-granting institution)*

- *Toxic waste storage and disposal is a rapidly growing expense....We will be spending over $82,000 annually. (Private, non-doctorate institution)*

- *Toxic waste disposal and animal holding facilities badly need improvement. There is a general and serious lack of funding for operation and maintenance of campus wide shared use and support facilities and equipment. (Public, doctorate-granting institution)*

In this connection, it is intriguing that the average unit cost of facilities construction projects actually undertaken in 1988-89 was considerably lower than the average for all projects that had been planned for this period: $231/NASF versus $288/NASF (Figure 3). This implies that the portion of the planned 1988-89 construction that ultimately was cut out or postponed tended to be of higher unit cost than the construction that did go forward. Apparently, in an environment where financial resources are not adequate to meet identified needs, the most high-tech (and high unit cost) projects, which may also be especially important in maintaining the university's long-term capabilities to remain in the forefront of research, may often be the first to be cut.

Construction Trends by Institution Type and by S/E Discipline

The relative amount of new construction activity in each of the various classes of institutions (e.g., doctorate-granting/non-doctorate-granting and public/private) can be compared by expressing the total NASF being built as a percentage of the existing R&D space at each type of institution. This figure currently stands at 9 percent of currently existing R&D space, which is consistent with the 1988 survey (Table 7).

Non-doctorate-granting institutions have relatively ambitious construction projects underway with construction projects that will add (or replace) 16 percent of all science and engineering research space, while the top 100 doctorate-granting institutions are building the equivalent of 7 percent of their presently available space. It should be noted, however, that this ambitious pace is not expected to continue into 1990-91. New construction plans for the coming two-year period represent only 8 percent of the current R&D space at non-doctorate-granting institutions.

This profile of increased construction activity among non-doctorate-granting institutions (and increasing activity among doctorate-granting institutions other than the top 100) is most apparent among public institutions. Public, non-doctorate-granting institutions started projects in 1986-87 representing over one quarter (27 percent) of then-existing R&D space, and projects representing another 20 percent were started in 1988-89. This program is expected to taper off to 12 percent of existing space in 1990-91.

Table 7. Total net assignable square feet (NASF) of R&D space to be created by recent and planned construction as a percentage of existing R&D space by institution type and year of project start: 1986-91*

Institution type and control	Year of construction project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	9	11	9	10
Doctorate-granting	8	10	9	10
Top 100 in R&D	9	10	7	9
Other	6	13	13	11
Non-doctorate-granting	22	11	16	8
Public	9	11	9	9
Doctorate-granting	8	10	9	9
In top 100 in R&D	9	9	7	8
Other	5	14	14	11
Non-doctorate-granting	27	16	20	12
Private	9	10	9	12
Doctorate-granting	8	11	9	13
In top 100 in R&D	8	11	8	13
Other	9	11	10	11
Non-doctorate-granting	12	1	8	2

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space

Reference: Appendix Tables 3-2 and 2-1

Source: National Science Foundation, SRS

The increasing costs of new construction to support science and engineering research at academic

institutions can be expressed in terms of the average biennial investment per institution for new construction (Table 8). For projects started in 1986 and 1987, the average investment per research institution was approximately $4 million.[9] This figure rose to almost $5 million in 1988-89, and is expected to grow to over $6.7 million in 1990-91. The top 100 institutions (as measured by annual S/E R&D expenditures) spent an average of approximately $16 million apiece in both of the two-year periods surveyed, and they expect to commit an average of almost $25 million per institution to new construction starts in the coming two years.

Table 8 Mean cost per institution of projects to construct new R&D space by institution type and control and year of project start, 1986-91*

Institution type and control	Year of construction project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(Dollars in millions)			
Total	3 9	6 5	4 7	6 7
Doctorate-granting	6 4	11 2	7 9	11 5
Top 100 in R&D	16 0	24 5	15 6	24 8
Other	1 5	4 3	3 9	4 7
Non-doctorate-granting	0 7	0 5	0 6	0 5
Public	4 2	6 6	5 4	6 7
Doctorate-granting	6 4	10 5	8 6	10 7
In top 100 in R&D	15 2	20 3	14 2	19 9
Other	1 3	4 8	5 2	5 3
Non-doctorate-granting	1 0	0 8	0 8	0 8
Private	3 4	6 3	3 6	6 6
Doctorate-granting	6 5	12 6	6 7	13 1
In top 100 in R&D	17 9	34 4	18 7	36 1
Other	1 8	3 4	1 8	3 7
Non-doctorate-granting	0 3	0 0	0 5	0 1

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space Means are based on all institutions with some assigned R&D space

Reference: Appendix Tables 3-2 and 2-1

Source National Science Foundation, SRS

[9] This includes all 525 research-performing institutions in the study universe, not just the ones that actually had facilities construction projects in 1986-87 (the mean for the latter subgroup is, of course, larger at $10.7 million per institution). The overall mean for all institutions of a given type is used to provide an indication of the average expected cost for institutions in that group.

Private institutions spent less, on average, than did their public counterparts, though private doctorate-granting institutions in the top 100 in R&D actually invested more (on a per-institution basis) than did public institutions in the top 100.

New construction is planned and underway in all academic science and engineering disciplines surveyed, though the space to be created represents varying proportions of the total research space currently in use in these disciplines (Table 9).

Table 9. Total net assignable square feet (NASF) of R&D space to be created by recent and planned construction as a percentage of existing R&D space by discipline and year of project start: 1986-91*

Discipline	Year of construction project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	9	11	9	10
Engineering	15	12	9	13
Physical sciences	5	11	12	10
Environmental sciences	6	7	5	9
Mathematics	1	5	3	6
Computer sciences	16	15	20	27
Agricultural sciences	9	5	6	4
Biological sciences	7	10	9	11
Medical sciences	10	17	11	14
Psychology	4	2	4	1
Social sciences	6	7	10	5
Other sciences, n e.c	14	15	23	2

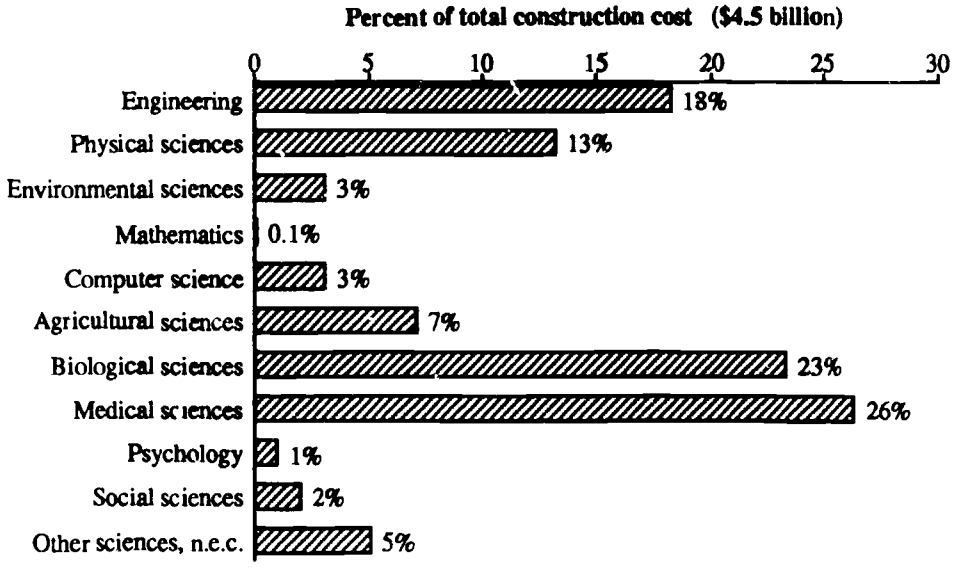
*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space

Reference Appendix Tables 3-4 and 2-6

Source National Science Foundation, SRS

Computer science leads the list in terms of new space as a proportion of existing space, with new construction representing 20 percent of existing space. This finding, though, can be attributed more to the relatively small amount of space allocated to computer science, rather than to any overwhelming construction initiative in the discipline. Aside from that, the largest potential increase in space is reported in the physical and medical sciences (12 percent and 11 percent of present space, respectively).

Figure 4
Distribution by discipline of the total cost of recent projects to construct new R&D space: 1986-89*



* Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space.
Reference. Appendix Table 3-4
Source. National Science Foundation, SRS

In dollar terms, almost half of all funds invested in new construction of research facilities during 1986-87 and 1988-89 was focused in the medical (26 percent) and biological (23 percent) sciences (Figure 4). This trend is expected to continue into 1990 and 1991 (Appendix Table 3-4). Two other disciplines, engineering and physical sciences, account for another 31 percent of all new construction investment in universities and colleges. New construction of engineering facilities had represented over 20 percent of all construction activity in 1986-87, but fell off to only 16 percent in 1988-89. New construction in the physical sciences, on the other hand, grew from 9 percent in 1986-87 to 16 percent in 1988-89, and is expected to grow to 18 percent of total new construction investment in 1990-91.

Repair/Renovation of Research Facilities, 1986-91

Institutions were asked to report recent and planned activity to repair and/or renovate existing research space, including the repair of facilities in poor condition, capital improvements, upgrading, and conversion of existing space to research use. Projects listed in this section of the survey were limited to those with R&D-related completion costs of $100,000 or more. Respondents reported the research-related portion of the total project cost (including planning, construction, and fixed equipment) as well as the amount of research space affected by the repairs.

Extent of Repair/Renovation Activity

Approximately half of all academic institutions began major repair and/or renovation projects during each of the two-year periods covered by the research facilities surveys (1986-87 and 1988-89, see Table 10). A larger proportion of public institutions reported such projects than did private institutions (51 percent versus 41 percent for 1988-89). These figures are somewhat higher than the number of institutions that planned such repair/renovation projects, particularly among private institutions.

Almost all of the top 100 research-performing institutions initiated repair/renovation projects during each of the two-year periods (9 percent in 1986-87, and 85 percent in 1988-89).

As would be expected, the disciplines that have the largest amounts of existing research space also have the most widespread repair/renovation activity. In 1988-89, for example, 35 percent of all institutions with research space in engineering had major repair/renovation projects in that discipline (Table 11). The other large disciplines -- the biological, medical, agricultural, and physical sciences -- also had widespread repair/renovation activity, ranging from

22 to 27 percent of the institutions with research programs in these disciplines. All other disciplines had major repair/renovation projects at comparatively few institutions: 4 to 8 percent of those with existing research space in the discipline.[10] Similar patterns of differences among disciplines were also seen for the 1986-87 period and for planned as well as for actual repair/renovation work.

Table 10 Percent of institutions performing major repair/ renovation of science and engineering R&D facilities by institution type and control and year: 1986-91*

Institution type and control	Year of repair/renovation project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	55	44	47	44
Doctorate-granting	76	65	70	57
Top 100 in R&D	96	90	85	80
Other	66	52	62	45
Non-doctorate-granting	28	16	19	27
Public	66	51	51	51
Doctorate granting in top 100 in R&D	85	68	70	62
Other	96	87	79	74
Non-doctorate-granting	79	57	66	54
Private	36	26	24	36
Doctorate-granting	38	32	41	32
In top 100 in R&D	60	59	69	48
Other	93	93	100	93
Non-doctorate-granting	44	44	56	29
	17	5	14	17

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space

Reference: Appendix Table 3-5

Source: National Science Foundation, SRS

Table 11 Percent of institutions performing major repair/ renovation of existing R&D space by discipline and year: 1986-91*

Discipline	Year of repair/renovation project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	55	44	47	44
Engineering	40	32	35	15
Physical sciences	21	21	22	16
Environmental sciences	12	9	6	10
Mathematics	5	3	6	6
Computer sciences	12	5	4	7
Agricultural sciences	31	24	23	20
Biological sciences	27	22	27	19
Medical sciences	29	26	27	22
Psychology	7	4	4	7
Social sciences	6	3	4	5
Other sciences, n.e.c	15	13	23	25

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space. The base of the percentage is the estimated number of institutions with any R&D space in the discipline in 1988

Reference: Appendix Table 3-7

Source: National Science Foundation, SRS

Overall Trends in Amounts and Costs of Repair/Renovation

The pattern of trends in facilities repair/renovation activity was essentially the mirror image of the pattern seen earlier for new construction. While institutions had planned large increases in facilities construction for 1988-89 and then found that they were not able to implement all of these plans, the opposite happened in the area of repair/renovation: in 1988, institutions projected that there would be substantial reductions in repair/renovation activity in 1988-89 as compared to the previous period, but the level of repair/renovation activity that actually did occur in 1988-89 was substantially higher than had been planned (Figure 5).[11]

[10] Because the study data were limited to projects that involved at least $100,000 of (prorated) research-related repair/renovation, these statistics understate the full extent of repair and renovation activity in any given period, and the underestimate may be especially pronounced for the smaller disciplines. No doubt, many institutions had projects involving repair or renovation to individual offices and laboratories that were not reported to the study because the work did not exceed the $100,000 threshold

[11] The possibility has been suggested that there may be a direct link between these two trends (e.g., perhaps some of the institutions that were unable to initiate as much new construction as they had planned chose instead to do additional repair/renovation work on their existing facilities). Little support for this hypothesis was found in the data, however, since unplanned increases in repair/renovation were found both at institutions with large amounts of deferred construction and also at institutions that did not have this problem

Thus, institutions repaired or renovated 11.5 million NASF in 1988-89, 22 percent more than they had planned as of early 1988 (9.4 million NASF). In dollar terms, institutions spent $1.04 billion for repair/renovation projects in 1988-89, 39 percent more than they had planned ($750 million).

As also happened in the 1988 study when institutions were asked to estimate the cost and space for 1988-89 repair/renovation projects, institutions again estimated in the current survey that their levels of repair/renovation activity for the upcoming two-year period (1990-91) will be lower than for the period just ended, in terms of both dollars and space (Figure 5).

These differences between new construction and repair/renovation may reflect inherent differences between the two types of projects. Thus, while construction projects are usually planned far in advance, needs for repair/renovation may be more difficult to predict. In the extreme, natural disasters such as Hurricane Hugo and the Loma Prieta earthquake in California can instantly produce unforseen repair problems of massive proportions. (Some of the data reported here were collected prior to these events, so that all of the specific ramifications are not reflected in this report.)

One area where trends for repair/renovation are similar to those for new construction is in unit costs, which have increased markedly for both types of projects. The average cost per square foot of facilities repair/renovation projects increased from $62 in 1986-87 to $91 in 1988-89, a 41-percent increase over this two year period. Further increases, to $111/square foot, are projected for 1990-91 repair/ renovation projects. Typical respondent comments in relation to this issue include the following:

- *The impact of items such as asbestos removal, PCB clean up, etc. are driving renovation budgets far beyond the cost of the actual construction. (Public, doctorate-granting institution)*

- *Regulatory mandated code modifications are part of almost every capital project throughout the campus....Recent renovation projects at (private, non-doctorate institution) have seen cost increases between 15 percent and 110 percent due to code requirements.*

- *The cost of a small renovation, of a laboratory for exampie, can be doubled because of regulations and codes relating to asbestos, PCB's, sprinklers, etc. (Public, doctorate-granting institution)*

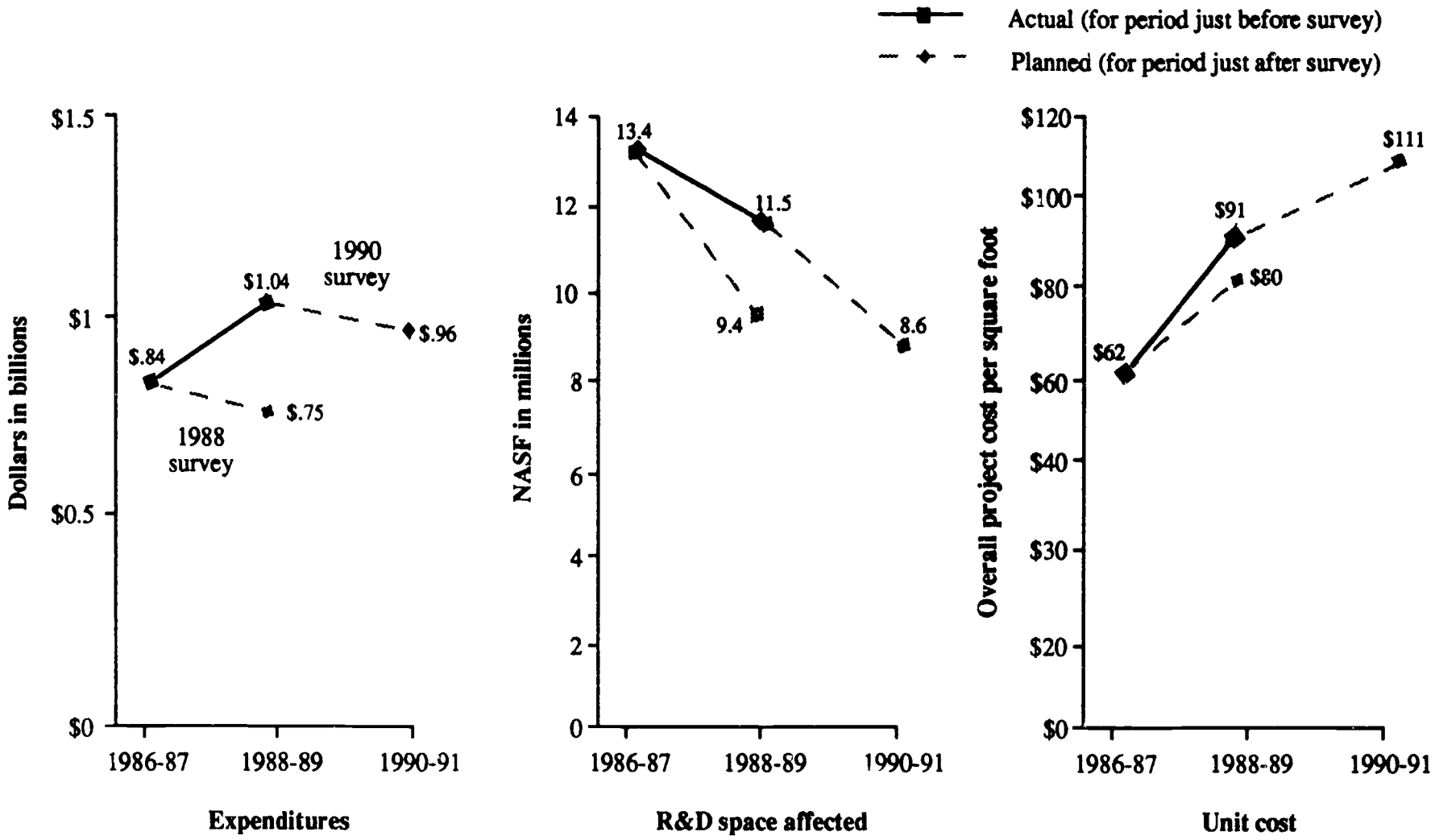
- *Regulatory changes related to animal welfare and hazardous chemicals have had a significant impact on repair/renovation projects. A number of regulatory issues are at the state and local level. Future projects which require hazardous chemicals and/or animal care will require an increase in funding. (Private, doctorate-granting institution)*

- *Project costs are nearly doubled in recent remodeling projects when asbestos abatement is required. (Public, doctorate-granting institution)*

- *Equally expensive are renovation costs for labs...with renovation costs of $200 per square foot in order to facilitate new faculty....The average useful life of university research buildings and facilities is approximately 20 years. (Private, doctorate-granting institution)*

This substantial increase in the unit costs of facilities repair and renovation exacerbates an already significant facilities planning problem. As seen above, institutions tend to underestimate the amount of research space that will need (and actually receive) repair/renovation in the near-term future. In addition, although planners have projected higher unit costs for future than for current repair/ renovation, they have tended to underestimate the extent of the increase. At least, that is what happened for the 1988-89 period, where the estimated unit cost of all planned repair/renovation was $80/square foot, but the actual cost proved to be $91/square foot, almost 15 percent higher. In some cases, the combination of the two factors can produce substantial underestimates of the cost of upcoming repair/renovation.

Figure 5
R&D - related cost, net assignable square footage affected, and cost per square foot of actual and planned repair/renovation of academic R&D facilities, by year: 1986-1991*



* Findings are limited to projects with R&D - related cost of $100,000 or more.
Reference: Appendix Table 3-6
Source: National Science Foundation, SRS

Repair/Renovation Trends by Institution Type and by S/E Discipline

Repair and renovation projects begun in 1988-89 affected approximately 10 percent of existing research space (Table 12). This is somewhat lower than the extent of repair/renovation work conducted in 1986-87 (12 percent of all research space) and somewhat higher than the amount that was planned for 1988-89 (8 percent) or the amount that is now planned for 1990-91 (7 percent). These differences were found consistently across institution type categories. The only departure from this pattern was the non-doctorate-granting group, which projected an unusually high level of repair/renovation activity in 1990-91 (the equivalent of 17 percent of existing research space). This was mainly due to non-doctorate-granting *public* institutions, which projected extremely high repair/renovation levels for 1990-91 (amounting to 22 percent of existing research space).

Table 12 Percent of existing R&D space undergoing major repair/renovation by institution type and control and year 1986-91*

Institution type and control	Year of repair/renovation project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	12	8	10	7
Doctorate-granting	12	9	10	7
Top 100 in R&D	11	9	10	7
Other	14	8	11	7
Non-doctorate-granting	13	4	9	17
Public	11	8	9	8
Doctorate-granting	10	8	9	7
In top 100 in R&D	10	8	9	7
Other	13	7	10	8
Non-doctorate-granting	14	5	10	22
Private	16	10	11	7
Doctorate-granting	16	10	11	6
In top 100 in R&D	16	11	11	7
Other	17	8	13	5
Non-doctorate-granting	10	1	7	8

*Findings are limited to projects with estimated total cost of $100 000 or more for R&D-related space

Reference Appendix Table 3-6 and 2-1

Source National Science Foundations, SRS

By discipline, relatively high levels of repair/renovation activity in 1988-89 were found in mathematics (17 percent of all research space) and in the environmental, biological, medical and physical sciences (all at 12-15 percent of existing space Table 13). Relatively low levels of repair/renovation activity were found in the agricultural and social sciences and psychology (all at 3-4 percent). These differences were generally stable across time periods, for both actual and planned repair/renovation. The only exceptions were mathematics and the environmental sciences, both of which had low levels of repair/renovation activity in 1986-87 followed by relatively high levels in 1988-89.

Table 13 Percent of existing R&D space undergoing major repair/renovation by discipline and year 1986-91*

Discipline	Year of repair/renovation project start			
	1986-87 (actual)	1988-89 (plan)	1988-89 (actual)	1990-91 (plan)
	(percent)			
Total	12	8	10	7
Engineering	17	9	10	6
Physical sciences	11	9	12	10
Environmental sciences ..	6	7	15	11
Mathematics . .	5	6	17	9
Computer sciences	13	6	10	8
Agricultural sciences	4	3	3	2
Biological sciences	15	10	13	10
Medical sciences	17	12	12	8
Psychology	8	3	3	7
Social sciences	5	3	4	6
Other sciences, n e c	11	8	10	11

*Findings are limited to projects with estimated total cost of $100,000 or more for R&D-related space

Reference Appendix Table 3-8 and 2-6

Source National Science Foundation, SRS

4. SOURCES OF FUNDS FOR RESEARCH FACILITIES PROJECTS

Highlights

- Funds for new facilities construction in 1988-89 came primarily from three sources: state/local governments, private donations, and debt financing. Private institutions obtained 70 percent of their construction funding from private donations and debt financing, while public institutions acquired almost half of their construction funding from state/local governments.

- As compared to the 1986-87 period, private institutions made greater use of debt financing, including taxable debt, and had less reliance on internal institution funds for 1988-89 construction projects. Public institutions had increased levels of construction funding from both Federal sources and institution funds during this period.

- Of the 30 private institutions that are among the top 100 in R&D expenditures, 19 have reached the $150 million limit on tax-exempt bonds, and three others expect to do so within the next two years. This may explain those institutions' growing use of relatively costly taxable bonds and other debt to finance facilities construction.

- Major sources of funding for repair and renovation include debt financing, private donations, and institutional funding. Both private and public institutions depend primarily upon institutional funding.

- Half of all private donations for new construction, and two-thirds of all such donations for repair/renovation come from foundation grants. A total of $263 million was contributed by foundations for projects started in 1988-89. Individual contributors are the second largest supporters, providing 37 percent of all private donations for new construction and 19 percent of repair/renovation donations.

Introduction

This chapter examines trends in the sources of funds institutions used to finance construction and repair/renovation of academic research facilities over the period 1986-89 and the sources involved in projects planned for 1990-91. Because very different funding mixes are involved, public and private institutions are discussed separately throughout most of this chapter, as are new construction and repair/renovation. After discussing overall funding trends, additional detail is presented about institutions' sources of private donations.

Sources of Funds for New Construction

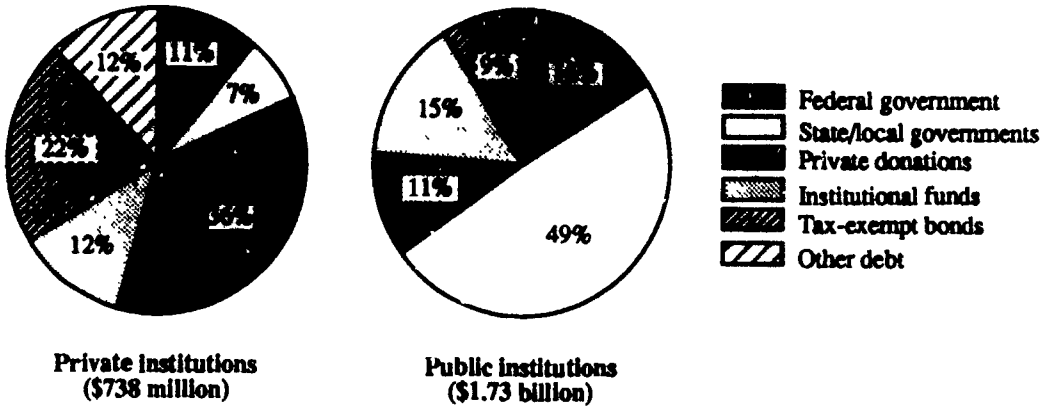
Current Sources: Public versus Private Institutions

As would be expected, private institutions obtained most (82 percent) of their 1988-89 construction funding from private (nongovernment) sources, while public institutions secured the bulk of their funding support (65 percent) from government sources (Figure 6).

State/local government was by far the largest source of facilities construction funding for public institutions in 1988-89, accounting for half (49 percent) of all such funds during this period. Federal agencies accounted for an additional 16 percent of public institutions' construction funding, followed closely by institution funds (15 percent). Relatively small funding shares were provided by private donations (11 percent) or debt financing (9 percent).

The profile for private institutions was quite different from the above. Thus, while state/local government sources provided half of all facilities construction funds for public institutions in 1988-89, they accounted for only 7 percent of private institutions' funds. Federal sources also played a smaller funding role at private institutions (contributing 11 percent of their funding) than at public universities and colleges (16 percent). Instead of relying on these government sources, private institutions relied mostly on private donations (36 percent) and on debt financing (34 percent). About two-thirds of this debt was in the form of tax-exempt bonds; the rest, 12 percent of the total, involved taxable debt. Finally, institution funds

Figure 6
Sources of funds for new construction of science/engineering research facilities: 1988 and 1989



Reference: Appendix Tables 4-1 and 4-2.
Source: National Science Foundation, SRS

were used to provide the remaining 12 percent of construction funds at private institutions, about the same level as was seen at public institutions (15 percent).

It should be noted that this funding mix information, which was provided at the time of the survey, can change somewhat over time, even after construction work begins on a given project. For example, the original proposed funding sources for a project may not include tax-exempt bonds. But, should the bond market become more favorable during or after construction, the institution may choose to refinance part of the cost of the project through the issue of bonds. Alternatively, if the institution were to receive a large donation, it might be used to retire all or part of the debt the institution had planned to incur. Institutions were asked to report the planned sources for the permanent financing of their construction projects,[12] but it must be recognized that existing financial management practices do sometimes produce adjustments to the funding mix.

Trends in Public Institutions' Construction Funding

Funding from state/local government, the principal source of construction funds for public institutions, increased from $754 million in 1986-87 to $838 million in 1988-89, and it is expected to increase further, to $1.01 billion in 1990-91 (Table 14). Federal funding support has grown even more rapidly during this period, from $40 million in 1986-87 to $274 million in 1988-89 to a projected $318 million for 1990-91. Use of institution funds for new construction has also increased, from $109 million in 1986-87 to $256 million in 1988-89 to an expected $273 million in 1990-91.

[12] Permanent financing refers to the planned means of financing the costs of a building over time. This excludes short-term arrangements (e.g., a 3-year construction loan) that allow the building process to go forward but are replaced by a more permanent funding mix within a relatively short time

Table 14 Public institutions' sources of funding for construction of new research facilities, 1986-1991

Index and time period	Total	Funding sources						
		Government		Private donations	Institution funds	Tax-exempt bonds	Other debt	Other/ unknown
		Federal	State/local					
		(Dollars in millions)						
Dollar contribution								
1986-87	1,355	40	754	259	109	190	2	<1
1988-89	1,727	274	838	193	256	154	8	1
1990-91 (plan)	2,131	318	1,014	157	273	245	89	7
	(percent of total)							
Relative contribution								
1986-87	100	3	56	19	8	14	<1	<1
1988-89	100	16	49	11	15	9	<1	<1
1990-91 (plan)	100	15	48	7	13	12	4	0

Note. Details may not sum to totals because of rounding

Reference Appendix Table 4-2

Source National Science Foundation, SRS

In contrast to these increasing sources of funding, private donations have dropped off, from $259 million in 1986-87 to $193 million in 1988-89 to a projected $157 million in 1990-91. In relative terms, this represents a decline from 19 percent of all construction funds at public institutions in 1986-87 to a projected 7 percent in 1990-91. Finally, debt financing (primarily through use of tax-exempt bonds, which is not Federally restricted for public institutions) has varied within a fairly narrow range: 9-16 percent.

Trends in Private Institutions' Construction Funding

In terms of non-inflation-adjusted dollars, government funding support for facilities construction at private institutions has remained stable over the period 1986-91. It totalled $130 million in both 1986-87 and 1988-89, and it is expected to be $148 million in 1990-91 (Table 15). Among government-sector sources, however, there appears to have been a progressive shift over the 1986-91 period toward less

Table 15 Private institutions' sources of funding for construction of new research facilities: 1986-1991

Index and time period	Total	Funding sources						
		Government		Private donations	Institution funds	Tax-exempt bonds	Other debt	Other/ unknown
		Federal	State/local					
		(dollars in millions)						
Dollar contribution								
1986-87	696	105	25	228	181	124	1	32
1988-89	738	78	52	266	88	166	88	<1
1990-91 (Plan)	1,364	54	91	406	267	350	107	1
	(percent of total)							
Relative contribution								
1986-87	100	15	4	33	26	18	<1	5
1988-89	100	11	7	36	12	22	12	<1
1990-91 (Plan)	100	4	7	30	20	26	8	5

Note: Details may not sum to totals because of rounding

Reference. Appendix Table 4-1

Source National Science Foundation, SRS

Federal support and greater state/local support for facilities construction at private institutions.

This ($50 million) decline in Federal support for private institutions stands in sharp contrast to the large ($280 million) increase in Federal support seen at public institutions over the same period. These differences may just represent a temporary fluctuation, however. At any given time, facilities construction projects tend to involve large amounts of money being spent at a relatively small number of institutions. Depending on the size and scheduling of the particular projects involved, small fluctuations in the public-private distribution of institutions receiving Federal construction support could produce large short-term shifts in aggregate dollar amounts.

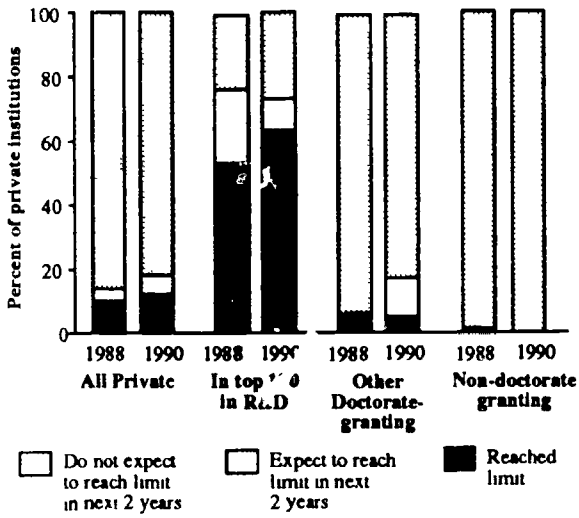
Private donations, upon which private institutions depend heavily to finance facilities projects, increased slightly from $228 million in 1986-87 to $266 million in 1988-89; they are expected to increase substantially in 1990-91, to $406 million.

The largest funding shift for private institutions in the period studied was that debt financing increased from 1986-87, where it was $124 million (18 percent of total construction funding), to 1988-89, where it doubled to $254 million (34 percent of the total). Additional debt is anticipated for construction projects to be initiated in 1990-91: $457 million (again, 34 percent of the anticipated total for that period). One disturbing aspect of this trend is that not only is debt financing increasing for private institutions (both in absolute and in relative terms), but much of the increase is in the form of taxable debt. Such debt, which was essentially nonexistent in 1986-87 ($1 million), grew to $88 million in 1988-89 and is expected to grow further to $107 million in 1990-91.

To some extent, these trends may be a result of the 1986 Federal Tax Reform Act, which established a $150 million cap on the tax-exempt bonds private institutions would be allowed to issue.[13] This cap has not yet had much effect on non-doctorate-granting private institutions: none of them have yet reached the cap, and none expect to reach it in the next two years (Figure 7). However, of the 30 private institutions that are among the top 100 R&D performers, 19 have now reached the cap, and 3 others expect to reach the cap within the next two years. The $195 million in actual and planned taxable debt reported for the period 1988-91 comes entirely from institutions in this category. Insofar as inability to use tax-exempt bonds is increasing the cost of money for these institutions, this constraint may make it especially difficult for the most prominent research institutions to follow through on the ambitious facilities construction programs they have planned for 1990-91. As one private, doctorate-granting institution replied:

> *The single greatest deterrent to the initiation of new research facility repair/renovation and construction projects at (private, doctorate-granting institution) is the $150 million cap on tax-exempt bonds enacted as a result of recent tax reform. As an institution primarily tuition-dependent for revenues, there is little discretionary spending as a result for such activities. The targeting of loan, loan guarantees and other debt financing programs are also significant factors in the University's ability to address facility needs.*

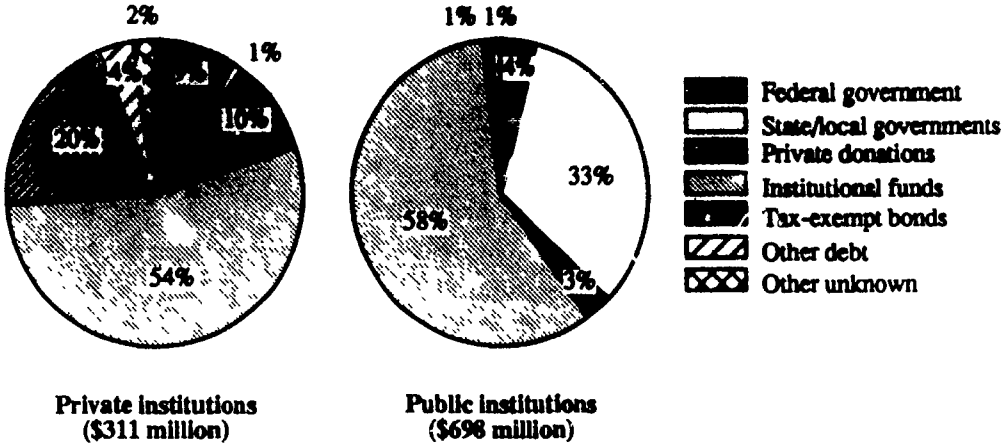
Figure 7
Status of private institutions relative to $150 million limit on tax-exempt bonds: 1988 and 1990



Reference Appendix Table 4-7
Source National Science Foundation, SF

[13] Internal Revenue Code of 1986, Section 145. This $150 million cap applies to all tax-exempt bonds, not just those that support construction at research facilities

Figure 8
Sources of funds for repair and renovation projects of science/engineering research facilities: 1988 and 1989



Reference: Appendix Tables 4-3 and 4-4
Source: National Science Foundation, SRS

Sources of Funds for Repair and Renovation

Expenditures for the repair and renovation of research facilities totalled $1 billion in 1988-89. For private institutions, which accounted for about one-third of this total ($311 million), institution funds provided the largest source of repair/renovation funds, 54 percent (Figure 8). An additional 24 percent of the funds ($74 million) came from debt financing, most of which ($63 million) was acquired through the issue of tax-exempt bonds (Appendix Table 4-3). Private donations provided an additional 10 percent, as did Federal sources. State/local government contributed only 1 percent of the cost of repair/renovation.

Public institutions also obtained over half (58 percent) of their repair/renovation funds from institutional monies. State/local government accounted for most of the rest (33 percent). Donations and debt financing together accounted for only 5 percent of all 1988-89 repair/renovation financing at public institutions.

Looking at trends from 1986-87 to 1990-91, public institutions consistently relied on institution funds and state/local government sources for their facilities repair/renovation. The sum of these two sources ranged from 88 percent in 1986-87 to 93 percent for planned work in 1990-91 (Table 16). The specific mix among these two sources varied considerably from period to period, however, presumably with institutions having to pick up whatever additional costs became incurred over and above those covered by state appropriations.

In relative terms, the repair/renovation funding mix for private institutions also remained fairly stable over the intervals studied. Thus, the relative contributions from government sources varied within a fairly narrow range (5-11 percent), as did those from debt financing (21-29 percent). Private donations appeared to play a declining role in funding repair/renovation, decreasing from 21 percent in 1986-87 to 7 percent of planned 1990-91 projects. Institution funds became correspondingly more prominent, in relative terms, increasing from 43 percent to 60 percent.

This analysis is somewhat misleading for private institutions, however. The actual dollar amount of institution funds for repair/renovation projects actually declined slightly--from $173 in 1986-87 to a

Table 16. Sources of funding for repair/renovation of research facilities by institution control: 1986-1991

Institution control and time period	Total (dollars in millions)	Funding sources						
		Government		Private donations	Institution funds	Tax-exempt bonds	Other debt	Other/ unknown
		Federal	State/local					
		(percent of total)						
Private								
1986-87	402	4	2	21	43	26	1	2
1988-89	311	10	1	10	54	20	4	2
1990-91 (Plan)	268	4	1	7	60	12	9	4
Public								
1986-87	436	3	52	4	36	6	<1	<1
1988-89	699	4	33	3	58	1	1	0
1990-91 (Plan)	687	0	76	5	17	2	0	0

Note Details may not sum to totals because of rounding

Reference: Appendix Tables 4-3 and 4-4.

Source National Science Foundation, SRS

projected $162 in 1990-91--but repair/renovation contributions from all other sources declined even more (Appendix Table 4-3). Perhaps the main conclusion to be drawn from this pattern is that, although private institutions are continuing to expend substantial amounts of their internal funds for facilities repair and renovation, they are finding it increasingly difficult to obtain outside sources of funding support for such work.

Sources of Private Donations

In the 1990 survey, institutions were asked to break down their sources of private donations for capital projects among corporations, foundations, private individuals, and other private donors. Foundations contributed a total of $230 million for new construction in 1988-89 (Appendix Table 4-5), accounting for half of all private donations (Table 17). Another third (37 percent) of the private donations ($171 million) came from individuals. Corporations contributed less than 10 percent of all private funds for construction of new research facilities.

Public institutions tended to get a larger share of their new construction funding from foundations (55 percent) than did private institutions (47 percent). Private institutions tended to have more of a balance between funding from foundations (47 percent) and from individuals (41 percent). This was due in large part to private institutions' strength in attracting donations from private individuals for R&D facilities construction, which totaled $110 million in 1988-89, while public institutions reported only $60 million in individual-based donations for this purpose.

A similar profile was observed for repair and renovation funding. In this case, foundations accounted for 63 percent of all donations ($32 million), while individuals donated 19 percent of the total. Again, public institutions reported a larger share from foundations than did private institutions (69 percent versus 58 percent).

Table 17 Sources of private donations for new construction and repair/renovation of S/E research facilities 1988-89

Sources of funds	New construction			Repair/renovation		
	Total	Public	Private	Total	Public	Private
Total (dollars in millions)	$459	$193	$266	$52	$22	$30
			(percent of total)			
Corporations	8	11	6	10	6	12
Foundations	50	55	47	63	69	58
Individuals	37	31	41	19	20	20
Other	5	3	6	8	5	10

Reference Appendix Tables 4-5 and 4-6

Source National Science Foundation, SRS

5. ADEQUACY AND CONDITION OF RESEARCH FACILITIES

Highlights

Need for More Research Space

- In each of the five largest S/E disciplines, 40 to 60 percent of the institutions that perform research in the discipline report needs for more research space. Reports of inadequate current amounts of research space were most prevalent among medical schools (in both the biological and medical sciences), and such reports from medical schools were more widespread in 1990 than they had been in 1988.

- However, in most disciplines and in most institution types, the perceived need for increased amounts of research space does not appear to have grown from 1988 to 1990. In the physical sciences and engineering, the proportions of schools reporting a need for more space declined slightly.

Facility Infrastructure

- Asked to assess the adequacy of various aspects of their research facility infrastructure (air decontamination capabilities, data communications systems, toxic waste disposal, etc.), 65 to 85 percent of the institutions in most institution type categories assessed most infrastructure elements as "adequate" or "generally adequate," and 1990 assessments were very similar to those given in 1988 in most cases.

- In the 1990 survey, non-doctorate-granting institutions reported infrastructure inadequacies more often than other groups and more often than they did in the 1988 survey.

Quality and Condition of Research Facilities

- There was a modest (12 percent) increase from 1988 to 1990 in the absolute amount of research space assessed as being "suitable for use in the most highly developed and scientifically sophisticated research in its field." The proportion of space in this category rose from 24 percent in 1988 to 26 percent in 1990.

- There was, however, no change in the proportion of research space reported to be in need of repair or renovation (39 percent in both survey years).

Deferred Repair/Renovation

- Although the amount of research space needing repair/renovation did not change significantly from 1988 to 1990, repair/renovation costs have increased and institution provisions for repair/renovation have declined. Consequently, the amount of deferred repair/renovation (the estimated cost of the unfunded backlog) has increased, from an estimated $2.8 billion at the time of the 1988 survey to $4.0 billion currently, a 45-percent increase over this two-year period.

- Another way of expressing the current backlog is that, for every dollar of planned repair/renovation spent in 1990-91, there will be an additional $4.25 of needed repair/renovation that will not be performed.

Deferred Construction

- The estimated amount of deferred construction needed to meet institutions' requirements for additional research space increased from $5.8 billion at the time of the 1988 survey to $8.0 billion currently, an increase of 38 percent over this period.

- The current level of deferred construction means that, for every dollar of planned facilities construction in 1990-91, an additional $3.11 of needed construction will not be performed.

Introduction

This chapter compares findings from the 1988 and 1990 surveys on institutions' qualitative assessments of the adequacy and of the quality/condition of their research facilities. Data concerning needs for additional or improved research space are then combined with other information, from Chapter 3, about institutions' planned expenditures for capital projects to develop estimates of trends in the amount of *deferred* construction and repair/renovation.

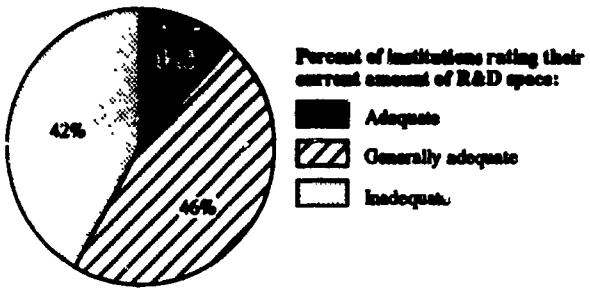
Adequacy of Research Facilities

Institutions were asked to assess the adequacy of several aspects of their S/E research facilities in each discipline. Discussions with a number of institutions indicated that, for the most part, reports on facilities' condition and adequacy were obtained from deans, in consultation with department chairs.

On one key indicator, the adequacy of their amount of research space, little overall change was seen from 1988 to 1990 (Figure 9). Averaged across disciplines:

- Twelve percent of the institutions assessed their 1990 amount of research space as "adequate -- sufficient to support all the needs of your research in the discipline," essentially the same as in 1988;
- Forty-six percent of the institutions assessed their 1990 space as "generally adequate -- sufficient to support most research needs in the discipline, but may have some limitations," down slightly from 48 percent in 1988; and
- Forty-two percent of the institutions described their 1990 space as "inadequate -- not sufficient to support the needs of your research in the discipline," up slightly from 40 percent in 1988.

Figure 9
Adequacy of institutions' current amount of R&D space: 1990



1990

Reference: Appendix Table 5-3.
Source: National Science Foundation, SRS

Institutions in the top 100 in overall S/E research expenditures assessed their 1990 amount of research space as "adequate" or "generally adequate" less often than institutions with smaller research programs: 50 percent of the top 100 institutions gave such assessments, as compared to 60 percent of other doctorate-granting institutions and 63 percent of non-doctorate-granting institutions. All three institutions types were somewhat more likely to report inadequate amounts of research space in 1990 than they had in 1988. All of these changes were of less than two percentage points, however.

Institutions' reports about inadequate amounts of research space were more widespread than concerns about other aspects of their research facilities. Overall, the percent of institutions assessing other facility aspects as being adequate or generally adequate in 1990 were:

- Air decontamination (e.g., fume hoods): 68 percent;
- Data communications systems: 70 percent;
- Heating, ventilation, and air conditioning (HVAC): 70 percent;
- Toxic waste disposal: 81 percent; and
- Power systems: 83 percent.

Although non-doctorate-granting institutions were somewhat less dissatisfied with their total amount of research space than were the two categories of doctorate-granting institutions in 1990, they were somewhat more likely than other institution types to complain about inadequacies in the infrastructural aspects of their existing research facilities (Figure 10). Non-doctorate-granting institutions' complaints in most of these areas increased from 1988 to 1990, more so than was true for other institution types. For example, with respect to data communications systems, HVAC, and power systems, doctorate-granting institutions in the top 100 in R&D became somewhat more satisfied between 1988 and 1990 with the adequacy of their research facilities, while non-doctorate-granting institutions increasingly reported inadequate facilities.

Air decontamination (fume hoods, etc.) was the one infrastructure area that was of growing concern for all three institution types. Even there, however, the growth in reporting of inadequacies was least for institutions in the top 100 in R&D (which had a change of 2 percentage points) and was greatest for non-doctorate-granting institutions (where the change was 10 percent).

Although there were some interesting institution-type differences and trends in facilities assessments, such trends are perhaps most meaningful when examined by discipline. Discipline-related changes from 1988 to 1990 are summarized below. The discussion presents the data in one of two formats: either as the percent of institutions in a discipline that assess their space as generally adequate or better (as shown in Table 18) or the percent that assess their space as inadequate (this is the complement of the percentage shown in Table 18; the two percentages always sum to 100 percent).

Discipline-related Changes

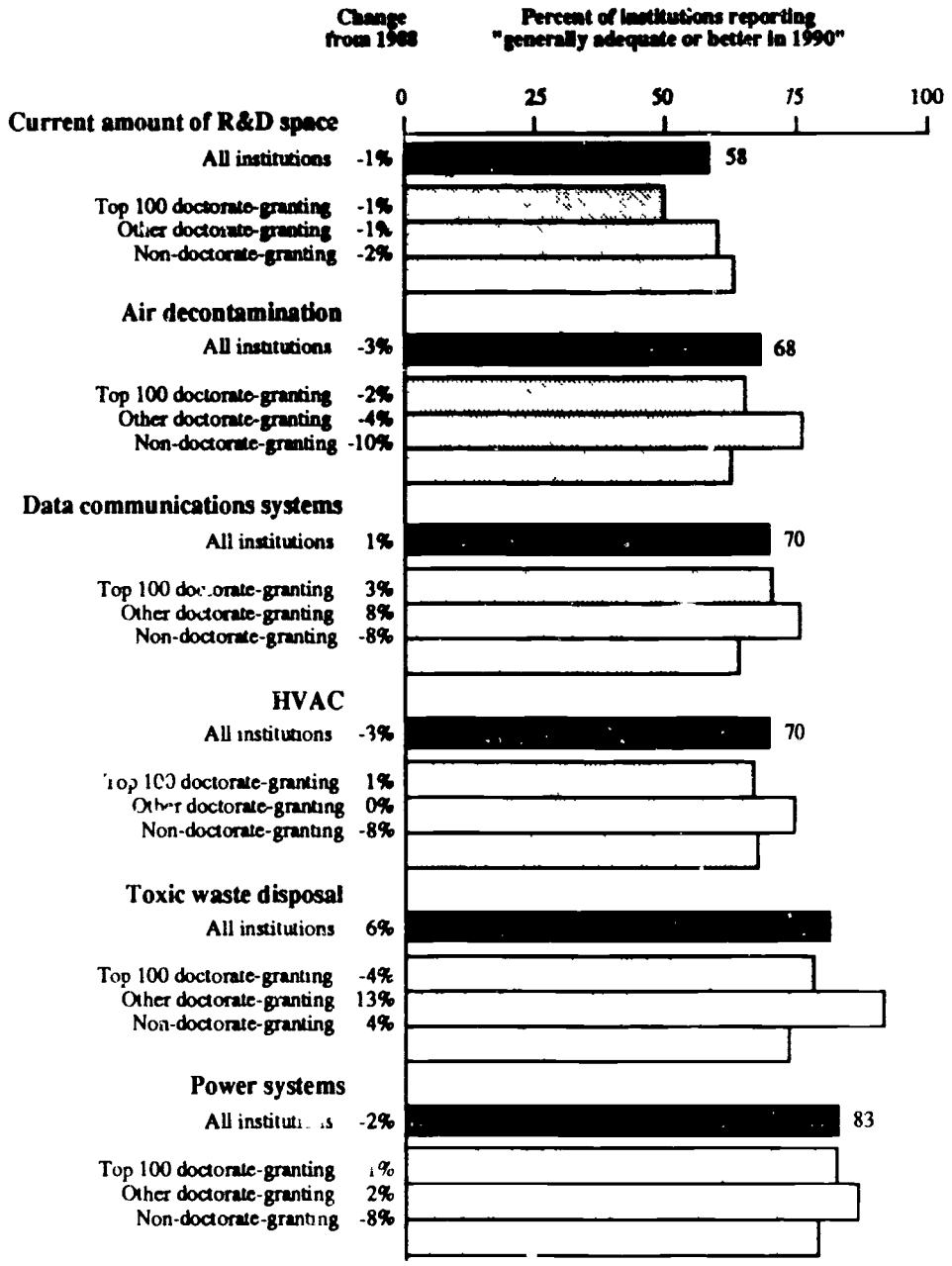
Amount of space. In most of the larger disciplines (e.g., engineering, physical sciences, biological sciences) the percentage of institutions reporting generally adequate or better amounts of research space increased slightly from 1988 to 1990. In the medical sciences, however, reports of inadequate space were especially widespread, and the prevalence of such reports increased significantly from 1988 to 1990. This was true both for medical science facilities located in medical schools and for those located in other academic settings. Reports of inadequate space were also relatively prevalent, and are becoming increasingly so, for biological science facilities that are located in medical schools. Satisfaction with the amount of research space also decreased from 1988 levels in mathematics and agricultural sciences, though only the latter discipline dropped below the overall average.

Air decontamination. The adequacy of fume hoods and other air decontamination equipment is a major safety concern affecting much research in the biomedical sciences, chemistry, and other fields. It seems to be a positive sign that in the physical sciences and in all subcategories of the biological and medical sciences -- where the concern is perhaps most relevant--increasing percentages of institutions reported generally adequate or better facilities in 1990 as compared to 1988. On the other hand, the percentages of institutions describing their air decontamination systems as generally adequate or better are considerably below 100 percent in each of these disciplines, suggesting that many institutions are not entirely satisfied about the level of safety their systems provide.

Toxic waste disposal. This is another important safety issue. Assessments of the adequacy of toxic waste disposal capabilities were obtained at the institution level in the 1990 survey rather than by discipline, because many institutions indicated that toxic and hazardous wastes are handled through centralized systems. The overall trend is again positive, with more institutions reporting generally adequate or better provisions in this area in 1990 than in 1988 (81 percent versus 76 percent). Again, however, it is a matter of some concern that 19 percent of all academic institutions still regard their toxic waste disposal capabilities as "inadequate."

Data communications. Considering the high levels of interest, activity, and spending institutions have shown in the past few years in networking of computer systems, telecommunications, and other aspects of data communication, the study findings show remarkably little variability among disciplines and remarkably little change from 1988 to 1990 on this dimension. The only discipline showing a change of more than 5 or 6 percentage points was the

Figure 10
Trends in rated adequacy of selected aspects of research infrastructure, by type of institution: 1988 and 1990



Reference Appendix Tables 5-3 to 5-7
Source National Science Foundation, SRS

Table 18 Adequacy of selected aspects of science/engineering research facilities by discipline 1988 and 1990

Discipline	Research facility aspects											
	Amount of R&D space		Air decontamination		Data communications		HVAC*		Toxic waste disposal		Power systems	
	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990
	(Percent of institutions reporting "generally adequate" or better)											
Total	59 6	58 2	70 8	68 1	68 7	69.8	72 6	69 8	75 5	81 2	84 5	82.7
Engineering	48 8	51 4	74 1	64 9	63 3	67 6	72 3	67 1	-	-	81 0	85.2
Physical sciences	57 1	59 5	59 2	60 6	66 4	68 6	63 6	58 1	-	-	84 2	85 6
Environmental sciences	60 4	59 5	69 6	59 2	63 6	70 0	69 4	61 4	-	-	81 3	68 5
Mathematics	74 6	64 8	90 8	-	69 7	65 8	74 9	73 7	-	-	84 0	84 8
Computer sciences	53 2	55 0	92 0	-	69 3	67 0	74 9	73 5	-	-	82 5	84 3
Agricultural sciences	62 2	56 9	64 3	61 7	60 5	70 4	68 0	66 9	-	-	78 1	79 1
Biological sciences	53 6	54 8	65 9	69 9	71 9	68 1	69 2	68 9	-	-	81 7	78 1
In universities and colleges	54 1	56 9	63 7	68 1	69 7	65 8	67 3	67 2	-	-	80 9	77 4
In medical schools	51 0	45 9	76 5	77 4	81 8	78 3	78 3	76 3	-	-	85 3	86 6
Medical sciences	57 5	47 9	73 3	75 4	70 7	69 3	78 9	78 0	-	-	86 7	82 9
In universities and colleges	60 3	53 3	70 9	72 5	65 4	63 8	78 9	78 0	-	-	87 6	81 9
In medical schools	53 4	40 8	76 2	78 8	78 1	76 7	79 2	77 9	-	-	85 4	84 2
Psychology	68 2	67 5	64 7	78 2	72 8	78 0	74 5	68 9	-	-	92 8	88 6
Social sciences	63 1	63 7	84 2	80 6	70 6	70 1	83 2	84 8	-	-	88 7	85 1
Other sciences, n a c	61 7	56 1	55 7	70 4	62 8	77 6	67 0	68 8	-	-	81 0	89 4

*HVAC = heating, ventilation, and air conditioning

Not applicable for individual discipline (or for this discipline)

Source National Science Foundation, SRS

agricultural sciences, where reporting of generally adequate or better data communications increased from an especially low level (compared to other disciplines) of 60 percent in 1988 to a mid-range level of 70 percent in 1990.

HVAC and power systems. There tended to be fewer complaints about these basic aspects of behind-the-walls facility infrastructure than about the other concerns discussed above: HVAC was assessed as generally adequate or better by 70 percent of the institutions in 1990, and 83 percent assessed their power systems as generally adequate or better. In both categories, however, concerns about inadequate facilities grew somewhat from 1988 to 1990. Growing concerns about HVAC were most prominent in the physical and environmental sciences and in engineering. Growing concerns about inadequate power were especially evident for the environmental sciences.

Discipline-related Comments

Representative comments from respondents to this survey concerning health and safety issues include the following:

> *Toxic materials handling and disposal requirements (new requirements and new materials which were previously not included in the requirements) outstrip our physical capacity to handle them. It is for this reason that we are expending over $2 million for the construction of new Environmental Health and Safety facilities.*
>
> *As research becomes more sophisticated, the facilities must keep pace with safety and environmental concerns. Early approaches to ventilation are no longer acceptable requiring a tremendous renovation effort in many existing buildings.*
>
> *Several campus-wide facilities or systems that support research are inadequate, requiring the investment of many millions of dollars over the next few years. By nature of its research and teaching functions, (institution) generates various waste, including low-level radioactive waste, hazardous chemical waste, and infectious waste. Proper handling and disposal of hazardous materials is of great concern to the campus; it has continually improved its hazardous waste management practices in order to be responsive to current needs, technology, regulations, and public expectations.*
>
> *(Institution)...is faced with equal or greater research facilities concerns as a result of the age of its current facilities and as a result of its present stage of development.... As new replacement faculty are hired, frequently two or three older laboratories have to be renovated to accommodate a single research team....not only must existing laboratories be renovated and reconfigured, but a substantial number of new R&D facilities also will need to be constructed.*
>
> *The biggest problem is the amount of space. Other significant problems include animal care facilities, health and safety issues, and overall renovation needs.*

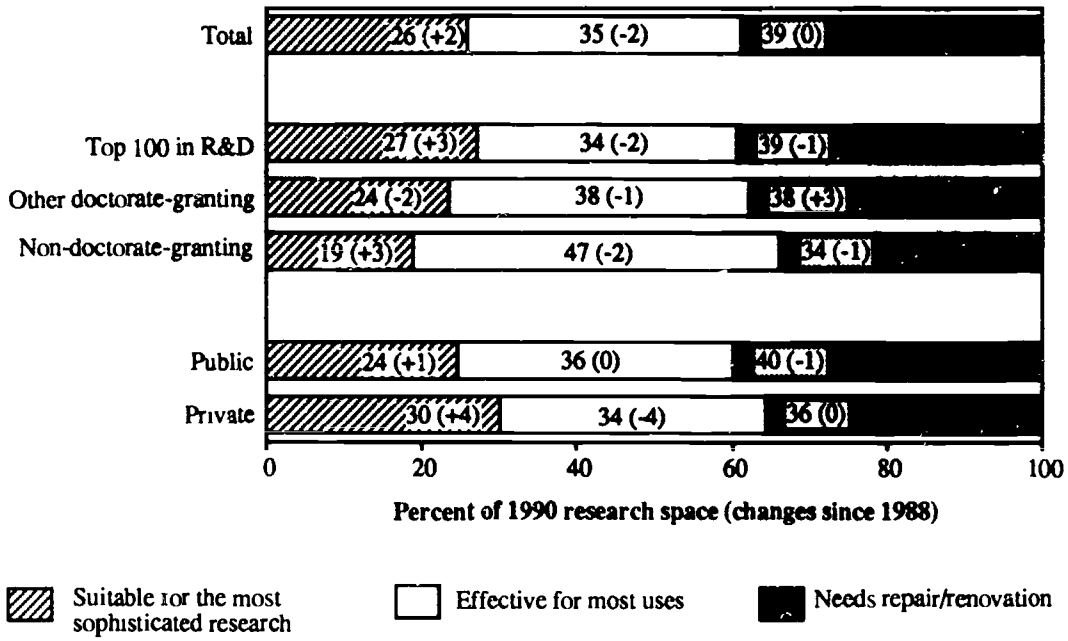
Quality and Condition of Research Facilities

In each applicable S/E discipline, institutions were asked to estimate the percentage of their current research space falling in the following categories:

> A - suitable for use in the most highly developed and scientifically sophisticated research in its field;
>
> B - effective for most purposes but not applicable to category A;
>
> C - effective for some purposes but in need of limited renovation or repair; and
>
> D - requiring major repair or renovation to be used effectively.

In 1990, respondents assessed 26 percent of all academic research space as being in category A (suitable for the most sophisticated research), an increase of 2 percentage points from 1988 (Figure 11). An additional 39 percent of all research space was assessed as needing either limited or major

Figure 11
Trends in reported quality/condition of academic research space by institution type and control: 1988 and 1990



Reference Appendix Table 5-1
Source National Science Foundation, SRS

renovation or repair in 1990, which is essentially unchanged from 1988.

By institution type, institutions in the top 100 in R&D expenditures reported a larger fraction of their research space in category A (27 percent) than was found for other doctorate-granting institutions (24 percent) or for non-doctorate-granting institutions (19 percent). However, the large R&D institutions also had relatively large amounts of space needing repair or renovation (39 percent for the top 100 institutions versus 34 percent for non-doctorate-granting institutions).

Although the average amount of research space is considerably smaller at private than at public institutions, private institutions reported a somewhat higher fraction of their research space in category A than did public institutions (30 percent versus 24 percent), and they also reported more of an increase from 1988 to 1990 in this top-quality space than did public institutions (4 percent versus 1 percent). Private institutions reported a somewhat lower fraction of space needing repair or renovation than did public institutions (36 percent versus 40 percent).

Discipline-related differences in the proportion of research space assessed as being suitable for the most sophisticated research were very stable from 1988 to 1990, seldom changing by more than 3 or 4 percentage points (Table 19). This stability is a noteworthy finding, considering the seemingly subjective nature of the assessment and the fact that these assessments were often assembled from several deans and department chairs from the various disciplines, rather than being done centrally by a single person.

Disciplines with above-average changes in the proportion of research space assessed as being in the top category were computer science, biological and medical sciences outside medical schools, and medical sciences in medical schools, all of which showed small increases in their proportions of top-grade research space.

Like the differences at the upper end of the quality/condition scale, discipline-related differences

Table 19 Quality/condition of research facilities by discipline, 1988 and 1990

Discipline	Total	Suitable for use in the most sophisticated research		Effective for most uses		Needs limited or major repair/ renovation	
		1988	1990	1988	1990	1988	1990
		(Percent of research space)					
Total	100.0	23.9	25.9	36.8	35.3	39.3	38.8
Engineering	100.0	26.1	27.9	37.6	35.6	36.3	36.5
Physical sciences	100.0	25.7	28.3	34.5	33.5	39.8	40.2
Environmental sciences	100.0	18.7	18.7	40.6	40.4	40.7	40.9
Mathematics	100.0	29.5	25.9	45.3	44.6	25.2	29.5
Computer sciences	100.0	32.6	38.3	35.0	35.6	32.4	26.1
Agricultural sciences	100.0	21.2	20.3	32.5	33.6	46.3	46.1
Biological sciences	100.0	27.5	29.8	35.5	34.0	37.0	36.2
In universities and colleges	100.0	23.2	27.5	36.2	34.3	40.6	38.2
In medical schools	100.0	36.2	34.3	34.0	33.5	29.9	32.2
Medical sciences	100.0	23.2	27.3	36.5	34.6	40.3	38.1
In universities and colleges	100.0	18.1	24.0	40.1	35.1	41.8	40.8
In medical schools	100.0	25.2	28.4	35.1	34.4	39.7	37.1
Psychology	100.0	23.2	20.5	43.7	46.6	33.1	33.0
Social sciences	100.0	14.8	17.2	47.7	45.0	37.5	37.8
Other sciences, n.e.c.	100.0	15.9	36.0	47.5	36.4	36.6	27.6

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS

in the proportion of research space needing repair/renovation were also very stable from 1988 to 1990. The only disciplines where the proportion of space reported as needing repair/renovation changed by more than 4 percentage points were the two smallest ones, which are most subject to statistical fluctuations caused by small changes: mathematics (where the proportion of space needing repair/renovation increased by 4.3 percentage points) and computer science (which showed a decrease of 6.3 percentage points). Neither of these differences is statistically significant.

Deferred Repair/Renovation

As noted previously, the amount and proportion of research space institutions assessed as needing repair or renovation were about the same in the 1990 survey as in the 1988 survey. However, repair/renovation costs and plans have changed considerably since the last survey, as detailed in Chapter 3. Consequently, the dollar amount of deferred repair/renovation (the estimated cost of the repair/renovation that is needed but not scheduled) has also changed, as summarized in Figure 12

As shown, institutions reported in 1988 that they planned to spend $0.76 billion for facilities repair/renovation in 1988-89. If all research space they reported to need repair/renovation were to receive it, at the same unit cost as the planned work, the total cost of all needed repair/renovation would have been $3.54 billion. The difference between needed and planned repair/renovation, $2.78 billion, may be viewed as an estimate of the unfunded backlog of needed work, i.e., the deferred repair/renovation.

Applying the same arithmetic to data reported in the 1990 survey leads to an estimate of $4.06 billion in deferred repair/renovation in 1990-91. This represents a 46-percent increase since 1988, and it implies that for each dollar of planned facilities repair/renovation in 1990-91, there will be an additional $4.25 of needed repair/renovation that will not be performed.

Deferred Construction

This section examines the extent to which institutions that have a perceived need for additional research space in a discipline (a) have set plans in motion to address the need through new facilities construction in the near future, or (b) have deferred their needed construction into the indefinite future.

Of the $3.5 billion in planned facilities construction in 1990-91 reported in Chapter 3, $2.6 billion (i.e., three-fourths) was found in disciplines (within institutions) where the current amount of research space was reported to be inadequate (Figure 13). The remaining one-fourth was planned in disciplines where the current amount of research space was not seen as inadequate. Presumably, the construction being planned in these latter situations is intended to modernize or upgrade the quality of the research space in a discipline, without necessarily increasing the overall amount of space.

If all institutions that reported an inadequate amount of research space in a discipline in 1990 had been able to develop plans to begin construction of additional research space in 1990 or 1991, at the same average cost per institution as that anticipated by the few institutions that actually do plan such construction projects, the total cost of the research space components of these would be $10.6 billion (Figure 13). Of this amount, only $2.6 billion in construction projects is actually being planned for 1990-91. The remainder, $8.0 billion in needed construction activity, is being deferred. At the time of the 1988 survey, the analogous figure was $5.8 billion of deferred construction. This implies that the dollar amount of deferred construction of academic research facilities has increased 38 percent from 1988 to 1990.

Another way of expressing this relationship is to note that, for each dollar of planned facilities construction spending in 1990-91, there will be an additional $3.11 of needed construction that will not be performed, up from $2.48 in the previous two-year period.

Figure 12
Trends in deferred repair/renovation of science/engineering research facilities: 1988 and 1990

1988 estimate of deferred repair/renovation in 1988-89:

44.0 million NASF	Amount of research space needing repair/renovation in 1988 (Appendix Table 5-1)
x $80.4 per sq. ft.	Unit cost of repair/renovation planned for 1988-89 (Figure 5)
$3.54 billion	Estimated cost of all needed repair/renovation
9.4 million NASF	Amount of planned repair/renovation in 1988-89 (Figure 5)
x $80.4 per sq. ft.	Planned unit cost (Figure 5)
$0.76 billion	Amount of planned repair/renovation
$2.78 billion	Deferred repair/renovation (needed - planned)

1990 estimate of deferred repair/renovation in 1990-91:

45.1 million NASF	Amount of research space needing repair/renovation in 1990 (Appendix Table 5-1)
x $111 per sq. ft.	Unit cost of repair/renovation planned for 1990-91 (Figure 5)
$5.01 billion	Estimated cost of all needed repair/renovation
8.6 million NASF	Amount of planned repair/renovation in 1990-91 (Figure 5)
x $111 per sq. ft.	Planned unit cost (Figure 5)
$0.95 billion	Amount of planned repair/renovation
$4.06 billion	Deferred repair/renovation (needed - planned)

Source: National Science Foundation, SRS

Figure 13
Trends in deferred construction of science/engineering research facilities: 1988 and 1990

1988 estimate:

	For institutions reporting an inadequate amount of research space in 1988 in a given discipline:
$2.3 billion	Cost of all construction projects planned for 1988 and 1989
$8.1 billion	Cost of all needed construction projects*
$5.8 billion	Deferred construction (need-plan)

1990 estimate:

	For institutions reporting an inadequate amount of research space in 1990 in a given discipline:
$2.6 billion	Cost of construction projects planned for 1990 and 1991
$10.6 billion	Cost of all needed construction projects*
$8.0 billion	Deferred construction (need-plan)

* Estimates were derived by multiplying the per institution average cost of planned construction (for institutions that reported they need additional research space in a discipline and plan new construction projects in the discipline) by the total number of institutions reporting insufficient current research space. These estimates were computed separately by institution type within discipline and were then aggregated to national totals.

Source: National Science Foundation, SRS

These deferred construction figures are minimal estimates. They reflect deferred needs for facilities expansion, but not deferred needs for upgrading and modernization of research facilities. If unmet needs for qualitative improvement of research facilities could be measured and added in, the estimated total amount of deferred construction would undoubtedly increase.

6. RESEARCH FACILITIES AT HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

Highlights

- There was about a 30-percent net increase in the total amount of research space in historically black colleges and universities (HBCUs) between 1988 (1,111,700 square feet) and 1990 (1,439,600 square feet). However, HBCUs still account for only 1 percent of all academic research space.

- Agriculture had the largest amount of research space of all the S/E disciplines, and had a marked increase from 23 percent to 30 percent of all HBCU research space between 1988 and 1990.

- HBCUs reported high levels of research facility construction activity for 1986-87, with project starts in that period involving the equivalent of 43 percent of all existing research space at these institutions. New construction starts in 1988-89 involved less space (the equivalent of 22 percent of existing research space), but were still at a level far above the national average for all academic institutions. Projected construction for 1990-91 is lower still, at a level (6 percent of existing space) comparable to other institutions. This high level of construction activity in 1986-89 accounts for the overall net increase in research space at HBCUs.

- HBCUs obtained about 80 percent of their research facilities construction and repair/renovation funding from government sources. HBCUs, which are predominately public and non-doctorate-granting, were not different from other public non-doctorate-granting institutions in this respect. However, the Federal government contributed a larger share of new construction funding for HBCUs (64 percent of the total) than for public non-doctorate granting institutions in general (6 percent). Conversely, state/local government contributed less to HBCUs for new construction (21 percent of the total) than to public non-doctorate granting institutions in general (82 percent).

- Facility condition and adequacy ratings are generally more positive than were seen in most other institution categories. This is consistent with the finding that HBCUs have had significant facilities construction activity over the last several years.

Introduction

This chapter examines recent trends in S/E research facilities at historically black colleges and universities (HBCUs). As defined by the National Advisory Committee on Black Higher Education and Black Colleges and Universities, there are a total of 107 HBCUs in the nation. These institutions were founded primarily for black Americans, although their charters were generally not exclusionary. Most HBCUs were founded in the period 50 to 100 years ago.

HBCUs continue to play a significant role in the training of black scientists and engineers. About 30 percent of the black Americans who earned S/E doctorate degrees in 1986-88 received their undergraduate training at HBCUs, and HBCUs account for a similar percentage of all S/E baccalaureate degrees earned by black Americans.[14]

Of the 107 HBCUs, there are 29 that are located in the continental United States and that reported separately budgeted R&D expenditures in NSF's FY 1983 R&D expenditures study. In 1988, these institutions accounted for about 1 percent of all separately budgeted R&D expenditures at academic institutions.[15] They accounted for 0.5 percent of all science/engineering doctorate degrees awarded in 1989.[16] All 29 of these institutions were included in both the 1988 and 1990 facilities surveys, and they are the subject of this chapter.[17] Of these 29 HBCUs, 22

[14] Hill, Susan T., "Factbook Blacks in Undergraduate Science/Engineering Education," National Science Foundation, SRS, July 1990 (unpublished paper).

[15] National Science Foundation, Academic Science/Engineering R&D Funds: Fiscal Year 1988, NSF 89-326, Washington, DC 1990.

[16] National Science Foundation, Early Release of Summary Statistics on Science and Engineering Doctorates, 1989, March 1990.

[17] In addition to hese 29 HBCUs, 40 other HBCUs have recently been identified by NSF as being involved in S/E research These latter institutions were identified too late for inclusion in the current survey, but NSF intends to represent them in future cycles of the study. Although these additional HBCUs are comparatively large in number, examination of Federal obligations data suggests that they collectively may account for only 10 to 15 percent of the sponsored research being conducted

are public institutions, and 25 are non-doctorate-granting.

Among the 107 HBCUs, the 29 surveyed institutions include all of the top 12 HBCU recipients of Federal R&D support in FY 1988, and they collectively account for 81 percent of all FY 1988 Federal obligations to HBCUs for R&D.[18] This suggests that, although there are many smaller research-performing HBCUs that are not represented in the current study, most sponsored research at HBCUs is being represented at the surveyed institutions.

It is important to realize the limitations of such a small number of institutions when analyzing these data. Large fluctuations for any selected parameter may be observed due to relatively small amounts of space and small numbers of space-related capital projects. Also, with only 29 institutions in the group, it is possible that one or two institutions can significantly affect the data as a whole, particularly data for a single year or discipline. On the other hand, the HBCU data are not subject to the usual sampling errors. The data were obtained from all HBCUs with reported R&D expenditures in fiscal year 1983, and the 1990 survey data were obtained from the same group of institutions. Thus, except insofar as reporting errors are involved, changes from 1988 to 1990 must be presumed to be real.

Amount of Research Space Available

HBCUs currently report 1.4 million net assignable square feet (NASF) of space used for organized research in the sciences and engineering up by 29 percent from 1.1 million in 1988 (Table 20). This represents about 1.2 percent of the 116 million R&D NASF at all research institutions, up slightly from 1.0 percent in 1988. Within these HBCUs, 23 percent of the total science and engineering NASF is assigned for organized research, an increase from 18 percent of total NASF in 1988. The average (mean) amount of research space at these 29 institutions is 49,700 NASF of S/E research space per institution, compared to 38,300 square feet in 1988, or an increase of about 30 percent.

Table 20 Total amount of space and amount of R&D space assigned to science/engineering disciplines at historically black colleges and universities: 1988 and 1990

Index	1988	1990
	(NASF in thousands)	
Total S/E space	6,077	6,175
R&D space	1,112	1,440
Mean amount of R&D space per institution	38.3	49.7
R&D space as a percent of total S/E space	18%	23%

Source: National Science Foundation, SRS

The distribution of R&D space across disciplines in 1990 was similar to the 1988 distribution (Table 21). Agriculture had the largest proportion of all disciplines for S/E research NASF among HBCUs, as was also the case in 1988. However, the proportion of the total research space represented by agriculture increased markedly from 23 percent (259,000 NASF) in 1988 to 30 percent (433,000 NASF) in 1990. This increase (174,000 NASF) accounted for over half of the total growth in HBCU research space from 1988 to 1990.

Table 21 Distribution of research space at historically black colleges and universities by discipline: 1988 and 1990

Discipline	1988	1990
Total R&D NASF (in thousands)	1,112	1,440
	(Percent of total)	
Engineering	14	12
Physical sciences	16	13
Environmental sciences	1	2
Mathematics	1	2
Computer science	4	2
Agricultural sciences	23	30
Biological sciences	21	20
In colleges and universities	13	12
In medical schools	8	8
Medical sciences	16	14
In colleges and universities	3	3
In medical schools	13	11
Psychology	1	1
Social sciences	3	3
Other sciences, n e c	<1	<1

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

at HBCUs For additional details about these institutions, see Appendix A (Technical Notes)

[18] National Science Foundation, Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Fiscal Year 1988, NSF 89-325, Washington, DC, 1989, Table B-24

New Construction

In 1986 and 1987, historically black institutions broke ground for $71.8 million in new construction projects, involving 481,200 square feet of research space (Table 22). In 1988 and 1989, new construction projects totalling a somewhat lower $55.1 million and involving 318,600 square feet of new space were initiated. This represents a 23-percent reduction in new construction expenditures over this two-year period, and a 34-percent decrease in square footage being developed. Further reductions are planned for the 1990-91 period, where only $11.6 million in new construction involving 82,300 NASF are anticipated.

Compared to other academic institutions, research facility construction activity at HBCUs was extremely high during 1986-87. The research space involved in construction projects begun in these two years alone was equivalent to 43 percent of the total research space that had been accumulated at HBCUs up to that time. The analogous figure for all academic institutions was 9 percent (see Chapter 2). The level of HBCU research facilities construction in 1988-89, while lower than it had been in the previous two years, was the equivalent of 22 percent of the existing HBCU research space and was still much higher than the overall national average. No doubt, the very high level of construction activity at HBCUs in the 1986-89 period accounts for the previously noted 30-percent net increase in HBCU research space from 1988 to 1990.

Table 22 Research facilities construction activity at historically black colleges and universities 1986-91

Index	Year of project start		
	1986 or 1987 (actual)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total cost for R&D components (in millions of dollars)	71 8	55 1	11 6
Total research NASF (in thousands of square feet)	481 2	318 6	82 3
NASF as a percent of existing R&D space .	43%	22%	6%

Source National Science Foundation, SRS

Repair/Renovation

While HBCUs showed a marked decline in new construction from 1986-87 to 1988-89, spending for facilities repair and renovation remained fairly stable. The dollar amount increased from $14.1 million in 1986-87 to $16.6 million in 1988-89, and it is projected to remain stable ($15.6 million) in 1990-91 (Table 23).

The amount of space involved in HBCU repair/renovation projects in 1986-87 was equivalent to 12 percent of their R&D space at that time. This is the same as the overall total for all R&D-performing academic institutions. Similarly, the space involved in projected repair/renovation in 1990-91 (9 percent of total R&D space) is also essentially the same as the all-institution total. In 1988-89, however, 21 percent of R&D space at HBCUs was reported to be under repair or renovation. This high space figure seems to be an anomaly, apparently reflecting the influence of specific projects that involved minor repairs or renovations affecting large amounts of research space (e.g., roof repairs at several research buildings). Such data fluctuations are inevitable when only a small number of institutions are being studied; a single large project at one institution can be sufficient to cause a noticeable spike in the data.

Table 23. Research facilities repair/renovation activity at historically black colleges and universities: 1986-91

Index	Year of project start		
	1986 or 1987 (actual)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total cost for R&D components (in millions of dollars)	14 1	16 6	15 6
Total research NASF (in thousands of square feet)	137 1	308 4	130 4
NASF as a percent of existing R&D space	12%	21%	9%

Source National Science Foundation, SRS

Sources of Funds

HBCUs, which are predominantly public and non-doctorate-granting, obtained upwards of 80 percent of their research facilities construction and repair/

Table 24 Sources of funds for science/engineering research facilities projects at historically black colleges and universities: 1986-1991

Funding sources	New construction			Repair and renovation		
	1986 and 1987 (actual)	1988 and 1989 (actual)	1990 and 1991 (plan)	1986 and 1987 (actual)	1988 and 1989 (actual)	1990 and 1991 (plan)
	(Dollars in millions)					
Total	71 8	55.1	11 6	14 1	16 6	15.6
Federal government	32 7	35 0	0.1	8 7	12 9	0 6
State/local government	25 8	11 5	11 4	4.9	0 8	14 3
Private donations	11 1	7 7	0 0	0 5	2 0	0 4
Institutional funds	2 3	0 9	0 0	0 0	0.1	0.0
Debt financing	0 0	0 0	0 0	0.0	0.0	0 3
Tax-exempt bonds	0 0	0 0	0.0	0 0	0.0	0.3
Other debt	0 0	0 0	0 0	0 0	0.0	0.0
Other sources	0 0	0 0	0 0	0 0	0 0	0.0

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

renovation funding in 1986-89 from government sources, as did public non-doctorate-granting institutions in general (Table 24). However, during this period, the Federal government played a more prominent role in funding facilities construction at HBCUs (where it accounted for 64 percent of the total) than it did for public non-doctorate-granting institutions in general (6 percent). Conversely, state/local government was a less prominent funding source for HBCUs in this period (accounting for 21 percent of their total construction funding) than for public non-doctorate-granting institutions in general (where it accounted for 82 percent of the total).

For the 1990-91 period, HBCUs projected about the same level of construction project funding support from state/local government sources as they had received in 1988-89 ($11.4 million and $11.5 million, respectively), and they projected a large increase in state/local government support for repair/renovation projects ($14.3 million in 1990-91, as compared to $0.8 million in 1988-89). For both types of activities, however, they projected almost no Federal support for the 1990-91 period. This may be an anomalous data fluctuation. However, the anomaly pertains not just to HBCUs but also to the larger group of public non-doctorate-granting institutions in general, none of which projected any Federal facilities funding support for construction in 1990-91 (see Appendix Table 4-2).

Condition and Adequacy of Research Facilities

The reported condition of science and engineering research facilities at HBCUs changed very little from 1988 to 1990. The percentage of R&D space rated as being "suitable for use in the most highly developed and scientifically sophisticated research in its field" declined very slightly, from 36 percent to 31 percent, and the percentage assessed as being "effective for most purposes but not applicable to [the above] category" increased, equally slightly, from 39 percent to 45 percent (Table 25). The amount of R&D space assessed as needing limited or major repair/renovation remained constant at 25 percent.

Similarly, little change was seen in the assessed adequacy of the amount of R&D space at HBCUs. Aggregating ratings across disciplines, 65 percent of HBCUs assessed their research space as being "adequate" or "generally adequate" in 1990, as compared to 69 percent in 1988. This slight difference represents a change of only one institution.

Table 25 Condition and adequacy of research facilities at historically black colleges and universities. 1988 and 1990

Index	1988	1990
Condition of research facilities	(Percent of R&D space)	
Total	100	100
Suitable for most highly developed and scientifically sophisticated research	36	31
Effective for most purposes	39	45
Requiring limited repair or renovation	18	18
Requiring major repair or renovation	7	7
Amount of research space	(Percent of institutions)	
Total	100	100
Adequate	16	16
Generally adequate	53	49
Inadequate	30	35

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

These condition and adequacy ratings for HBCUs are somewhat more positive than those discussed in Chapter 5 for most other institution categories. This is consistent with the finding of significant facilities construction activity at HBCUs in the 1986-89 period, which has created relatively large amounts of relatively new research facilities at these institutions.

APPENDIX A
TECHNICAL NOTES

TECHNICAL NOTES

This section describes the study methodology, including the universe and sample, survey questionnaire, data collection procedures, and response rates. The discussion includes both the original 1988 survey and the current 1990 survey. In addition, there is a discussion of the study's weighting and estimation procedures, of the reliability of the survey estimates, and of other considerations the reader should bear in mind when interpreting the data presented in this report.

Universe and Sample

1988 survey. The 1988 survey was designed to provide estimates for all research-performing academic institutions, as defined in NSF's FY 1983 Survey of Scientific and Engineering Expenditures at Universities and Colleges.[1] The FY 1983 Expenditures Study universe datafile included all universities and colleges that offered a master's or doctoral degree in the sciences and engineering (S/E), all others that had reported separately budgeted S/E research and development (R&D) expenditures of $50,000 or more, and all historically black colleges and universities (HBCUs) reporting any R&D expenditures. This file represented the most recent available universe survey of R&D expenditures at academic institutions. The file contained a total of 566 institutions.

All historically black colleges and universities in the frame were included in the sample with certainty (N = 30), and a stratified probability sample of 223 institutions was selected from among the remaining institutions in the frame. These institutions were first stratified by control (public versus private) and highest degree awarded in science/engineering (doctorate-granting versus non-doctorate-granting). A minimum sample size of 25 was set for each of the four resulting strata, and the remaining sample size was allocated to strata in proportion to the "size" of each stratum. Stratum size was defined as the square root of the aggregate R&D expenditures in science and engineering of the institutions in the stratum. Academically administered Federally Funded Research and Development Centers were excluded from this survey.

Within strata, institutions were sampled with probability proportionate to size. Again, size was defined as the square root of the institution's FY 1983 R&D expenditures. This design ensured solid representation in the sample of each of the four analytic strata and heavy representation of the larger R&D-performing institutions; at the same time, it also ensured moderate representation of institutions with relatively small S/E research programs.

Following the selection of an initial sample of 253 institutions, NSF determined that several of the sampled institutions were out of the scope of the survey. Out-of-scope institutions included those in outlying territories, military academies, and three highly specialized institutions considered inappropriate, given the nature of their programs. With the elimination of these out-of-scope cases, the final sample size was reduced to 247 institutions, of which 29 were HBCUs, and 99 had (or were) medical schools. The resulting weighted national total represented by this sample is 525 institutions.

The institution sample included all of the 50 largest R&D performers and 98 of the top 100. The sampled institutions accounted for more than 75 percent of all academic R&D expenditures in FY 1983 and at least 70 percent of the R&D spending in each major S/E discipline.

1990 survey. The institution sample for the 1990 survey was the same as for the 1988 survey, with the following exceptions:

The sample was updated to reflect recent R&D patterns as shown in NSF's FY 1988 R&D expenditures study, which collected expenditures data for all institutions in the survey frame for the first time since FY 1983. School-by-school comparisons of these two databases resulted in the identification of 12 institutions whose FY 1988 R&D expenditures would have given them substantially higher probabilities of selection than they had using FY 1983 expenditures. These 12 institutions were made certainty selections for the 1990 survey. Five were already in the sample, having been noncertainty selections in the 1988 study; the other seven were added to the sample for the 1990 survey.

Between the 1988 and 1990 surveys, two minor changes occurred within the 1988 sample: one

[1] Although this report deals only with academic institutions, the study also collected data from samples of nonacademic performers of biomedical research (see The Status of Biomedical Research Facilities 1988, National Institutes of Health, 1989)

sampled institution merged with another (unsampled) institution and thus became larger, and another institution became out of scope when it distributed its assets among other institutions in the same state system.

These sample changes produced a net increase of 6 institutions from the 1988 to 1990 surveys: from 247 to 253 institutions. The universe represented by the sample, however, did not change.

In addition to the changes noted above, an effort was made to review and expand the HBCU (historically black colleges and universities) component of the sample. After receiving information indicating that more HBCUs perform S/E research than the 29 that were represented in the 1988 survey, NSF undertook a telephone survey of all other HBCUs and identified an additional 40 with ongoing research. Although this information did not become available until midway through the 1990 study's data collection period, a supplemental sample of 9 of these 40 institutions was selected, and efforts were made to collect questionnaire data from them on an expedited basis.

Only 3 of these institutions were able to respond within the study's remaining time frame for data collection, and this was determined to be inadequate to represent the 40 newly identified HBCUs. Therefore, the HBCU sample for the 1990 study consists of the same 29 institutions that were surveyed in the 1988 study. These 29 institutions include all of the top 12 HBCU recipients of Federal R&D support in FY 1988, and they collectively account for 81 percent of all FY 1988 Federal obligations to HBCUs for R&D.[2] This suggests that, although there are many smaller research-performing HBCUs that are not represented in the current study, most sponsored research at HBCUs is being represented at the surveyed institutions.

The Survey Questionnaire

Prior to the 1988 survey, the National Science Foundation developed a draft research facilities questionnaire, in consultation with several universities and associations. During a workshop with several higher education associations and university representatives in the spring of 1987, the definitions and questionnaire items were revised. The questionnaire was then pretested during site visits to a group of 22 institutions. NSF and contractor personnel met with institutional administrators and staff to discuss the definitions, questions, and survey procedures. Institutional administrators and staff included vice presidents for research, directors of sponsored research, facilities and budget administrators, institutional research directors, science and engineering deans, department chairs, and principal investigators. Advisory panel members also participated in several of the pretest site visits. After completion of the pretest phase, recommended questionnaire improvements were presented to the associations, university representatives, and the project's advisory panel, prior to implementation in the 1988 survey.

There was little difference between the 1988 and 1990 survey questionnaires. Some modifications were made to the questionnaire to clarify and emphasize key instructions. Additional detail was added to the "sources of funds" questions to gather needed information on specific private sources. The column on toxic waste facilities (Item 3) was condensed to a single item as a result of information from institutions that such facilities are generally central rather than discipline-specific. Finally, the data for main institutions and associated medical schools, which were collected on separate questionnaires in 1988, were combined into one questionnaire for the 1990 survey.

The 1990 survey questionnaire requested the following information:

- The total net assignable square feet (NASF) of space in science and engineering disciplines, and the NASF used for organized research;
- The amount of research space that is leased by the institution and the amount housed in temporary facilities;
- The condition of research facilities in each science/ engineering (S/E) discipline;
- The adequacy of selected aspects of research facilities, by discipline;

[2] From Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Fiscal Year 1988, National Science Foundation, NSF 89-325, 1989 Table B-24

- The project costs, NASF, and sources of funds for repair/renovation and new construction activities initiated in 1988 and 1989, and planned for 1990 and 1991;
- The status of the institutions relative to the cap on tax-exempt bonds (this item is applicable to private universities and colleges only); and
- A narrative description of the institution's facilities needs and factors that drive facilities costs.

Data Collection and Response Rates

In June 1989, a letter from Mr. Erich Bloch, Director, NSF, and Dr. James Wyngaarden, Director, NIH, was sent to the president or chancellor of each sampled institution, asking them to participate in the study and to name a coordinator for the survey. A few days following the two-week deadline for returning the coordinator identification card, telephone followup was conducted with all sampled institutions that had not yet identified a survey coordinator. Survey materials were mailed to the coordinators during late August, with a requested return date of October 16. 1989. Receipt of the survey materials was confirmed by telephone during the first week of September. A letter reminding coordinators of the requested return date was sent in late September. Nonresponse followup was conducted between October 16, 1989 and January 31, 1990.

After the questionnaires were edited, additional followup was conducted to resolve questions or problems with the survey responses ("data retrieval"). This extensive followup was required because of the complexity of the instrument. Many unfinished items were completed during this data retrieval process. In addition, a followup was conducted to resolve disparities between 1988 and 1990 responses. Where possible, the data retrieval and cross-year review were done at the same time.

After data collection, additional site visits were conducted, during which NSF and contractor staff members met with survey respondents to discuss the questionnaire, interpretation and reliability of the data provided, and the survey procedures. The purposes of these visits were (1) to obtain information about the data provided to assist in the analysis of the findings, and (2) to obtain information that could be used in planning for the 1992 survey

The overall response rate for the survey was 94 percent. As Table A-1 indicates, response rates were quite high for all categories. All of the institutional categories achieved response rates of over 90 percent. Response rates for public and private institutions were similar for this survey. Finally, although non-doctorate-granting institutions have much less research space than doctorate-granting institutions, both types of institutions showed a high degree of willingness to participate.

Table A-1 Academic research facilities survey response rates by type of institution 1990

Institution type	Sample	Responses	
		Number	Percent
Total	253	237	94
Doctorate-granting	176	166	94
Non-doctorate-granting	77	71	92
Public	159	151	95
Private	94	86	91
Historically black colleges and universities	29	29	100

Item Nonresponse

As a result of the extensive data retrieval activities conducted during the 1990 survey, 89 percent of the returned questionnaires ultimately contained respondent-provided information for all applicable questions. Consequently, overall nonresponse rates for individual questionnaire items were extremely low. For example, question 1A on total assigned space and total R&D space by S/E discipline had an overall item nonresponse rate of only 0.2 percent.

The highest levels of item nonresponse were obtained for question 2 on condition of R&D facilities (1.0 percent) and question 3 on adequacy of selected aspects of R&D facilities (1.1 percent). All other questionnaire items had nonresponse rates below 1 percent.

Altogether, there were 647 missing values in the 1990 database, out of a total of 140,179 data elements. These missing values were imputed. For questions 1, 2, and 3, imputations were made primarily on the basis of information from the school's 1988 questionnaire. In questions 4, 5, and 6 (on new

construction and repair/renovation), all item nonresponse problems involved only partial missing data: either the project square footage was reported and the project cost was missing, or the reverse. In these cases, the missing element of information was imputed from the reported element, using 1988 data on average cost per square foot either to impute missing project cost from reported project square feet or to impute in the opposite direction.

Weighting

After data collection, sampling weights were created for use in preparing national estimates from the data. The weighting procedures used were very similar to those employed in the 1988 study. The first stage of the process was the creation of a base weight for each institution. The base weight is the inverse of the probability of selecting the institution for the sample. Since all the sampled institutions did not participate in this study, the base weights were adjusted to account for this unit nonresponse. An additional adjustment of the weights was made to bring the number of estimated institutions into accordance with the known number of institutions in various categories. For this final "poststratification" adjustment, the institutions were classified by Top 100, Level (Highest Award), Control (Public or Private), and Historically Black Colleges and Universities. The poststratified weights were used to produce the estimates shown in this report.

Reliability of Survey Estimates

The findings presented in this report are based on a sample and are therefore subject to sampling variability. Sampling variability arises because not all institutions are included in the study. If a different sample of institutions had been selected, then the results might have been somewhat different. The standard error of an estimate is a statistic that can be used to measure the extent of sampling variability for that particular estimate.

One of the ways that the standard error can be used to measure the amount of sampling variability is in the construction of confidence intervals. If all possible samples were selected and surveyed under similar conditions, then the intervals of 2 standard errors below the estimates to 2 standard errors above the estimates would include the average result of these samples in about 95 percent of the cases. Since only one sample is actually selected and surveyed, we must estimate the standard error from the sample itself. The interval constructed using the estimated standard error from the sample is called a 95 percent confidence interval. Estimated standard errors for 1988 and 1990 selected statistics and the difference between the years are shown in Table A-2.

The standard errors for this study were estimated using a replication method called the jackknife repeated replication method. In essence, the sample is divided into 11 replicates, and estimates are produced for each replicate. The variability among these replicate estimates is then used to estimate the standard error.

This method of variance estimation is particularly useful in this study for measuring the fact that a large fraction of the sampled institutions from the 1988 study were also included in the 1990 study. Since most of the reports of the institutions between the two times are positively correlated, the estimated differences have smaller standard errors than independent or uncorrelated samples. The jackknife method incorporates this information and produces estimates of standard errors that are appropriate for this overlapping design.

Data Considerations and Limitations

In addition to sampling errors, survey estimates can be adversely affected by nonsampling errors. Errors of this type include those resulting from reporting and processing of data. In this survey, extensive followup with respondents was used to ensure that the data were as accurate as possible. This included cross-year review which verified inconsistencies between the current year and 1988. Where appropriate (e.g., to correct earlier reporting errors), revisions to the 1988 data were made. Thus, 1988 totals in this report may differ slightly from those in the 1988 report.

Research Square Footage. The definition of organized research, as specified in OMB Circular A-21 (the form used for calculation of indirect costs) was used in this survey. That definition is as follows: "**Organized research** *means all research and development activities of an institution that are separately budgeted and accounted for. It includes:* (1) **Sponsored research** *means all research and development activities that are sponsored by Federal*

Table A-2 Standard errors for selected estimates

Statistic	Total		Doctorate-granting						Non-doctorate		Public		Private	
			Total		Top 100 in R&D		Other							
	Estimate	S E	Estimate	S E	Estimate	S E	Estimate	S E	Estimate	S E	Estimate	S E	Estimate	S E
Total research square footage (in thousands)														
1988	112,062	1,864	107,443	2,004	80,627	1,419	26,815	2,019	4,619	437	82,384	1,627	29,678	868
1990	116,327	4,054	111,166	4,092	81,659	1,327	29,508	3,574	5,161	485	86,880	3,538	29,447	1,591
Difference (90-88)	4,265	3,586	3,723	3,659	1,032	2,533	2,693	3,659	542	205	4,496	3,026	-231	1,385
Percent change	4	3	3	3	1	3	10	10	12	5	5	4	-1	5
Repair/renovation cost (dollars in millions)														
1986-87	838	60	793	58	596	10	197	59	45	8	436	38	402	27
1988-89	1,010	265	979	264	483	12	496	259	30	15	699	266	311	18
Difference	172	269	186	267	-113	18	299	261	-15	22	263	265	-91	35
Percent change	20	32	23	33	-19	3	152	155	-33	38	60	61	-23	7
Repair/renovation NASF (in thousands)														
1986-87	13,431	1,305	12,841	1,345	9,124	304	3,717	1,299	590	90	8,745	1,196	4,685	528
1988-89	11,449	576	10,993	488	7,781	179	3,212	464	456	229	8,223	473	3,226	237
Difference	-1,982	1,343	-1,848	1,252	-1,343	351	-505	1,276	-134	251	-522	1,233	-1,459	384
Percent change	-15	9	-14	9	-15	3	-14	40	-23	40	-6	15	-31	5
New construction cost (dollars in millions)														
1986-87	2,051	73	1,888	72	1,599	64	288	53	163	19	1,355	36	696	75
1988-89	2,464	128	2,315	131	1,558	34	757	114	150	56	1,727	108	38	62
Difference	414	140	427	128	-41	83	469	127	-13	60	372	102	42	84
Percent change	20	7	23	7	-3	5	163	66	-8	36	27	7	6	12
New construction NASF (in thousands)														
1986-87	9,922	387	8,908	401	7,261	215	1,647	407	1,014	117	7,344	223	2,578	271
1988-89	10,647	851	9,840	776	6,673	86	3,767	747	807	337	8,115	805	2,532	153
Difference	726	903	932	765	-1,188	242	2,120	881	-207	366	771	772	-46	244
Percent change	7	9	10	9	-16	3	129	82	-20	35	10	10	-2	9

Table A-2 Standard errors for selected estimates (continued)

Statistic	Condition							
	Suitable for sophisticated research		Effective for most purposes		Needs limited repair/renovation		Needs major repair/renovation	
	Estimate	S E	Estimate	S.E	Estimate	S.E	Estimate	S.E.
Amount of research space (NASF in thousands)								
1988 .	26,793	836	41,114	1,175	26,264	646	17,702	397
1990	30,135	1,239	41,072	1,794	27,047	914	18,073	983
Percent change	12	3 0	-1	1 6	3	1 5	2	2.2
Percent of research space								
1988	24	8	37	5	23	4	16	3
1990.	26	9	35	6	23	3	16	5

and non-Federal agencies and organizations... (2) **University research** *means all research and development activities that are separately budgeted by the institution under an internal application of institutional funds."* Space information based on OMB Circular A-21 is available at many institutions, and that is the reason for using the A-21 definition in this study. However, the definition excludes departmental research that is not separately budgeted and accounted for. Therefore, research space reported on this survey may underestimate total research space at some institutions. For example, because one of the primary missions of non-doctorate-granting institutions is research training and instruction, much of the space used for these purposes is not "primarily devoted to research" and as such may be multi-use space not classified as research space.[3] When a number of respondents were asked to quantify the magnitude of the underestimate, most confirmed that the overall extent of the underestimate was less than 10 percent.

Institutions' facilities recordkeeping systems vary considerably. In general, public institutions are more likely than private ones to have central computerized facilities inventories that allow more accurate reporting of square footage data. Larger private institutions, however, generally do have such systems, often based on space surveys conducted specifically for OMB Circular A-21. Those institutions with smaller research programs do not calculate square footage for OMB Circular A-21, and are less likely to include estimates of the square footage used for organized research in their records. In such cases, the institutions estimated the data for this survey. Table A-3 shows the distribution of sources used by the institutions to report square footage. The percentages sum to more than 100, since some institutions used more than one source in compiling the information.

Capital Projects Involving Research Facilities. Relatively few institutions maintain information on repair, renovation, and construction projects that relate specifically to research facilities. Many capital projects involve both research and nonresearch space. As a result, institutions had to estimate the proportion of a given project that was related to research facilities when the project was not exclusively for research. A guideline for this purpose was included in the questionnaire instructions as follows: *For multi-purpose facilities, prorate the costs to reflect the proportion of R&D space involved in the projects (e.g., if 20 percent of the space involved is used for organized research, report 20 percent of the total project completion costs).*

Table A-3 Sources of square footage data 1988 and 1990

Source	Percent	
	1988	1990
A-21 space survey	32	26
A-21 proportional calculation based on R&D salaries and wages	3	2
Facilities inventory based on Facilities Inventory and Classification Manual	27	27
Facilities inventory not based on FICM	28	30
Other sources	27	30

Note "Other sources" included departmental surveys conducted specifically for this study, reviews of university or college architectural drawings or plans, and other methods.

Some projects, such as whole-building renovations or new construction, may take more than one year to complete, and other projects may overlap fiscal years. Projects were allocated to the year in which construction activity began or will begin (e.g., groundbreaking).

Because institutions use different dollar values to identify "major projects," this survey established a guideline to ensure consistency of reporting. Projects with costs of $100,000 or more **associated with R&D facilities** were included.

Condition and Adequacy of Research Facilities. A number of respondents stated that reports of the condition of facilities and the adequacy of selected aspects of facilities are, by their very nature, subjective. Two persons may have different assessments of the same facility, or different opinions of what is required in order for a facility to be suitable for a particular type of research. Despite the subjectivity involved, these items do capture an overall picture of the current status of facilities. Discussions with a number of institutions indicated that, for the most part, deans in consultation with department chairs reported on the condition and adequacy of facilities. A few institutions indicated that they have detailed condition data on a central

[3] Modernizing Academic Research Facilities A Comprehensive Plan, National Science Foundation, June 1989

database. In those cases, the facilities office was able to respond to these items.

A small number of institutions indicated that it is conceptually difficult to assess the condition of a research facility without including instrumentation in that assessment. Most respondents, however, indicated that they had no such problem, and were able to report on the condition of the "bricks and mortar."

Cost per Square Foot Data. The study did not collect unit cost data for individual construction or repair/renovation projects, just the aggregate R&D-related costs and the aggregate R&D-related space involved in all projects begun during specified periods. These aggregates can be combined into indices of average cost per square foot, which are useful in tracking broad cost trends over time. However, they are of very little practical value as guidelines for project planning. By all accounts, unit costs for both construction and repair/renovation projects are highly variable, depending on the specific requirements of the particular project and and on many other factors as well (e.g., geographic region of the country). Such differences, which are of crucial importance in project planning, are obscured in the kinds of averages that can be constructed from this study's data.

Institution Variability in Research Space

Both within and between institution categories, considerable variation exists in the total amount (NASF) of S/E research space. This variation is summarized in Table A-4, which presents weighted estimates from the current survey.

Table A-4 Institution variability in amount of research space for major institution groupings: 1990

Statistic	All institutions	Institution type			Control		HBCUs
		100 largest in R&D	Other doctorate-granting	Non-doctorate-granting	Private	Public	
Number of institutions	525	100	193	232	206	319	29
Mean research NASF	221,520	817,000	152,850	22,410	142,720	272,410	49,640
Median research NASF	51,450	623,760	116,520	16,300	28,940	84,800	29,160
Distribution of research NASF	(percent of institutions)						
Total	100	100	100	100	100	100	100
Under 5,000	10	0	3	21	10	10	7
5,000-9,999	8	0	3	14	11	6	10
10,000-24,999	15	0	2	34	25	9	28
25,000-49,999	15	0	10	23	16	13	10
50,000-99,999	12	0	27	6	9	14	28
100,000-249,999	14	7	33	2	13	16	17
250,000-499,999	13	27	21	0	7	16	0
500,000-999,999	7	39	0	0	7	8	0
1,000,000-1,499,999	4	14	1	0	1	5	0
1,500,000-2,599,174	2	13	0	0	1	3	0

Source: National Science Foundation, SRS

APPENDIX B

LIST OF SAMPLED INSTITUTIONS

Public, Doctorate-granting Institutions

	University of Alaska at Fairbanks	AK
*	University of Alabama at Birmingham	AL
	University of South Alabama	AL
	University of Alabama (1990 only)	AL
	University of Alabama at Huntsville (1990 only)	AL
*	Auburn University	AL
	University of Arkansas at Fayetteville	AR
	University of Arkansas Medical Sciences Campus	AR
	University of Arizona	AZ
	San Diego State University	CA
	University of California Field Stations	CA
*	University of California at Berkeley	CA
*	University of California at Davis	CA
*	University of California at Irvine	CA
*	University of California at Los Angeles	CA
*	University of California at Riverside	CA
*	University of California at San Diego	CA
*	University of California at San Francisco	CA
*	University of California at Santa Barbara	CA
	University of California at Santa Cruz	CA
*	Colorado State University	CO
*	University of Colorado - Boulder	CO
*	University of Colorado - Health Science Center	CO
	University of Colorado - Colorado Springs	CO
	University of Colorado - Denver	CO
*	University of Connecticut	CT
	University of Delaware	DE
*	Florida State University	FL
*	University of Florida	FL
	Medical College of Georgia	GA
*	University of Georgia	GA
*	Georgia Institute of Technology	GA
*	University of Hawaii at Manoa	HI
*	Iowa State University of Science and Technology	IA
*	University of Iowa	IA
	University of Idaho	ID
	Southern Illinois University at Carbondale	IL
*	University of Illinois at Urbana	IL
*	University of Illinois at Chicago	IL
*	Indiana University	IN
*	Purdue University	IN
*	Kansas State University	KS
*	University of Kansas	KS
*	University of Kentucky	KY
*	Louisiana State University	LA

* Top 100 in R&D

	University of Southwestern Louisiana	LA
*	University of Massachusetts at Amherst	MA
*	University of Maryland Baltimore Professional Schools	MD
*	University of Maryland Baltimore County	MD
*	University of Maryland at College Park	MD
	University of Maine at Orono	ME
*	Michigan State University	MI
*	Wayne State University	MI
*	University of Michigan - Ann Arbor	MI
*	University of Minnesota	MN
	University of Missouri System Office (1988 only)	MO
*	University of Missouri at Columbia	MO
*	Mississippi State University	MS
	University of Southern Mississippi	MS
	University of Mississippi	MS
	Montana State University	MT
	East Carolina University	NC
*	North Carolina State University at Raleigh	NC
*	University of North Carolina at Chapel Hill	NC
	University of North Dakota	ND
*	University of Nebraska at Lincoln	NE
	University of Nebraska Medical Center at Omaha	NE
	University of New Hampshire	NH
*	Rutgers, the State University of New Jersey	NJ
	New Mexico Institute of Mining and Technology	NM
*	New Mexico State University	NM
*	University of New Mexico	NM
	SUNY Health Sciences Center at Brooklyn	NY
	SUNY at Binghamton	NY
	SUNY Health Sciences Center at Syracuse	NY
*	SUNY at Buffalo	NY
*	SUNY at Stony Brook	NY
	University of Nevada at Reno	NV
	Cleveland State University	OH
	Northeast Ohio University College of Medicine	OH
*	Ohio State University	OH
	Ohio University	OH
*	University of Cincinnati	OH
	Wright State University	OH
	University of Akron	OH
	Oklahoma State University	OK
*	University of Oklahoma	OK
*	Oregon State University	OR
*	Pennsylvania State University	PA
*	University of Pittsburgh	PA
	University of Rhode Island	RI
*	Clemson University	SC
	Medical University of South Carolina	SC

* Top 100 in R&D

	University of Tennessee Center for Health Sciences	TN
	Lamar University	TX
*	Texas A & M University	TX
	Texas Tech University	TX
*	University of Texas System Cancer Center	TX
*	University of Texas at Austin	TX
	University of Texas Health Sciences Center at San Antonio	TX
*	University of Texas Health Sciences Center at Dallas	TX
	University of Texas at El Paso	TX
	University of Texas Medical Branch at Galveston	TX
*	University of Utah	UT
*	Utah State University	UT
*	Virginia Commonwealth University	VA
*	University of Virginia	VA
*	Virginia Polytechnic Institute & State University	VA
	University of Vermont and State Agricultural College	VT
*	University of Washington	WA
*	Washington State University	WA
*	University of Wisconsin at Madison	WI
	University of Wisconsin at Milwaukee	WI
	West Virginia University	WV
	University of Wyoming	WY

Private, Doctorate-granting Institutions

*	California Institute of Technology	CA
	Loma Linda University	CA
*	Stanford University	CA
*	University of Southern California	CA
	Claremont Graduate School	CA
*	Yale University	CT
	George Washington University	DC
*	Georgetown University	DC
	Howard University	DC
	Nova University	FL
*	University of Miami	FL
	Atlanta University (1988 only)	GA
	Clark Atlanta (1990)	GA
*	Emory University	GA
	Mercer University	GA
	Morehouse School of Medicine	GA
	Illinois Institute of Technology	IL
*	Northwestern University	IL
*	University of Chicago	IL
	University of Notre Dame	IN
*	Tulane University	LA

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*Top 100 in R&D

	Boston College	MA
*	Boston University	MA
	Brandeis University	MA
*	Harvard University	MA
*	Massachusetts Institute of Technology	MA
*	Tufts University	MA
*	Woods Hole Oceanographic Institute	MA
	Worcester Polytechnic Institute	MA
*	Johns Hopkins University	MD
	Washington University	MO
	St. Louis University	MO
	Albany Medical College	NY
*	Duke University	NC
	Wake Forest University (1990 only)	NC
	Dartmouth College	NH
*	Princeton University	NJ
*	Columbia University Main Division	NY
	New York Medical College	NY
*	New York University	NY
	Polytechnic University	NY
	Rensselaer Polytechnic Institute	NY
*	Rockefeller University	NY
	St. John's University	NY
*	University of Rochester	NY
*	Yeshiva University	NY
*	SUNY Mt. Sinai School of Medicine	NY
*	Cornell University	NY
	Syracuse University	NY
*	Case Western Reserve University	OH
	University of Dayton	OH
*	Carnegie-Mellon University	PA
	Hannemann University	PA
	Thomas Jefferson University	PA
*	University of Pennsylvania	PA
	Brown University	RI
	Meharry Medical College	TN
*	Vanderbilt University	TN
	Southern Methodist University	TX
	Texas Christian University	TX
*	Baylor College of Medicine	TX
	Marquette University	WI
	Medical College of Wisconsin	WI

* Top 100 in R&D

Public, Non-doctorate-granting Institutions

Alabama A & M University	AL
University of Arkansas at Pine Bluff	AR
Arkansas State University	AR
California State University at Chico	CA
San Francisco State University	CA
California State University at Fullerton	CA
San Jose State University	CA
University of the District of Columbia	DC
Florida A & M University	FL
University of West Florida	FL
Albany State College	GA
Western Illinois University	IL
Kentucky State University	KY
Murray State University	KY
Grambling State University	LA
McNeese State University	LA
Southern University and A & M College	LA
Southeastern Massachusetts University	MA
University of Massachusetts at Boston	MA
Morgan State University	MD
University of Maryland Eastern Shore	MD
Eastern Michigan University	MI
Moorhead State University	MN
Jackson State University	MS
Mississippi Valley State University	MS
Alcorn State University	MS
North Carolina Agricultural and Technical State University	NC
North Carolina Central University	NC
University of North Carolina at Charlotte	NC
SUNY Brooklyn College	NY
SUNY College at Buffalo	NY
SUNY College at New Paltz	NY
University of Nevada at Las Vegas	NV
Youngstown State University	OH
Lincoln University	PA
Edinboro University	PA
South Carolina State College	SC
Tennessee State University	TN
Southwest Texas State University	TX
Prairie View A & M University	TX
University of Houston at Clear Lake	TX
Texas Southern University	TX
James Madison University	VA
Virginia State University	VA
Norfolk State University	VA

Private, Non-doctorate-granting Institutions

Tuskegee University	AL
Harvey Mudd College	CA
Pomona College	CA
Occidental College	CA
Quinnipac College (1990 only)	CA
Colorado College	CO
Gallaudet University	DC
Rollins College	FL
Lake Forest College	IL
Drake University	IA
Grinnell College	IA
Dillard University	LA
Wellesley College	MA
Williams College	MA
Wentworth Institute of Technology	MA
Augsburg College	MN
Carleton College (1990 only)	MN
Canisius College	NY
Barnard College	NY
Vassar College	NY
Xavier University	OH
Pacific University	OR
University of Portland (1990 only)	OR
Franklin and Marshall College (1990 only)	PA
Haverford College	PA
Saint Joseph's University	PA
Swarthmore College	PA
Fisk University	TN
Middlebury College	VT
Walla Walla College	WA
Lawrence University	WI
Milwaukee School of Engineering	WI

Historically Black Colleges and Universities

Alabama A&M University	AL
Tuskegee University	AL
University of Arkansas at Pine Bluff	AR
Howard University	DC
University of the District of Columbia	DC
Florida A&M University	FL
Albany State University	GA
Atlanta University (1988 only)	GA
Clark Atlanta (1990 only)	GA
Morehouse School of Medicine	GA
Kentucky State University	KY

Dillard University	LA
Grambling State University	LA
Southern University and A&M College	LA
Morgan State University	MD
University of Maryland-Eastern Shore	MD
Alcorn State University	MS
Jackson State University	MS
Mississippi Valley State University	MS
North Carolina Ag and Tech University	NC
North Carolina Central University	NC
Lincoln University	PA
South Carolina State College	SC
Tennessee State University	TN
Fisk University	TN
Meharry Medical College	TN
Prairie View A&M University	TX
Texas Southern University	TX
Virginia State University	VA
Norfolk State University	VA

APPENDIX C
SURVEY QUESTIONNAIRE

NSF Form: 1264 (8-89)

OMB # 3145-0101
Expires 2/29/90

1989-90 SURVEY OF SCIENTIFIC AND ENGINEERING R&D FACILITIES AT COLLEGES AND UNIVERSITIES

National Science Foundation
National Institutes of Health

Acting out of concerns raised by the academic community, Congress directed the National Science Foundation to collect and analyze data on the availability, condition, need, cost, and funding sources of science and engineering research and development facilities at colleges and universities and to report to the Congress every two years This survey is being conducted in response to that requirement Institutions are requested to return the completed survey to:

WESTAT, INC.
1650 Research Blvd
Rockville, MD 20850

This information is solicited under the authority of the National Science Foundation Act of 1950, as amended. All information you provide will be used for statistical purposes only Your response is entirely voluntary and your failure to provide some or all of the information will in no way adversely affect your institution Where exact data are not available, estimates are acceptable. Your estimates will be better than ours

We requested that the president or chancellor of your institution designate an individual to coordinate data collection for this survey The name, title, and address of that person appear below, please correct the label if any of the information is incorrect

LABEL

If someone other than the person listed above completes this questionnaire, please provide the following information

Name **Title/Department** **Telephone No. and ext.**

This form should be returned by October 16, 1989. Your cooperation in returning the survey questionnaire promptly is very important. If you have any questions regarding this survey, please contact Ms Terrie Squadere at Westat's toll-free number 800-937-8281, or contact Ms. Judith Coakley of NSF at 202-634-4673

It is estimated that the response to this survey will require an average of 40 hours If you wish to comment on this burden, please contact Herman Fleming at (202) 357-9520.

How many person hours were required to complete this form? _____

DEFINITIONS AND GUIDELINES

RESEARCH AND DEVELOPMENT (R&D)

R&D for purposes of this survey refers to "organized research" as defined in Section B.1.b of OMB Circular A-21 (revised). "**Organized research** *means all research and development activities of an institution that are separately budgeted and accounted for. It includes:* (1) **Sponsored research** *means all research and development activities that are sponsored by Federal and non-Federal agencies and organizations...* (2) **University research** *means all research and development activities that are separately budgeted by the institution under an internal application of institutional funds.*"

This definition of R&D does **not** include departmental research that is not separately budgeted. Note that sponsored research may be funded by government, foundation, corporate, university or other sources.

R&D FACILITIES

Using the definition of R&D above, "R&D facilities" refers to the physical plant (e.g., "bricks and mortar," research vessels) in which organized R&D activities take place, including building infrastructure (power, HVAC, etc.), fixed equipment (benches, fume hoods, etc.), and non-fixed equipment costing over $1 million. **Non-fixed equipment costing less than $1 million is not included; these data are gathered in a separate NSF/NIH survey.**

Be sure to report all R&D facilities that are administered by the institution, including facilities that are leased or rented by the institution, facilities at branch campuses, agricultural experiment stations, field and mobile laboratories, etc. **Do not include** facilities that have been designated as Federally-funded R&D Centers (e.g., Brookhaven, Kitt Peak, Fermi, etc.), and do not include facilities that are used by faculty but are not actually administered by the institution (e.g., research space at VA or other non-university hospitals)

R&D SPACE

R&D space refers to the net assignable square feet (NASF) of space in R&D facilities, within which organized R&D activities take place. Specific examples of R&D facilities are

- research laboratories,
- controlled environment space such as clean or white rooms,
- technical support space such as carpenter and machine shops,
- animal quarters including animal production colonies, holding rooms, isolation and germ-free rooms,
- faculty or staff offices, to the extent they are used for R&D,
- department libraries, to the extent they are used for R&D, and
- fixed (built-in) equipment such as fume hoods and benches.

Do not include central libraries or central academic computing centers

For **multi-purpose** space such as faculty offices, prorate the space (NASF) to reflect the proportion of use devoted to organized R&D activity. For example, if a room or building is devoted to R&D activity approximately 40% of the time, count 40% of the NASF as R&D space.

REPAIR/RENOVATION AND NEW CONSTRUCTION

Report repair/renovation projects (repair of deteriorated condition, capital improvement, conversion, etc.) and new construction projects (addition to an existing building, new building) involving R&D facilities. Include only those projects that involve **total project costs associated with R&D facilities** of $100,000 or more.

For **multi-purpose** facilities, **prorate** the cost to reflect the proportion of R&D space involved in the project (e.g., if 20% of the space involved is used for organized research, report 20% of the total project completion costs)

For **multi-year** projects, allocate the entire project completion cost (planning, construction, fixed equipment) to the fiscal year in which the construction activity actually began or is expected to begin (e.g., groundbreaking).

DO NOT include projects that involve only central infrastructure systems such as central chillers, or steam or power plants.

SCIENCE AND ENGINEERING DISCIPLINES

In order to facilitate comparison of data collected in this survey with that of other NSF and NIH survey data, we request that you provide the information in the academic disciplines listed below. A crosswalk of NSF disciplines and NCES program classification codes appears at the end of this questionnaire. Use your best judgment in reporting fields that cross over discipline categories used in this survey. If you are unable to report separately the data for academic programs, please report the combined data as "Other sciences, n.e.c." **and indicate what disciplines they represent.**

Engineering
Physical Sciences
Environmental Sciences
Mathematical Sciences
Computer Sciences
Agricultural Sciences
Biological Sciences
Medical Sciences
Psychology
Social Sciences
Other Sciences, n.e.c. (not elsewhere classified)

NOT INCLUDED in this survey are law, business administration/management (except economics), humanities, history, the arts, or education (except educational psychology).

See the NSF-NCES Crosswalk at the end of the questionnaire for additional details on classification of fields

ITEM 1A. PRESENT AVAILABILITY OF R&D FACILITIES IN THE SCIENCES AND ENGINEERING, BY DISCIPLINE

- In column 1 below, please report the **total** net assignable square feet (NASF) assigned to science and engineering (S/E) disciplines at your institution. The totals should include all space assigned to the disciplines or departments within the disciplines, including departmental and faculty offices, conference and seminar rooms, research space, and instructional space. Include space leased by your institution.

- In column 2, report net assignable square feet devoted to **R&D** in S/E disciplines, using the OMB A-21 definition of **organized research** provided on page 2. Include space leased by your institution.

Disciplines	Total NASF	NASF Used For R&D
S/E FACILITIES TOTAL		
Engineering		
Physical Sciences		
Environmental Sciences		
Mathematics		
Computer Science		
Agricultural Sciences		
Biological Sciences Other than medical school		
Biological Sciences Medical school		
Medical Sciences Other than medical school		
Medical Sciences Medical school		
Psychology		
Social Sciences		
Other Sciences, n.e.c.		

Please specify below the disciplines included in "Other sciences, n e c."

_____

_____

ITEM 1B: LEASED R&D SPACE

Please indicate the net assignable square feet of **R&D** space reported in Item 1A which is leased by your institution

_____ NASF leased R&D space

ITEM 1C: TEMPORARY R&D FACILITIES

Please indicate the net assignable square feet of **R&D** space reported in Item 1A which is housed in facilities such as trailers, quonset huts and other temporary buildings

_____ NASF temporary R&D facilities

ITEM 1D: SOURCE OF SQUARE FOOTAGE DATA

Please indicate the source and year of data on square feet of R&D space

- ☐ A-21 space survey . . . . . YEAR_____
- ☐ A-21 proportional calculation based on R&D salaries and wages . . . . YEAR_____
- ☐ Facilities inventory based on Facilities Inventory and Classification Manual (old HEGIS codes) . . . . YEAR_____
- ☐ Facilities inventory NOT based on Facilities Inventory and Classification Manual (old HEGIS codes) . . . . . YEAR_____
- ☐ Other (specify)_____ YEAR_____

ITEM 2. PRESENT CONDITION OF RESEARCH AND DEVELOPMENT FACILITIES

Please indicate the percentage of R&D space reported in Item 1A that falls into each category (A through D) defined below

- Provide ratings only for those disciplines for which you reported organized research space in Item 1A
- Rate the condition of facilities based on the type of research **currently** conducted in the facility.
- Do **not** include non-fixed research instrumentation costing **less** than $1 million in your consideration of the status of research facilities in S/E disciplines.

A – suitable for use in the most highly developed and scientifically sophisticated research in its field
B – effective for most purposes but not applicable to category A
C – effective for some purposes but in need of limited renovation or repair
D – requiring major repair or renovation to be used effectively

Engineering

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Physical Sciences

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Environmental Sciences

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Mathematics

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Computer Science

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Agricultural Sciences

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Biological Sciences
Other than medical school

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Biological Sciences
Medical school

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Medical Sciences
Other than medical school

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Medical Sciences
Medical school

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Psychology

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Social Sciences

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

Other Sciences, n.e.c.

A _____%
B _____%
C _____%
D _____%
TOTAL 100 %

ITEM 3: ADEQUACY OF SELECTED ASPECTS OF R&D FACILITIES

Please rate the adequacy of your R&D facilities to support your current research program in terms of the aspects of the facilities indicated in each column heading. Assign ratings as follows

1 -- Adequate -- sufficient to support all the needs of your research in the discipline
2 -- Generally adequate -- sufficient to support most research needs in the discipline, but may have some limitations
3 -- Inadequate -- not sufficient to support the needs of your research in the discipline
4 -- Nonexistent, but needed
5 -- Inapplicable or not needed

- Provide ratings only for those disciplines for which you reported organized research space in Item 1A
- Provide an overall rating for toxic waste disposal below.

S/E Discipline	Adequacy of Amount of R&D Space	Data Communication Systems	Power Systems	Building HVAC*	Air decontamination (e.g., fume hoods)
Engineering					
Physical Sciences					
Environmental Sciences					
Mathematics					
Computer Science					
Agricultural Sciences					
Biological Sciences Other than medical school					
Biological Sciences Medical school					
Medical Sciences Other than medical school					
Medical Sciences Medical school					
Psychology					
Social Sciences					
Other Sciences n.e.c.					

*HVAC -- heating, ventilation, and air conditioning

Toxic Waste Disposal: _____

NOTE: The assessment of facilities for toxic waste disposal should be made by your institution's bio-safety officer, and should focus on buildings (facilities) and not movable equipment or process

ITEM 4A. R&D FACILITIES PROJECTS: FY 1988

Please provide the **project completion costs** (in thousands) for repair/renovation and new construction of **R&D facilities** on which construction was started (e g , groundbreaking) during your institution's **Fiscal Year 1988**. Provide an estimate of the **R&D space** (net assignable square footage) involved.

- Report only costs and square feet associated with space used for R&D, prorating the projects as necessary
- Report only projects with costs **associated with R&D facilities** of $100,000 or more
- Do not include projects involving only campus-wide infrastructure, e g , central chillers, or steam or power plants

Disciplines	Repair/Renovation		New Construction	
	R&D-related Project Cost (in thousands)	**R&D NASF**	**R&D-related Project Cost (in thousands)**	**R&D NASF**
S/E R&D FACILITIES TOTAL				
Engineering				
Physical Sciences				
Environmental Sciences				
Mathematics				
Computer Science				
Agricultural Sciences				
Biological Sciences Other than medical school				
Biological Sciences Medical school				
Medical Sciences Other than medical school				
Medical Sciences Medical school				
Psychology				
Social Sciences				
Other Sciences, n.e.c.				

ITEM 4B. SOURCES OF FUNDING FOR R&D FACILITIES PROJECTS: FY 1988

Please indicate the planned sources of funding for the permanent financing of the **total** project costs for **S/E R&D facilities** listed in the first row of Item 4A (previous page) by reporting the percentage of funding in each category

Sources	Repair/Renovation	New Construction
	Total = 100%	Total = 100%
Federal government		
State/local government		
Private donation		
Corporations		
Foundations		
Individuals		
Other private		
Institutional funds (operating funds, endowments, indirect cost recovery, etc.)		
Debt Financing		
Tax-exempt bonds		
Other debt		
Other*		

*Please specify the "other funding sources" below

ITEM 5A. R&D FACILITIES PROJECTS: FY 1989

Please provide the **project completion costs** (in thousands) for repair/renovation and new construction of **R&D facilities** on which construction was started (e.g., groundbreaking) during your institution's **Fiscal Year 1989**. Provide an estimate of the R&D space (net assignable square footage) involved.

- Report only costs and square feet associated with space used for R&D, prorating the projects as necessary.
- Report only projects with costs **associated with R&D facilities** of $100,000 or more.
- Do not include projects involving only campus-wide infrastructure, e.g., central chillers, or steam or power plants.

Disciplines	Repair/Renovation		New Construction	
	R&D-related Project Cost (in thousands)	**R&D NASF**	**R&D-related Project Cost (in thousands)**	**R&D NASF**
S/E R&D FACILITIES TOTAL				
Engineering				
Physical Sciences				
Environmental Sciences				
Mathematics				
Computer Science				
Agricultural Sciences				
Biological Sciences Other than medical school				
Biological Sciences Medical school				
Medical Sciences Other than medical school				
Medical Sciences Medical school				
Psychology				
Social Sciences				
Other Sciences, n.e.c.				

ITEM 5B. SOURCES OF FUNDING FOR R&D FACILITIES PROJECTS: FY 1989

Please indicate the planned sources of funding for the permanent financing of the **total** project costs for **S/E R&D facilities** listed in the first row of Item 5A (previous page) by reporting the percentage of funding in each category.

Sources	Repair/Renovation	New Construction
	Total = 100%	Total = 100%
Federal government		
State/local government		
Private donation		
Corporations		
Foundations		
Individuals		
Other private		
Institutional funds (operating funds, endowments, indirect cost recovery, etc.)		
Debt Financing		
Tax-exempt bonds		
Other debt		
Other*		

*Please specify the "other funding sources" below:

_____

_____

ITEM 6A. PLANNED R&D FACILITIES PROJECTS: FY 1990 AND 1991

Please provide the **project completion costs** (in thousands) for repair/renovation and construction of **R&D facilities** on which construction will be started (e.g., groundbreaking) during your institution's **Fiscal Years 1990 and 1991**. Provide an estimate of the R&D space (net assignable square footage) involved.

- Report only costs and square feet associated with space used for R&D, prorating the projects as necessary.
- Report only projects with costs **associated with R&D facilities** of $100,000 or more.
- Do not include projects involving only campus-wide infrastructure, e.g., central chillers, or steam or power plants.

Disciplines	Repair/Renovation		New Construction	
	R&D-related Project Cost (in thousands)	R&D NASF	R&D-related Project Cost (in thousands)	R&D NASF
S/E R&D FACILITIES TOTAL				
Engineering				
Physical Sciences				
Environmental Sciences				
Mathematics				
Computer Science				
Agricultural Sciences				
Biological Sciences Other than medical school				
Biological Sciences Medical school				
Medical Sciences Other than medical school				
Medical Sciences Medical school				
Psychology				
Social Sciences				
Other Sciences, n.e.c.				

ITEM 6B. SOURCES OF FUNDING FOR PLANNED R&D FACILITIES PROJECTS: FY 1990 AND 1991

Please indicate the planned sources of funding for the permanent financing of the **total** project costs for **S/E R&D facilities projects** listed in the first row of Item 6A (previous page) by reporting the percentage of funding to be obtained from **each** source.

Sources	Repair/Renovation	New Construction
	Total = 100%	Total = 100%
Federal government		
State/local government		
Private donation		
Corporations		
Foundations		
Individuals		
Other private		
Institutional funds (operating funds, endowments, indirect cost recovery, etc.)		
Debt Financing		
Tax-exempt bonds		
Other debt		
Other*		

*Please specify the "other funding sources" below:

_____

_____

ITEM 7: LIMIT ON TAX-EXEMPT BONDS

(APPLICABLE TO PRIVATE COLLEGES AND UNIVERSITIES ONLY)

Recent tax reform legislation established a limit on tax-exempt bonds of $150 million per private college or university. Has your institution reached the limit on tax-exempt bonds?

- ☐ Yes
- ☐ No, but expect to within next two fiscal years
- ☐ No, and do not expect to within next two fiscal years
- ☐ Not applicable (i.e., public institution)

ITEM 8: RESEARCH FACILITIES ISSUES

Please use the remaining space to discuss the following research facilities related issues:

1. the significance for your institution of possibly increasing the use allowance for facilities or a shift to depreciation as a possible means to finance research facilities.
2. needs related to campus-wide facilities (e.g., for toxic waste storage/disposal, animal quarters, etc.) or systems (e.g., utilities, data communications) that support research.
3. the extent to which repair/renovation and construction projects are driven by regulatory changes, the type of projects most often initiated as a result of such changes, and the extent to which these changes impact project costs.

CROSSWALK BETWEEN NSF DISCIPLINE CODES AND THE NCES CLASSIFICATION OF INSTRUCTIONAL PROGRAMS

The following set of discipline codes is used to categorize science and engineering departments in the Survey of Science and Engineering Research Facilities. Representative department names are shown under each of the discipline codes.

ENGINEERING

101	AEROSPACE ENGINEERING	
	14 02	AEROSPACE, AERONAUTICAL, AND ASTRONAUTICAL ENGINEERING
102	AGRICULTURAL ENGINEERING	
	14 03	AGRICULTURAL ENGINEERING
103	BIOMEDICAL ENGINEERING	
	14 05	BIOENGINEERING AND BIOMEDICAL ENGINEERING
104	CHEMICAL ENGINEERING	
	03 0509	WOOD SCIENCES
	14 07	CHEMICAL ENGINEERING
105	CIVIL ENGINEERING	
	04 02	ARCHITECTURE
	14 04	ARCHITECTURAL ENGINEERING
	14 08	CIVIL ENGINEERING
	14 14	ENVIRONMENTAL HEALTH ENGINEERING
106	ELECTRICAL ENGINEERING	
	14 09	COMPUTER ENGINEERING
	14 10	ELECTRICAL, ELECTRONICS, AND COMMUNICATIONS ENGINEERING
	14 1002	MICROELECTRONIC ENGINEERING
107	ENGINEERING SCIENCE	
	14 12	ENGINEERING PHYSICS
	14 13	ENGINEERING SCIENCE
108	INDUSTRIAL ENGINEERING/MANAGEMENT SCIENCE	
	14 17	INDUSTRIAL ENGINEERING
	14 27	SYSTEMS ENGINEERING
	30 08	SYSTEMS SCIENCE
109	MECHANICAL ENGINEERING	
	14 11	ENGINEERING MECHANICS
	14 19	MECHANICAL ENGINEERING
110	METALLURGICAL AND MATERIALS ENGINEERING	
	14 06	CERAMIC ENGINEERING
	14 18	MATERIALS ENGINEERING
	14 20	METALLURGICAL ENGINEERING
	40 0701	METALLURGY
111	MINING ENGINEERING	
	14 15	GEOLOGICAL ENGINEERING
	14 16	GEOPHYSICAL ENGINEERING
	14 21	MINING AND MINERAL ENGINEERING
112	NUCLEAR ENGINEERING	
	14 23	NUCLEAR ENGINEERING
113	PETROLEUM ENGINEERING	
	14 25	PETROLEUM ENGINEERING
114	ENGINEERING, N E C.	
	14 01	ENGINEERING, GENERAL
	14 22	NAVAL ARCHITECTURE AND MARINE ENGINEERING
	14 24	OCEAN ENGINEERING
	14 26	TEXTILE ENGINEERING
	14 99	ENGINEERING, OTHER
	19 09	TEXTILES AND CLOTHING (EXCLUDING 19 0902, FASHION DESIGN)
	30 03	ENGINEERING AND OTHER DISCIPLINES

PHYSICAL SCIENCES

201	ASTRONOMY	
	40 02	ASTRONOMY
	40 03	ASTROPHYSICS
	40 09	PLANETARY SCIENCE
202	CHEMISTRY	
	40 05	CHEMISTRY
203	PHYSICS	
	40.08	PHYSICS
204	PHYSICAL SCIENCES, N E.C	
	40 01	PHYSICAL SCIENCES, GENERAL
	40 0799	MISCELLANEOUS PHYSICAL SCIENCES, OTHER
	40.099	PHYSICAL SCIENCES, OTHER

ENVIRONMENTAL SCIENCES

301	ATMOSPHERIC SCIENCES	
	40.4	ATMOSPHERIC SCIENCES AND METEROLOGY
302	GEOSCIENCES	
	14 28	SURVEYING AND MAPPING SCIENCES
	40 06	GEOLOGICAL SCIENCES
	40 0703	EARTH SCIENCES
303	OCEANOGRAPHY	
	26 0807	MARINE BIOLOGY
	40 0702	OCEANOGRAPHY
304	ENVIRONMENTAL SCIENCES, N E C	

MATHEMATICAL SCIENCES

402	MATHEMATICS AND APPLIED MATHEMATICS	
	06 1302	OPERATIONS RESEARCH (QUANTITIVE METHODS)
	27 01	MATHEMATICS, GENERAL
	27 03	APPLIED MATHEMATICS
	27 04	PURE MATHEMATICS
	27 99	MATHEMATICS, OTHER
	30 08	MATHEMATICS AND COMPUTER SCIENCE
403	STATISTICS	
	27 02	ACTUARIAL SCIENCES
	27 05	STATISTICS

COMPUTER SCIENCES

401	COMPUTER SCIENCE	
	06 12	MANAGEMENT INFORMATION SYSTEMS
	11	COMPUTER AND INFORMATION SCIENCES, GENERAL
	30.09	IMAGING SCIENCE

AGRICULTURAL SCIENCES (SEE ALSO 102 AND 901)

501	AGRICULTURAL SCIENCES	
	02 01	AGRICULTURAL SCIENCES, GENERAL
	02 02	ANIMAL SCIENCES
	02 03	FOOD SCIENCES
	02 04	PLANT SCIENCES
	02 05	SOIL SCIENCES
	02 99	AGRICULTURAL SCIENCES, OTHER
	03 01	RENEWABLE NATURAL RESOURCES, GENERAL
	03 03	FISHING AND FISHERIES
	03 05	FORESTRY AND RELATED SCIENCES
	03 06	WILDLIFE MANAGEMENT
	03 99	RENEWABLE NATURAL RESOURCES, OTHER
	31 04	WATER RESOURCES

BIOLOGICAL SCIENCES

501 ANATOMY
- 18 0201 CLINICAL ANATOMY
- 26 0501 ANATOMY

502 BIOCHEMISTRY
- 18 0202 CLINICAL BIOCHEMISTRY
- 26 02 BIOCHEMISTRY AND BIOPHYSICS

503 BIOLOGY
- 26 01 BIOLOGY GENERAL
- 26 0804 EMBRYOLOGY

504 BIOMETRY AND EPIDEMIOLOGY
- 18 2202 EPIDEMIOLOGY
- 26.0802 BIOMETRICS AND BIOSTATISTICS

505 BIOPHYSICS

506 BOTANY
- 26 03 BOTANY (EXCLUDING 26 0302, BACTERIOLOGY–SEE 611)

507 CELL BIOLOGY
- 26 04 CELL AND MOLECULAR BIOLOGY
- 26 0808 HISTOLOGY

508 ECOLOGY
- 26.0803 ECOLOGY

509 ENTOMOLOGY AND PARASITOLOGY
- 26 0810 PARASITOLOGY
- 26 07102 ENTOMOLOGY

510 GENETICS
- 26 0703 GENETICS, HUMAN AND ANIMAL

511 MICROBIOLOGY, IMMUNOLOGY, AND VIROLOGY
- 18 0203 CLINICAL MICROBIOLOGY
- 18.1002 ALLERGIES AND ENDOMOLOGY
- 18 1009 IMMUNOLOGY
- 26 0302 BACTERIOLOGY
- 26 05 MICROBIOLOGY

512 NUTRITION
- 19 05 FOOD SCIENCES AND HUMAN NUTRITION
- 20 0106 FOOD AND NUTRITION
- 26 0809 NUTRITIONAL SCIENCES

513 PATHOLOGY
- 18 0204 CLINICAL PATHOLOGY
- 18 1018 PATHOLOGY
- 26 0704 PATHOLOGY, HUMAN AND ANIMAL

514 PHARMACOLOGY
- 18 0206 CLINICAL TOXICOLOGY
- 26 0612 TOXICOLOGY
- 26 0705 PHARMACOLOGY, HUMAN AND ANIMAL
- 42 14 PSYCHOPHARMACOLOGY

515 PHYSIOLOGY
- 18 0205 PHYSIOLOGY
- 26 0706 PHYSIOLOGY, HUMAN AND ANIMAL

516 ZOOLOGY
- 26 0701 ZOOLOGY
- 26 0799 ZOOLOGY, OTHER

517 BIOSCIENCES, N E C
- 26 0699 MISCELLANEOUS SPECIALIZED AREAS, LIFE SCIENCES, OTHER
- 26 99 LIFE SCIENCES, OTHER

MEDICAL SCIENCES (SEE ALSO 103)

701 ANESTHESIOLOGY
- 18 1003 ANESTHESIOLOGY

702 CARDIOLOGY

703 CANCER RESEARCH/ONCOLOGY

704 ENDOCRINOLOGY
- 26 0806 ENDOCRINOLOGY

705 GASTROENTEROLOGY

706 HEMATOLOGY
- 18 08 HEMATOLOGY

707 NEUROLOGY
- 18.1024 NEUROLOGY
- 26.0808 NEUROSCIENCES

708 OBSTETRICS AND GYNECOLOGY
- 18.1013 OBSTETRICS AND GYNECOLOGY

709 OPHTHALMOLOGY
- 18.1014 OPHTHALMOLOGY
- 18.12 OPTOMETRY

710 OTORHINOLARYNGOLOGY
- 18.1017 OTORHINOLARYNGOLOGY/OTOLARYNGOLGY

711 PEDIATRICS
- 18.1018 PEDIATRICS
- 20 0102 CHILD DEVELOPMENT, CARE, AND GUIDANCE

712 PREVENTIVE MEDICINE AND COMMUNITY HEALTH
- 18.1007 FAMILY PRACTICE
- 18.1022 PREVENTIVE MEDICINE

713 PSYCHIATRY
- 18.1023 PSYCHIATRY
- 18.1109 PSYCHIATRY/MENTAL HEALTH

714 PULMONARY DISEASE

715 RADIOLOGY
- 18.1012 NUCLEAR MEDICINE
- 18 1025 RADIOLOGY
- 26 0811 RADIOBIOLOGY

716 SURGERY
- 18 1004 COLON AND RECTAL SURGERY
- 18 1011 NEUROLOGICAL SURGERY
- 18 1018 ORTHOPEDIC
- 18 1021 PLASTIC SURGERY
- 18.1026 SURGERY
- 18.1027 THORACIC SURGERY

717 CLINICAL MEDICINE, N.E.C.
- 18 0299 BASIC CLINICAL HEALTH SCIENCES, OTHER
- 18.1001 MEDICINE, GENERAL
- 18.1005 DERMATOLOGY
- 18.1009 GERIATRICS
- 18 1010 INTERNAL MEDICINE
- 18.1020 PHYSICAL MEDICINE AND REHABILITATION
- 18.1028 UROLOGY
- 18.1099 MEDICINE, OTHER
- 18 13 OSTEOPATHIC MEDICINE
- 18.15 PODIATRY
- 30.01 BIOLOGICAL AND PHYSICAL SCIENCES

718 DENTAL SCIENCES
- 18 04 DENTISTRY
- 18 1015 ORTHODONTIC SURGERY

719 NURSING
- 18 11 NURSING (EXCLUDING 18 1106, PSYCHIATRY/MENTAL HEALTH - SEE 713)

720 PHARMACEUTICAL SCIENCES
- 18 14 PHARMACY

721 VETERINARY SCIENCES
- 18.24 VETERINARY MEDICINE

722 HEALTH RELATED, N.E.C.
- 17.0807 OCCUPATIONAL THERAPY
- 17.0813 PHYSICAL THERAPY
- 17.0899 REHABILITATION SERVICES, OTHER
- 17.99 ALLIED HEALTH, OTHER
- 18.07 HEALTH SCIENCES ADMINISTRATION
- 18.09 MEDICAL LABORATORY
- 18.22 PUBLIC HEALTH
- 18.99 HEALTH SCIENCES, OTHER

723 SPEECH PATHOLOGY AND AUDIOLOGY
- 18.01 AUDIOLOGY AND SPEECH PATHOLOGY

PSYCHOLOGY

801 PSYCHOLOGY
- 13.06 SCHOOL PSYCHOLOGY
- 17.0801 ART THERAPY
- 42 PSYCHOLOGY

SOCIAL SCIENCES

901 AGRICULTURAL ECONOMICS
- 01.0102 AGRICULTURAL BUSINESS AND MANAGEMENT
- 01.0103 AGRICULTURAL ECONOMICS

902 ANTHROPOLOGY (CULTURAL AND SOCIAL)
- 45.02 ANTHROPOLOGY
- 45.03 ARCHEOLOGY

903 ECONOMICS (EXCEPT AGRICULTURAL)
- 06.06 BUSINESS ECONOMICS
- 45.06 ECONOMICS

904 GEOGRAPHY
- 45.07 GEOGRAPHY

905 HISTORY AND PHILOSOPHY OF SCIENCE

906 LINGUISTICS
- 23.06 LINGUISTICS
- 42.12 PSYCHOLINGUISTICS

907 POLITCAL SCIENCE
- 44.01 PUBLIC AFFAIRS, GENERAL
- 44.03 INTERNATIONAL PUBLIC SERVICE
- 44.04 PUBLIC ADMINISTRATION
- 44.05 PUBLIC POLICY STUDIES
- 44.99 PUBLIC AFFAIRS, OTHER
- 45.09 INTERNATIONAL AFFAIRS
- 45.10 POLITICAL SCIENCE AND GOVERNMENT

908 SOCIOLOGY
- 45.05 DEMOGRAPHY
- 45.11 SOCIOLOGY

909 SOCIOLOGY AND ANTHROPOLOGY

910 SOCIAL SCIENCES, N.E.C.
- 04.03 CITY, COMMUNITY AND REGIONAL PLANNING
- 05 AREA AND ETHNIC STUDIES
- 06.06 HUMAN RESOURCES DEVELOPMENT
- 06.15 ORGANIZATIONAL BEHAVIOR
- 31.03 PARKS AND RECREATION MANAGEMENT
- 43.01 CRIMINAL JUSTICE
- 44.02 COMMUNITY SERVICES
- 44.07 SOCIAL WORK
- 45.01 SOCIAL SCIENCES, GENERAL
- 45.04 CRIMINOLOGY
- 45.12 URBAN STUDIES
- 45.99 SOCIAL SCIENCES, OTHER

APPENDIX D
DETAILED STATISTICAL TABLES

Table 2-1. Number of institutions, total net assignable square feet (NASF) of space in science/engineering disciplines, and total NASF used for R&D by institution type and control: 1988 and 1990

Institution type and control	Number of institutions		Total NASF		Total R&D NASF	
	1988	1990	1988	1990	1988	1990
			(NASF in millions)			
Total	525	525	270.6	276.0	112.1	116.3
Doctorate-granting	293	293	240.7	243.9	107.4	111.2
Top 100 in R&D	100	100	165.7	163.9	80.6	81.7
Other	193	193	75.1	80.0	26.8	29.5
Non-doctorate-granting	232	232	29.9	32.1	4.6	5.2
Public	320	319	204.3	211.7	82.4	86.9
Doctorate-granting	191	190	183.5	188.9	79.3	83.6
In top 100 in R&D	70	70	128.4	128.8	59.3	61.3
Other	121	120	55.1	60.1	20.0	22.3
Non-doctorate-granting	129	129	20.8	22.8	3.1	3.3
Private	205	206	66.3	64.4	29.7	29.4
Doctorate-granting	102	103	57.2	55.1	28.2	27.6
In top 100 in R&D	30	30	37.3	35.1	21.3	20.4
Other	73	73	20.0	19.9	6.9	7.2
Non-doctorate-granting	103	103	9.1	9.3	1.5	1.8

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS

Table 2-2. Number of institutions with any assigned space in science/engineering disciplines by discipline and institution type: 1988 and 1990

Discipline	Institution type							
	Total		Doctorate-granting				Non doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
Total	525	525	100	100	193	193	232	232
Engineering	295	299	86	86	128	129	81	84
Physical sciences	473	471	93	93	150	147	230	231
Environmental sciences	323	326	84	85	120	112	118	129
Mathematics	455	457	93	93	148	145	215	219
Computer science	426	404	86	86	133	131	207	187
Agricultural sciences	104	103	42	41	30	27	32	35
Biological sciences	499	509	100	100	170	181	229	228
in colleges and universities	475	479	96	95	151	156	229	228
in medical schools	94	105	50	55	44	50	0	0
Medical sciences	294	318	87	87	120	140	88	91
in colleges and universities	235	250	68	68	79	91	88	91
in medical schools	138	144	64	64	74	80	0	0
Psychology	472	470	91	91	155	155	227	225
Social sciences	461	447	94	95	153	155	214	198
Other sciences, n e c	111	75	47	40	40	23	24	12

Note. Details may not sum to totals because of rounding

Source National Science Foundation, SRS.

Table 2-3. Number of institutions with any assigned R&D space in science/engineering disciplines by discipline and institution type: 1988 and 1990

Discipline	Institution type							
	Total		Doctorate-granting				Non-doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
Total	513	517	100	100	188	187	225	229
Engineering	283	296	85	86	128	129	70	81
Physical sciences	446	450	92	92	142	141	212	217
Environmental sciences	299	284	80	82	120	112	98	89
Mathematics	318	296	85	88	105	85	129	124
Computer science	332	281	78	79	95	89	159	113
Agricultural sciences	96	94	42	41	30	27	24	26
Biological sciences	480	482	100	100	163	174	217	208
in colleges and universities	456	451	95	94	144	149	217	208
in medical schools	94	105	50	55	44	50	0	0
Medical sciences	268	267	85	87	114	123	69	57
in colleges and universities	205	189	67	67	70	64	69	57
in medical schools	134	141	63	64	71	77	0	0
Psychology	403	402	87	86	131	132	185	184
Social sciences	360	347	89	91	127	117	144	140
Other sciences, n e c	92	69	45	40	35	18	12	11

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 2-4. Number of institutions with any assigned space or with any assigned R&D space in science/engineering disciplines by discipline and control: 1988 and 1990

Discipline	Any assigned S/E space				Any assigned R&D space			
	Public		Private		Public		Private	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	320	319	205	206	316	319	197	198
Engineering	219	225	76	73	207	222	76	73
Physical sciences	286	285	188	186	280	280	165	170
Environmental sciences	224	221	99	105	213	195	87	86
Mathematics	277	275	178	182	218	197	101	98
Computer science	253	247	173	158	213	164	120	116
Agricultural sciences	99	96	6	7	90	87	6	7
Biological sciences	309	313	190	196	305	298	175	184
in colleges and universities	291	291	184	187	287	277	168	174
in medical schools	68	70	26	35	68	70	26	35
Medical sciences	220	233	74	85	197	190	71	77
in colleges and universities	196	202	38	48	170	152	36	37
in medical schools	86	89	51	55	82	86	51	55
Psychology	286	285	186	185	263	261	140	141
Social sciences	272	278	189	169	246	244	114	103
Other sciences, n.e.c.	92	63	19	13	73	57	19	13

Note: Details may not sum to totals because of rounding.

Source National Science Foundation, SRS.

Table 2-5. Total net assignable square feet (NASF) of space in science/engineering disciplines by discipline and institution type: 1988 and 1990

Discipline	Institution type							
	Total		Doctorate-granting				Non-doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
	(NASF in thousands)							
Total	270,621	276,041	165,655	163,911	75,070	80,024	29,895	32,107
Engineering	40,063	42,291	24,422	24,810	11,353	12,177	4,288	5,303
Physical sciences	35,634	37,542	18,807	19,264	9,677	9,854	7,150	8,425
Environmental sciences	12,268	12,019	7,816	7,598	3,239	3,222	1,214	1,199
Mathematics	4,786	5,190	2,179	2,279	1,490	1,662	1,116	1,249
Computer science	4,938	4,625	2,245	2,430	1,594	1,318	1,099	877
Agricultural sciences	29,994	34,003	22,276	24,706	5,948	7,194	1,771	2,103
Biological sciences	45,184	53,321	26,768	28,276	12,591	15,023	5,826	6,022
in colleges and universities	32,445	34,385	18,769	19,046	7,850	9,318	5,826	6,022
in medical schools	12,739	14,936	7,999	9,231	4,741	5,705	0	0
Medical sciences	66,231	63,168	43,201	39,024	21,782	22,930	1,247	1,214
in colleges and universities	21,387	21,955	14,599	15,050	5,441	5,651	1,247	1,214
in medical schools	44,843	41,213	28,502	23,934	16,341	17,279	0	0
Psychology	9,011	9,124	4,182	4,025	2,528	2,759	2,302	2,339
Social sciences	16,433	15,158	9,766	8,798	3,264	3,424	3,403	2,936
Other sciences, n.e.c.	6,078	3,602	3,993	2,701	1,604	461	480	440

Note Details may not sum to totals because of rounding.

Source. National Science Foundation, SRS

Table 2-6. Total net assignable square feet (NASF) of space used for R&D in science/engineering disciplines by discipline and institution type: 1988 and 1990

Discipline	Institution type							
	Total		Doctorate-granting				Non-doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
	(R&D NASF in thousands)							
Total	112,062	116,327	80,627	81,659	26,815	29,508	4,620	5,161
Engineering	15,900	17,057	11,444	12,130	3,928	4,214	529	713
Physical sciences	16,024	16,121	10,443	10,429	4,236	4,232	1,344	1,459
Environmental sciences	6,313	6,056	4,645	4,534	1,458	1,314	210	208
Mathematics	722	790	397	415	260	300	65	75
Computer science	1,437	1,445	835	1,017	431	315	170	113
Agricultural sciences	17,622	20,821	14,433	16,032	2,821	4,247	368	542
Biological sciences	23,910	26,154	16,804	17,546	6,105	7,480	1,001	1,128
in colleges and universities	16,072	17,569	11,403	11,715	3,668	4,727	1,001	1,128
in medical schools	7,838	8,584	5,401	5,831	2,437	2,754	0	0
Medical sciences	19,363	19,721	14,573	14,090	4,681	5,518	109	113
in colleges and universities	5,320	4,959	4,208	4,133	1,004	713	109	113
in medical schools	14,042	14,762	10,365	9,957	3,677	4,805	0	0
Psychology	3,085	2,978	1,771	1,581	896	984	418	413
Social sciences	3,337	3,338	2,380	2,359	635	671	322	309
Other sciences, n.e.c.	4,350	1,846	2,903	1,526	1,364	232	83	87

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS.

Table 2-7. Total net assigned square feet (NASF) of space in science/engineering disciplines, and NASF used for R&D by discipline and institution control: 1988 and 1990

Discipline	Total NASF				R&D NASF			
	Public		Private		Public		Private	
	1988	1990	1988	1990	1988	1990	1988	1990
	(NASF in thousands)							
Total	204,302	211,651	66,318	64,390	82,384	86,881	29,678	29,447
Engineering	29,780	32,224	10,284	10,066	11,593	12,562	4,306	4,495
Physical sciences	24,505	26,595	11,129	10,947	10,719	10,944	5,305	5,177
Environmental sciences	9,624	9,393	2,644	2,626	5,045	4,832	1,267	1,223
Mathematics	3,520	3,874	1,266	1,316	505	5.	217	264
Computer science	3,530	3,041	1,408	1,584	875	735	562	710
Agricultural sciences	29,238	32,510	756	1,493	17,233	19,434	389	1,387
Biological sciences	32,596	35,837	12,588	13,484	16,327	18,307	7,583	7,847
in colleges and universities	24,164	26,449	8,281	7,937	11,473	13,240	4,599	4,329
in medical schools	8,433	9,388	4,307	5,547	4,854	5,067	2,984	3,517
Medical sciences	48,810	47,691	17,420	15,478	12,315	13,160	7,047	6,562
in colleges and universities	16,920	18,755	4,468	3,200	3,948	4,137	1,373	822
in medical schools	31,891	28,935	12,953	12,278	8,368	9,022	5,675	5,739
Psychology	6,254	6,415	2,758	2,706	2,216	2,102	869	876
Social sciences	12,284	11,071	4,149	4,087	2,794	2,684	543	655
Other sciences, n.e.c.	4,162	3,000	1,917	602	2,761	1,593	1,589	253

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 2-8. Amount of science/engineering research space that is leased or housed in temporary facilities by institution type and control: 1988 and 1990

Institution type and control	Leased R&D space				Temporary R&D space			
	Square feet (in thousands)		Percent of total R&D NASF		Square feet (in thousands)		Percent of total R&D NASF	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	3,771	3,551	3.4	3.1	1,978	1,731	1.8	1.5
Doctorate-granting	3,760	3,536	3.5	3.2	1,922	1,694	1.8	1.5
Top 100 in R&D	2,847	2,601	3.5	3.2	1,567	1,408	1.9	1.7
Other	913	935	3.4	3.2	355	285	1.3	1.0
Non-doctorate-granting	11	15	0.2	0.3	56	37	1.2	0.7
Public	2,315	2,145	2.8	2.5	1,692	1,477	2.1	1.7
Private	1,456	1,406	4.9	4.8	286	254	1.0	0.9

Note: Details may not sum to totals because of rounding

Source. National Science Foundation, SRS

Table 3-1. Number of institutions starting any projects to construct new science/engineering R&D space by institution type and control and year of project start: 1986-91*

Institution type and control	Construction project start year			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total	192	226	227	183
Doctorate-granting	135	178	154	161
Top 100 in R&D	72	79	71	82
Other	64	99	83	79
Non-doctorate-granting	57	48	73	22
Public	140	179	158	139
Doctorate-granting	103	133	106	121
In top 100 in R&D	55	60	52	60
Other	49	73	54	60
Non-doctorate-granting	37	46	52	18
Private	52	48	68	44
Doctorate-granting	32	45	48	40
In top 100 in R&D	17	20	19	22
Other	15	26	29	18
Non-doctorate-granting	19	2	21	4

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only

Note: Details may not sum to totals because of rounding

Source: National Science Foundation, SRS

Table 3-2. For projects to construct new R&D space, estimated net assignable square feet (NASF) of R&D space to be created and estimated total cost of the construction of this R&D space by institution type and control and year of project start: 1986-91*

Institution type and control	Construction project start year							
	1986 or 1987 (actual)		1988 or 1989 (plan)		1988 or 1989 (actual)		1990 or 1991 (plan)	
	NASF	Cost	NASF	Cost	NASF	Cost	NASF	Cost
	(NASF in thousands; dollars in millions)							
Total	9,922	$2,051	11,793	$3,392	10,647	$2,464	11,222	$3,495
Doctorate-granting	8,908	1,888	11,274	3,284	9,840	2,315	10,781	3,381
Top 100 in R&D	7,261	1,599	7,769	2,454	6,073	1,558	7,497	2,477
Other	1,647	288	3,506	830	3,767	757	3,284	904
Non-doctorate-granting	1,014	163	518	108	807	150	441	114
Public	7,344	1,355	8,691	2,105	8,115	1,727	7,696	2,131
Doctorate-granting	6,516	1,220	8,186	2,000	7,460	1,626	7,299	2,026
In top 100 in R&D	5,470	1,063	5,433	1,421	4,382	996	4,791	1,395
Other	1,046	158	2,753	579	3,078	629	2,508	632
Non-doctorate-granting	828	134	505	106	656	101	397	105
Private	2,578	696	3,102	1,287	2,532	738	3,525	1,364
Doctorate-granting	2,392	667	3,088	1,284	2,381	689	3,482	1,354
In top 100 in R&D	1,791	537	2,336	1,033	1,691	562	2,706	1,082
Other	600	131	753	251	689	128	776	272
Non-doctorate-granting	186	29	13	2	152	48	44	9

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS.

Table 3-3. Number of institutions starting any projects to construct new science/engineering R&D space by discipline and year of project start: 1986-91*

Discipline	Construction project start year			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total	192	226	227	183
Engineering	79	57	52	59
Physical sciences	41	67	67	50
Environmental sciences	28	33	17	24
Mathematics	3	9	5	8
Computer science	28	23	21	16
Agricultural sciences	36	36	32	31
Biological sciences	58	109	107	76
in colleges and universities	43	92	87	56
in medical schools	20	21	26	27
Medical sciences	54	77	47	69
in colleges and universities	18	19	14	27
in medical schools	42	61	35	54
Psychology	21	9	11	7
Social sciences	19	16	13	12
Other sciences, n.e.c	14	15	13	3

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding

Source: National Science Foundation, SRS

Table 3-4. For projects to construct new R&D space, estimated net assignable square feet (NASF) of R&D space to be created, and estimated total cost of the construction of this R&D space by discipline and year of project start: 1986-91*

Discipline	Construction project start year							
	1986 or 1987 (actual)		1988 or 1989 (plan)		1988 or 1989 (actual)		1990 or 1991 (plan)	
	NASF	Cost	NASF	Cost	NASF	Cost	NASF	Cost
	(NASF in thousands; dollars in millions)							
Total	9,922	$2,051	11,793	$3,392	10,647	$2,464	11,222	$3,495
Engineering	2,390	436	1,871	492	1,490	388	2,196	529
Physical sciences	799	182	1,765	527	2,000	401	1,564	624
Environmental sciences	380	57	423	125	324	82	520	165
Mathematics	9	2	34	5	25	8	45	11
Computer science	237	61	220	67	286	65	392	99
Agricultural sciences	1,513	150	794	212	1,146	152	756	186
Biological sciences	1,708	463	2,422	663	2,262	577	2,808	944
in colleges and universities	1,275	324	1,747	487	1,549	396	1,521	516
in medical schools	433	139	674	177	712	181	1,287	428
Medical sciences	1,948	505	3,327	1,106	2,253	647	2,723	877
in colleges and universities	613	203	266	64	306	61	394	153
in medical schools	1,335	302	3,061	1,042	1,948	587	2,329	724
Psychology	132	23	76	28	115	25	21	9
Social sciences	202	38	229	61	329	48	162	34
Other sciences, n e c	603	139	633	106	418	70	36	17

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only

Note Details may not sum to totals because of rounding.

Source National Science Foundation, SRS

Table 3-5. Number of institutions performing major repair/renovation of science/engineering R&D facilities by institution type and control and year of project start: 1986-91*

Institution type and control	Year of repair/renovation			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total	288	229	248	229
Doctorate-granting	224	190	204	166
Top 100 in R&D	96	90	85	80
Other	128	100	119	86
Non-doctorate-granting	64	38	44	63
Public	210	163	164	163
Doctorate-granting	163	130	133	117
In top 100 in R&D	67	61	55	52
Other	96	69	79	65
Non-doctorate-granting	47	33	31	46
Private	78	66	84	66
Doctorate-granting	61	60	71	49
In top 100 in R&D	28	28	30	28
Other	32	32	41	21
Non-doctorate-granting	17	5	14	17

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS.

Table 3-6. For projects to repair/renovate R&D space, estimated net assignable square feet (NASF) of R&D space affected and estimated total cost of this repair/renovation by institution type and control and year of project start: 1986-91*

Institution type and control	Year of repair/renovation							
	1986 or 1987 (actual)		1988 or 1989 (plan)		1988 or 1989 (actual)		1990 or 1991 (plan)	
	NASF	Cost	NASF	Cost	NASF	Cost	NASF	Cost
	(NASF in thousands; dollars in millions)							
Total	13,431	$838	9,380	$754	11,449	$1,010	8,634	$955
Doctorate-granting	12,841	793	9,194	717	10,993	979	7,757	704
Top 100 in R&D	9,124	596	7,173	567	7,781	483	5,515	528
Other	3,717	197	2,021	150	3,212	496	2,141	177
Non-doctorate-granting	590	45	186	36	456	30	877	250
Public	8,745	436	6,532	442	8,223	699	6,697	687
Doctorate-granting	8,307	399	6,366	408	7,890	674	5,970	453
In top 100 in R&D	5,792	258	4,891	294	5,593	230	4,192	308
Other	2,515	141	1,474	114	2,297	444	1,779	145
Non-doctorate-granting	438	37	167	34	333	25	726	234
Private	4,685	402	2,848	311	3,226	311	1,937	268
Doctorate-granting	4,534	393	2,829	309	3,102	305	1,786	252
In top 100 in R&D	3,332	338	2,282	273	2,188	253	1,423	220
Other	1,202	55	546	36	915	52	363	32
Non-doctorate-granting	152	9	19	2	123	6	151	16

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only

Note: Details may not sum to totals because of rounding

Source: National Science Foundation, SRS

Table 3-7. Number of institutions performing major repair/renovation of science/engineering R&D facilities by discipline and year of project start: 1986-91*

Discipline	Year of repair/renovation			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
Total	288	229	248	229
Engineering	118	95	106	46
Physical sciences	98	98	104	75
Environmental sciences	40	30	26	32
Mathematics	25	12	26	29
Computer science	49	22	16	30
Agricultural sciences	32	25	24	21
Biological sciences	137	112	138	99
in colleges and universities	112	85	121	71
in medical schools	44	44	44	47
Medical sciences	85	77	85	71
in colleges and universities	28	28	32	24
in medical schools	75	60	70	59
Psychology	35	19	20	35
Social sciences	29	12	17	21
Other sciences, n e c.	17	14	17	19

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 3-8. For projects to repair/renovate research space, estimated net assignable square feet (NASF) of R&D space affected and estimated total cost of this repair/renovation by discipline and year of project start: 1986-91*

Discipline	Year of repair/renovation							
	1986 or 1987 (actual)		1988 or 1989 (plan)		1988 or 1989 (actual)		1990 or 1991 (plan)	
	NASF	Cost	NASF	Cost	NASF	Cost	NASF	Cost
	(NASF in thousands; dollars in millions)							
Total	13,431	$838	9,380	$754	11,449	$1,010	8,634	$955
Engineering	2,716	141	1,376	120	1,630	361	959	72
Physical sciences	1,746	105	1,491	124	1,928	165	1,592	323
Environmental sciences	362	21	436	24	930	18	646	35
Mathematics	37	4	41	4	136	11	70	12
Computer science	193	17	90	6	144	9	115	14
Agricultural sciences	628	20	496	22	530	23	478	22
Biological sciences	3,611	225	2,496	156	3,461	201	2,497	244
in colleges and universities	2,555	146	1,661	95	2,203	126	1,384	132
in medical schools	1,056	78	834	60	1,259	76	1,113	112
Medical sciences	3,236	226	2,403	248	2,302	185	1,659	181
in colleges and universities	737	52	722	80	705	24	295	25
in medical schools	2,499	174	1,681	168	1,598	161	1,365	156
Psychology	256	14	102	10	88	11	221	21
Social sciences	181	36	95	8	119	8	198	11
Other sciences, n.e.c	465	30	355	31	180	17	200	21

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only

Note. Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 4-1. Private institutions' sources of funds for science/engineering research facility construction projects by year of project start and institution type: 1986-91*

Year of project start and type of private institution	Source of construction funds							
	Total	Govern		Private donations	Institutional funds	Tax-exempt bonds	Other debt	Other
		Federal	State/ local					
	(Dollars in millions)							
1986 or 1987 (actual)								
Total	695.8	105.1	24.6	228.4	180.6	123.6	0.7	31.7
Top 100 doctorate-granting	536.5	69.6	24.5	196.5	110.7	101.8	0.7	31.7
Other doctorate-granting	130.8	28.9	0.0	27.4	69.3	5.2	0.0	0.0
Non-doctorate-granting	28.5	6.6	0.2	4.5	0.6	16.7	0.0	0.0
1988 or 1989 (planned)								
Total	1,286.7	32.7	45.7	562.7	145.8	340.7	151.5	10.7
Top 100 doctorate-granting	1,033.2	2.7	45.7	461.7	110.4	299.6	105.4	10.7
Other doctorate-granting	251.1	29.5	0.0	100.1	35.0	40.5	46.1	0.0
Non-doctorate-granting	2.4	0.6	0.0	0.9	0.4	0.7	0.0	0.0
1988 or 1989 (actual)								
Total	737.5	77.7	52.3	266.3	87.5	165.7	87.8	0.2
Top 100 doctorate-granting	561.7	34.6	48.6	185.6	50.8	154.3	87.8	0.0
Other doctorate-granting	127.7	36.1	3.7	41.3	35.1	11.3	0.0	0.2
Non-doctorate-granting	48.1	7.0	0.0	39.4	1.7	0.0	0.0	0.0
1990 or 1991 (planned)								
Total	1,363.8	53.6	93.5	405.7	267.1	349.6	107.4	1.2
Top 100 doctorate-granting	1,092.4	44.0	92.5	355.9	147.7	249.8	107.4	0.0
Other doctorate-granting	[illegible]	9.6	1.0	41.4	119.0	99.1	0.0	1.2
Non-doctorate-granting		0.0	0.0	8.4	0.4	0.6	0.0	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS

Table 4-2. Public institutions' sources of funds for science/engineering research facility construction projects by year of project start and institution type: 1986-91*

Year of project start and type of private institution	Source of construction funds							
	Total	Government		Private donations	Institutional funds	Tax-exempt bonds	Other debt	Other
		Federal	State/ local					
	(Dollars in millions)							
1986 or 1987 (actual)								
Total	1,354.8	40.3	754.5	259.1	109.2	189.5	2.4	0.2
Top 100 doctorate-granting	1,062.8	30.7	537.2	218.4	103.5	171.0	2.4	0.0
Other doctorate-granting	157.6	0.7	128.7	20.2	5.7	2.1	0.0	0.2
Non-doctorate-granting	134.4	8.9	88.5	20.6	0.0	16.4	0.0	0.0
1988 or 1989 (planned)								
Total	2,105.2	189.8	1094.4	213.2	249.6	320.4	15.0	24.0
Top 100 doctorate-granting	1,420.5	104 0	657.7	176.7	163.4	303.1	15.0	1.7
Other doctorate-granting	579.0	81.6	338.9	34.2	84.8	17.3	0.0	22.3
Non-doctorate-granting	105.7	4.2	97.8	2.2	1.4	0.0	0.0	0.0
1988 or 1989 (actual)								
Total	1,727 0	274 3	838.4	192.9	256.3	154.5	8.1	0.6
Top 100 doctorate-granting.	996.2	110.6	439.0	143.6	168.4	124.1	8.1	0.6
Other doctorate-granting.	629 4	157 7	316.0	41.2	84.0	30.5	0.0	0.0
Non-doctorate-granting	101.4	6 0	83.4	8.1	3.9	0.0	0.0	0.0
1990 or 1991 (planned)								
Total	2,131.3	317.5	1,014.1	156 6	273.4	245.1	89.4	7.3
Top 100 doctorate-granting	1,394.6	150.9	594.6	141.2	243.0	166.2	89.4	7.3
Other doctorate-granting	63' 7	166.7	314.5	15.4	30.4	78.9	0.0	0.0
Non-doctorate-granting	105.0	0.0	105.0	0.0	0.0	0.0	0.0	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note Details may not sum to totals because of rounding

Source: National Scien e Foundation, SRS.

Table 4-3. Private institutions' sources of funds for science/engineering research facility repair/renovation projects by year of project start and institution type: 1986-91*

Year of project start and type of private institution	Source of repair/renovation funds							
	Total	Government		Private donations	Institutional funds	Tax-exempt bonds	Other debt	Other
		Federal	State/ local					
	(Dollars in millions)							
1986 or 1987 (actual)								
Total	402.0	14.1	6.5	86.0	172.9	112.1	3.5	7.2
Top 100 doctorate-granting	338.0	7.0	6.4	83.3	129.1	103.6	1.9	7.2
Other doctorate-granting	55.4	5.6	0.2	1.7	42.7	3.6	1.6	0.0
Non-doctorate-granting	8.6	1.5	0.0	1.0	1.2	4.9	0.0	0.0
1988 or 1989 (planned)								
Total	311.1	28.0	6.0	59.6	140.2	59.9	3.6	14.8
Top 100 doctorate-granting	273.4	24.7	6.0	57.0	108.9	59.3	3.6	14.8
Other doctorate-granting	36.0	3.0	0.0	1.7	30.9	0.3	0.0	0.0
Non-doctorate-granting	1.7	0.3	0.0	0.9	0.3	0.2	0.0	0.0
1988 or 1989 (actual)								
Total	311.0	29.7	4.5	30.1	167.3	63.3	11.0	5.2
Top 100 doctorate-granting	253.4	13.7	4.5	24.0	141.4	58.4	11.0	0.5
Other doctorate-granting	51.9	15.7	0.0	4.2	22.4	4.9	0.0	4.7
Non-doctorate-granting	5.7	0.2	0.0	1.9	3.6	0.0	0.0	0.0
1990 or 1991 (planned)								
Total	267.6	10.5	1.9	18.7	161.8	31.1	22.9	11.6
Top 100 doctorate-granting	219.7	8.3	1.9	12.0	124.1	29.9	22.8	11.6
Other doctorate-granting	32.2	0.1	0.0	2.2	29.2	0.7	0.0	0.0
Non-doctorate-granting	15.7	2.1	0.0	4.6	8.4	0.5	0.1	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS

Table 4-4. Public institutions' sources of funds for science/engineering research facility repair/renovation projects by year of project start and institution type: 1986-91*

Year of project start and type of private institution	Source of repair/renovation funds							
	Total	Government		Private donations	Institutional funds	Tax-exempt bonds	Other debt	Other
		Federal	State/ local					
	(Dollars in millions)							
1986 or 1987 (actual)								
Total	435.9	13.2	226.6	15.0	155.1	25.5	0.3	0.2
Top 100 doctorate-granting	258.0	10.3	108.3	7.0	107.8	24.0	0.3	0.2
Other doctorate-granting	141.3	0.6	86.8	7.3	45.6	1.0	0.0	0.0
Non-doctorate-granting	36.6	2.2	31.4	0.6	1.8	0.5	0.0	0.0
1988 or 1989 (planned)								
Total	442.4	10.5	238.3	6.5	150.5	22.6	13.0	1.2
Top 100 doctorate-granting	293.6	3.9	136.6	5.6	111.0	22.5	13.0	1.2
Other doctorate-granting	114.4	5.3	72.7	0.5	35.9	0.0	0.0	0.0
Non-doctorate-granting	34.4	1.3	29.0	0.4	3.6	0.0	0.0	0.0
1988 or 1989 (actual)								
Total	698.5	31.4	229.3	22.0	403.5	6.6	4.9	0.0
Top 100 doctorate-granting	229.5	19.7	95.3	6.1	97.3	6.2	4.9	0.0
Other doctorate-granting	444.4	6.8	126.8	7.8	302.5	0.3	0.0	0.0
Non-doctorate-granting	24.6	4.9	7.1	8.1	3.6	0.0	0.0	0.0
1990 or 1991 (planned)								
Total	687.0	2.6	519.2	31.2	113.[illegible]	12.0	0.0	0.0
Top 100 doctorate-granting	307.8	1.8	184.5	24.1	92.5	4.8	0.0	0.0
Other doctorate-granting	144.8	0.0	110.7	7.0	20.[illegible]	6.9	0.0	0.0
Non-doctorate-granting	234.4	0.8	224.0	0.0	1.0	0.3	0.0	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding

Source: National Science Foundation, SRS.

Table 4-5. Sources of private donations for science/engineering research facility construction projects started in 1988-89 or planned for 1990-91 by institution type and control: 1990*

Institution type and control	Source of private donations for construction projects									
	Total		Corporations		Foundations		Individuals		Other	
	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
	(Dollars in millions)									
Total	459.2	562.3	36.9	78.4	230.3	306.5	171.0	98.3	21.0	79.1
Doctorate-granting	411.7	553.9	27.1	77.7	215.0	302.4	158.2	94.8	11.3	79.1
Top 100 in R&D	329.2	497.1	6.5	71.8	180.4	294.7	132.2	88.5	10.1	42.2
Other	82.4	56.8	20.7	5.9	34.6	7.8	25.9	6.2	1.2	36.9
Non-doctorate-granting	47.5	8.4	9.7	0.8	15.3	4.1	12.8	3.5	9.7	0.0
Public	192 9	156 6	21.0	53.8	106.3	29.0	60.6	36.4	5.0	37.4
Doctorate-granting	184.8	156.6	21.0	53.8	100.8	29.0	58.0	36.4	5.0	37.4
In top 100 in R&D	143 6	141.2	5.0	48.3	77.4	28.8	56.2	30 9	5.0	33.3
Other	41.2	15.4	16.0	5.5	23.4	0.2	1.8	5.6	0.0	4.1
Non-doctorate-granting	8.1	0.0	0.0	0.0	5.5	0.0	2.6	0.0	0.0	0.0
Private	266.3	405.7	15.9	24.7	124.0	277.5	110.4	61.8	16.0	41.7
Doctorate-granting	226.9	397.3	6.2	23.9	114.2	273.4	100.2	58.3	6.3	41.7
In top 100 in R&D	185.6	355.9	1.4	23.5	103.0	265.8	76.1	57.7	5.1	8.9
Other	41.3	41.4	4.7	0.4	11.2	7.5	24.1	0.7	1.2	32.8
Non-doctorate-granting	39.4	8.4	9.7	0.8	9.7	4.1	10.2	3 5	9.7	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only. Data are from 1990 survey only.

Note: Details may not sum to totals because of rounding.

Source National Science Foundation, SRS

Table 4-6. Sources of private donations for science/engineering research facility repair/renovation projects started in 1988-89 or planned for 1990-91 by institution type and control: 1990*

Institution type and control	Source of private donations for repair/renovation projects									
	Total		Corporations		Foundations		Individuals		Other	
	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
	(Dollars in millions)									
Total	52.1	49.9	5.0	25.9	32.7	7.3	10.1	16.2	4.3	0.4
Doctorate-granting	42.0	45.3	4.3	25.3	26.0	6.7	7.4	12.8	4.3	0.4
Top 100 in R&D	30.1	36.1	3.1	18.7	15.5	5.1	7.4	11.9	4.2	0.4
Other	11.9	9.2	1.2	6.6	10.6	1.6	0.1	1.0	0.1	0.0
Non-doctorate-granting	10.1	4.6	0.7	0.6	6.7	0.6	2.7	3.3	0.0	0.0
Public	22.0	31.2	1.4	23.4	15.2	2.3	4.3	5.5	1.2	0.0
Doctorate-granting	13.9	31.2	1.4	23.4	9.8	2.3	1.5	5.5	1.2	0.0
In top 100 in R&D	6.1	24.1	1.4	16.8	2.0	1.8	1.5	5.5	1.2	0.0
Other	7.8	7.0	0.0	6.6	7.8	0.5	0.0	0.0	0.0	0.0
Non-doctorate-granting	8.1	0.0	0.0	0.0	5.4	0.0	2.7	0.0	0.0	0.0
Private	30.1	18.7	3.6	2.5	17.5	5.1	5.9	10.7	3.1	0.4
Doctorate-granting	28.1	14.1	2.9	1.9	16.2	4.5	5.9	7.4	3.1	0.4
In top 100 in R&D	24.0	12.0	1.7	1.9	13.4	3.3	5.8	6.4	3.0	0.4
Other	4.2	2.2	1.2	0.0	2.8	1.2	0.1	1.0	0.1	0.0
Non-doctorate-granting	1.9	4.6	0.7	0.6	1.2	0.6	0.0	3.3	0.0	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only. Data are from 1990 survey only.

Note Details may not sum to totals because of rounding.

Source. National Science Foundation, SRS.

Table 4-7. Number of private institutions by status relative to $150 million limit on institutional tax-exempt bonds: 1988 and 1990

Status relative to $150 million limit on tax-exempt bonds	Total		Doctorate-granting				Non-doctorate-granting	
			Top 100 in R&D		Other			
	1988	1990	1988	1990	1988	1990	1988	1990
Total . .	205	206	30	30	73	73	103	103
Have reached the limit	20	23	16	19	4	4	0	0
Have not, but expect to in next two fiscal years	9	12	7	3	1	9	1	0
Have not, and do not expect to in next two fiscal years	176	171	7	8	68	60	102	103

Note: Details may not sum to total because of rounding

Source: National Science Foundation, SRS

Table 5-1. Condition of science/engineering research facilities by institution type and control: 1988 and 1990

Institution type and control	Condition of research facilities and year							
	Suitable for use in most scientifically sophisticated research		Effective for most uses, but not most scientifically sophisticated		Requiring limited repair/renovation to be used effectively		Requiring major repair/ renovation to be used effectively	
	1988	1990	1988	1990	1988	1990	1988	1990
	(R&D NASF in thousands)							
Total	26,793	30,135	41,114	41,072	26,264	27,047	17,702	18,073
Doctorate-granting	26,076	29,158	38,836	38,636	25,170	25,870	17,193	17,503
Top 100 in R&D	19,230	22,210	28,200	27,253	19,345	18,718	13,765	13,478
Other	6,846	6,948	10,635	11,383	5,824	7,152	3,428	4,025
Non-doctorate-granting	717	977	2,278	2,437	1,095	1,177	509	571
Public	19,042	21,265	29,758	31,021	20,040	20,794	13,457	13,801
Doctorate-granting	18,496	20,566	28,265	29,550	19,291	20,041	13,132	13,408
In top 100 in R&D	13,303	15,699	20,710	21,209	15,049	14,429	10,217	9,926
Other	5,193	4,867	7,555	8,341	4,242	5,611	2,915	3,482
Non-doctorate-granting	546	699	1,493	1,471	748	754	325	393
Private	7,750	8,870	11,356	10,052	6,225	6,252	4,245	4,272
Doctorate-granting	7,580	8,592	10,571	9,085	5,878	5,830	4,062	4,094
In top 100 in R&D	5,927	6,512	7,490	6,043	4,296	4,288	3,548	3,552
Other	1,653	2,081	3,080	3,042	1,582	1,541	514	543
Non-doctorate-granting	170	278	785	966	347	423	184	178

Table 5-1. Condition of science/engineering research facilities, by institution type and control: 1988 and 1990--Continued

Institution type and control	Condition of research facilities and year							
	Suitable for use in most scientifically sophisticated research		Effective for most uses, but not most scientifically sophisticated		Requiring limited repair/renovation to be used effectively		Requiring major repair/ renovation to be used effectively	
	1988	1990	1988	1990	1988	1990	1988	1990
	(Percent of R&D NASF)							
Total	23.9	25.9	36.8	35.3	23.5	23.3	15.8	15.5
Doctorate-granting	24.3	26	36.2	34.8	23.5	23.3	16.0	15.7
Top 100 in R&D	23.9	27	35.0	33 4	24.0	22.9	17.1	16.5
Other	25 6	23.5	39 8	38 6	21.8	24.2	12.8	13.6
Non-doctorate-granting	15 6	18.9	49.5	47.2	23.8	22.8	11.1	11.1
Public	23.1	24.5	36 2	35 7	24 4	23.9	16.4	15 9
Doctorate-granting	23.4	24 6	35.7	35.4	24.4	24.0	16.6	16.0
In top 100 in R&D	22 4	25.6	34.9	34 6	25.4	23.6	17.2	16.2
Other	26 1	21.8	38.0	37 4	21 3	25.2	14.6	15.6
Non-doctorate-granting	17.5	21 1	48.0	44 3	24 0	22.7	10.4	11.8
Private	26 2	30 1	38 4	34 1	21 0	21 2	14.4	14.5
Doctorate-granting	27 0	31 1	37 6	32.9	20.9	21.1	14.5	14.8
In top 100 in R&D	27 9	31 9	35.2	29 6	20.2	21.0	16.7	17.4
Other	24 2	28.9	45 1	42.2	23.2	21 4	7.5	7.5
Non-doctorate-granting	11.5	15 1	52.8	52 4	23.3	22.9	12.4	9.7

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 5-2. Condition of science/engineering research facilities by discipline: 1988 and 1990

Discipline	Condition of research facilities and year							
	Suitable for use in most scientifically sophisticated research		Effective for most uses, but not most scientifically sophisticated		Requiring limited repair/renovation to be used effectively		Requiring major repair/ renovation to be used effectively	
	1988	1990	1988	1990	1988	1990	1988	1990
	(R&D NASF in thousands)							
Total	26,793	30,135	41,114	41,072	26,264	27,047	17,702	18,073
Engineering	4,144	4,759	5,974	6,077	3,568	3,746	2,217	2,474
Physical sciences	4,121	4,240	5,531	5,403	3,572	3,824	2,799	2,655
Environmental sciences	1,182	1,132	2,559	2,447	1,642	1,580	926	898
Mathematics	213	205	327	352	140	173	42	60
Computer science	463	554	503	514	233	261	232	117
Agricultural sciences	3,744	4,228	5,726	6,996	4,624	5,011	3,527	4,586
Biological sciences	6,530	7,781	8,431	8,896	5,281	5,884	3,513	3,593
in universities and colleges	3,711	4,836	5,786	6,019	3,996	4,257	2,470	2,457
in medical schools	2,819	2,945	2,645	2,877	1,284	1,626	1,042	1,136
Medical sciences	4,493	5,389	7,059	6,824	4,690	4,684	3,100	2,824
in universities and colleges	959	1,191	2,125	1,743	1,442	1,181	773	844
in medical schools	3,534	4,197	4,934	5,081	3,248	3,503	2,327	1,980
Psychology	715	610	1,348	1,388	643	636	381	344
Social sciences	494	574	1,592	1,502	892	937	359	327
Other sciences, n.e.c.	689	664	2,063	673	981	317	605	198

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS.

Table 5-3. Adequacy of the current amount of science/engineering research space by discipline: 1988 and 1990

Discipline	Number of institutions*		Percent of institutions					
			Adequate		Generally adequate		Inadequate	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	513	517	11.4	11.8	48.2	46.4	40.4	41.8
Engineering	283	296	8.7	10.6	40.1	40.8	51.1	48.6
Physical sciences	445	450	4.7	8.7	52.4	50.8	42.9	40.5
Environmental sciences	297	284	11.0	11.1	49.4	48.4	39.5	40.5
Mathematics	318	296	21.0	17.6	53.6	47.2	25.4	35.2
Computer science	331	280	15.0	13.5	38.2	41.5	46.9	45.0
Agricultural sciences	96	94	11.0	17.0	51.2	39.9	37.7	43.1
Biological sciences	470	482	7.5	9.0	46.1	45.8	46.4	45.2
in universities and colleges	444	451	8.3	8.7	45.8	48.2	45.9	43.1
in medical schools	91	105	3.7	10.4	47.3	35.5	49.0	54.1
Medical sciences	255	267	8.8	10.4	48.7	37.5	42.5	52.0
in universities and colleges	191	189	14.3	13.0	46.0	40.3	39.7	46.7
in medical schools	134	141	0.8	7.0	52.6	33.8	46.6	59.2
Psychology	403	398	16.8	13.2	51.4	54.3	31.8	32.4
Social sciences	360	345	12.9	12.7	50.2	51.0	36.9	36.2
Other sciences, n e c	90	69	10.4	16.9	51.3	39.2	38.4	44.0

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed."

Note Percentages may not sum to 100 because of rounding.

Source National Science Foundation, SRS

Table 5-4. Adequacy of DATA COMMUNICATIONS SYSTEMS by discipline: 1988 and 1990*

Discipline	Number of institutions*		Percent of institutions					
			Adequate		Generally adequate		Inadequate**	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	510	517	16.5	16.2	52.2	53.6	31.4	30.2
Engineering	281	295	26.5	28.0	36.8	39.6	36.7	32.4
Physical sciences	434	447	11.9	15.5	54.5	53.1	33.6	31.4
Environmental sciences	283	282	20.0	14.1	43.6	55.9	36.3	30.0
Mathematics	307	282	14.9	15.7	54.8	50.1	30.3	34.2
Computer science	329	279	16.9	18.4	52.4	48.6	30.7	33.0
Agricultural sciences	96	94	9.2	9.6	51.3	60.8	39.4	29.6
Biological sciences	458	480	12.9	10.5	59.0	57.6	28.2	31.9
in colleges and universities	432	448	14.8	10.8	54.9	55.0	30.3	34.3
in medical schools	91	105	3.6	9.3	78.2	69.0	18.2	21.7
Medical sciences	241	264	10.6	8.9	60.1	60.4	29.3	30.7
in colleges and universities	180	185	14.6	9.2	50.8	54.6	34.7	36.2
in medical schools	131	141	5.1	8.6	73.0	68.1	21.9	23.3
Psychology	387	399	23.4	23.5	49.4	54.5	27.2	22.0
Social sciences	342	332	17.6	16.2	53.0	53.9	29.4	29.9
Other sciences, n.e.c.	88	68	13.7	18.7	49.1	58.9	37.2	22.5

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed."

**Includes responses "Inadequate" and "Nonexistent, but needed."

Note. Percentages may not sum to 100 because of rounding.

Source: National Science Foundation, SRS.

Table 5-5. Adequacy of POWER SYSTEMS by discipline: 1988 and 1990*

Discipline	Number of institutions*		Percent of institutions					
			Adequate		Generally adequate		Inadequate**	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	513	517	30.1	29.6	54.4	53.1	15.5	17.2
Engineering	283	296	24.8	28.2	56.2	57.0	19.0	14.8
Physical sciences	434	450	16.4	21.8	67.8	63.8	15.7	14.4
Environmental sciences	285	284	23.7	26.1	57.6	42.4	18.6	31.5
Mathematics	288	262	39.7	31.1	44.3	53.7	15.9	15.2
Computer science	294	252	34.1	28.4	48.4	55.9	17.5	15.7
Agricultural sciences	96	94	17.5	18.7	60.8	59.5	21.8	21.8
Biological sciences	462	482	29.5	26.2	52.2	52.9	18.3	20.9
in colleges and universities	436	451	30.7	25.1	50.2	52.3	19.0	22.6
in medical schools	91	105	23.5	31.1	61.8	55.5	14.7	13.4
Medical sciences	248	259	35.6	33.0	51.1	49.9	13.3	17.1
in colleges and universities	183	180	39.1	32.7	48.5	4[illegible]2	12.4	18.1
in medical schools	134	141	30.9	33.4	54.5	50.8	14.6	15.8
Psychology	386	393	44.7	44.3	48.1	44.3	7.2	11.3
Social sciences	320	319	30.9	32.1	57.8	53.0	11.3	14.9
Other sciences, n.e.c.	88	69	22.5	32.4	58.5	57.0	19.1	10.7

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed."

**Includes responses "Inadequate" and "Nonexistent, but needed."

Note. Percentages may not sum to 100 because of rounding.

Source: National Science Foundation, SRS.

Table 5-6. Adequacy of HEATING, VENTILATION AND AIR CONDITIONING (HVAC) by discipline: 1988 and 1990*

Discipline	Number of institutions*		Percent of institutions					
			Adequate		Generally adequate		Inadequate**	
	1988	1990	1988	1990	1988	1990	1988	1990
Total	509	517	19.5	18.7	53.1	51.1	27.5	30.2
Engineering	283	296	17.4	18.5	54.9	48.6	27.7	32.9
Physical sciences	432	450	11.7	14.1	51.9	44.0	36.4	41.9
Environmental sciences	289	284	20.4	16.5	49.0	44.9	30.5	38.6
Mathematics	272	285	26.4	24.1	48.5	49.6	25.1	26.3
Computer science	297	255	28.6	19.4	46.3	54.1	25.0	26.5
Agricultural sciences	96	94	7.4	6.2	60.6	60.7	31.9	33.1
Biological sciences	462	482	12.2	15.2	57.0	53.7	30.8	31.1
in colleges and universities	435	450	10.6	14.0	56.7	53.2	32.7	32.9
in medical schools	91	105	19.9	20.5	58.4	55.8	21.7	23.7
Medical sciences	245	267	22.6	22.3	56.3	55.7	21.0	22.0
in colleges and universities	180	189	22.2	17.8	56.7	60.2	21.2	22.0
in medical schools	134	141	23.3	28.3	55.9	49.6	20.8	22.1
Psychology	392	401	26.2	22.6	48.3	46.3	25.5	31.1
Social sciences	308	319	21.7	22.2	61.5	62.6	16.8	15.2
Other sciences, n.e.c.	90	68	15.6	21.4	51.4	47.4	33.0	31.2

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed."

**Includes responses "Inadequate" and "Nonexistent, but needed."

Note: Percentages may not sum to 100 because of rounding.

Source: National Science Foundation, SRS

Table 5-7. Adequacy of AIR DECONTAMINATION by discipline and adequacy of TOXIC WASTE DISPOSAL: 1988 and 1990*

Discipline	Number of institutions*		Percent of institutions					
			Adequate		Generally adequate		Inadequate**	
	1988	1990	1988	1990	1988	1990	1988	1990
Air Decontamination								
Total	505	514	19.6	16.6	51.2	51.5	29.3	31.9
Engineering	256	273	14.0	18.5	60.1	46.4	25.9	35.0
Physical sciences	435	445	14.0	10.8	45.2	49.8	40.7	39.4
Environmental sciences	277	275	18.8	17.1	50.8	42.1	30.4	40.7
Mathematics	72	-	38.5	-	52.3	-	9.2	-
Computer science	104	-	38.2	-	53.8	-	8.0	-
Agricultural sciences	87	93	15.5	17.2	48.8	44.5	35.7	38.3
Biological sciences	462	477	12.1	12.0	53.8	57.9	34.1	30.1
in colleges and universities	436	444	11.3	10.2	52.4	57.9	36.3	31.9
in medical schools	91	105	16.0	19.4	60.5	58.0	23.5	22.6
Medical sciences	228	254	23.0	18.6	50.3	56.8	26.7	24.7
in colleges and universities	162	175	22.9	14.9	48.0	57.6	29.1	27.4
in medical schools	134	141	23.0	23.1	53.2	55.7	23.8	21.2
Psychology	222	237	32.9	23.6	51.8	54.6	15.3	21.8
Social sciences	93	113	32.3	31.9	51.9	48.7	15.8	19.5
Other sciences, n e c	78	50	18.8	21.8	36.9	48.6	44.4	29.5
Toxic Waste Disposal								
Total	500	480	22.4	22.8	53.1	58.4	24.5	18.9

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed"

**Includes responses "Inadequate" and "Nonexistent, but needed"

- Not applicable for this discipline

Note: Percentages may not sum to 100 because of rounding.

Source: National Science Foundation, SRS

Table 5-8. Adequacy of selected aspects of research infrastructure by type and control of institution: 1988 and 1990

Infrastructure aspect and adequacy rating	Total		Doctorate-granting				Non-doctorate-granting		Public		Private	
			Top 100		Other							
	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990
	(Percent of institutions)											
Current amount of R&D space	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	11.4	11.8	6.0	9.5	12.9	11.5	13.9	13.8	10.3	10.8	13.9	13.9
Generally adequate	48.2	46.4	44.4	40.3	48.4	48.6	50.7	49.2	47.5	43.1	49.7	53.4
Inadequate	40.4	41.8	49.6	50.2	38.6	39.9	35.3	37.0	42.2	46.2	36.4	32.7
Data communications systems	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	16.5	16.2	12.5	14.6	12.2	17.0	23.8	16.7	16.0	14.8	17.4	19.2
Generally adequate	52.2	53.6	54.5	[illegible]	54.8	58.5	47.8	47.1	50.8	51.8	55.3	57.3
Inadequate	31.4	30.2	33.0	29.9	33.0	24.5	28.4	36.1	33.2	33.4	27.4	23.5
Power systems	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	30.1	29.6	22.4	23.0	29.1	33.0	37.3	31.7	28.5	26.8	33.9	35.7
Generally adequate	54.4	53.1	59.3	59.5	55.2	53.8	49.7	47.2	54.4	52.8	54.4	53.8
Inadequate	15.5	17.2	18.3	17.5	15.7	13.2	13.0	21.1	17.1	20.5	11.8	10.5
HVAC**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	19.5	18.7	12.5	13.4	22.0	24.2	22.4	17.5	18.4	17.1	21.8	21.9
Generally adequate	53.1	51.1	52.9	53.4	52.9	50.3	53.4	50.0	53.6	51.7	51.9	49.7
Inadequate	27.5	30.2	34.6	33.2	25.1	25.5	24.3	32.5	28.0	31.1	26.3	28.4

Table 5-8. Adequacy of selected aspects of research infrastructure by type and control of institution: 1988 and 1990--Continued

Infrastructure aspect and adequacy rating	Total		Doctorate-granting				Non-doctorate-granting		Public		Private	
			Top 100		Other							
	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990	1988	1990
	(Percent of institutions)											
Air decontamination	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	19.6	16.6	14.8	13.2	17.6	20.0	25.6	15.9	20.2	17.3	18.2	14.8
Generally adequate	51.2	51.5	52.5	51.9	54.2	56.0	47.0	46.6	50.1	49.7	53.5	55.5
Inadequate	29.3	31.9	32.7	35.0	28.2	24.0	27.4	37.4	29.7	32.9	28.3	29.7
Toxic waste disposal	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adequate	22.4	22.8	18.7	24.6	29.7	31.0	17.7	14.6	26.8	21.8	15.6	24.3
Generally adequate	53.1	58.4	63.7	53.5	49.3	60.6	51.4	58.8	49.4	59.8	58.8	56.1
Inadequate	24.5	18.9	17.5	21.9	21.0	8.3	30.9	26.6	23.8	18.4	25.6	19.6

**HVAC - heating, ventilation, and air conditioning

Note: Percentages may not sum to 100 because of rounding

Source: National Science Foundation, SRS

Table 6-1. Total net assignable square feet (NASF) of space in science/engineering disciplines and NASF used for R&D in historically black colleges and universities: 1988 and 1990

Discipline	Total NASF		Total R&D NASF	
	1988	1990	1988	1990
Number of institutions with any space	29	29	29	29
Total NASF	6,077 2	5,175 4	1,111 7	1,439.6
		(NASF in thousands)		
Engineering	776 7	979 0	151.7	167.4
Physical sciences	803 8	810 1	179 4	189.5
Environmental sciences	44 1	56 0	10.3	26.3
Mathematics	173 2	163.5	12.2	25.8
Computer science	150 0	113.9	43 4	29.9
Agricultural sciences	604 0	834.1	259 3	433.1
Biological sciences	1,130 1	933 9	231 7	290 7
in colleges and universities	509 0	545 5	141.1	170 1
in medical schools	621 1	388 4	90 6	120.6
Medical sciences	1,846 1	1,766 3	177.4	207 4
in colleges and universities	593 0	956.0	36.6	49.7
in medical schools	1,253 1	810 3	140 9	157 7
Psychology	118 7	105 1	14.2	18 8
Social sciences	304 2	322.1	28.4	46.6
Other sciences, n e c	126 3	91 3	3.7	4 0

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 6-2. Construction and repair/renovation projects at historically black colleges and universities by year of project start: 1986-1991*

Project type and index	Year of project start			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
Construction projects				
Total project completion costs (in millions)	$71.8	$36.5	$55.1	$11.6
Total square feet (in thousands)	481.2	90.5	318.6	82.3
Square feet as percent of total R&D space	43%	8%	22%	6%
Repair/renovation				
Total project completion costs (in millions)	14.1	4.9	16.6	15.6
Total square feet (in thousands)	137.1	88.6	308.4	130.4
Square feet as percent of total R&D space	12%	8%	21%	9%

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only.

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS.

Table 6-3. Sources of funds for science/engineering research facilities construction projects at historically black colleges and universities by year of project start: 1986-1991*

Sources of funds	Year of project start			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
	(dollars in millions)			
Total	71 8	36.5	55.1	11.6
Funds from each source				
Federal goverment	32 7	5 7	35 0	0.1
State/local government	25.8	30 8	11.5	11.4
Private donations	11 1	0 0	7.7	0 0
Institutional funds	2.3	0 0	0 9	0.0
Debt financing	0 0	0 0	0.0	0.0
Tax-exempt bonds	0 0	0 0	0.0	0.0
Other debt	0 0	0 0	0.0	0.0
Other sources	0.0	0 0	0.0	0.0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space. Project cost and space estimates are prorated to reflect R&D component only

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 6-4. Sources of funds for science/engineering research facilities repair/renovation projects at historically black colleges and universities by year of project start: 1986-1991*

Sources of funds	Year of project start:			
	1986 or 1987 (actual)	1988 or 1989 (plan)	1988 or 1989 (actual)	1990 or 1991 (plan)
	(dollars in millions)			
Total	14 1	4 9	16 6	15.6
Funds from each source				
Federal goverment	8 7	1.9	12 9	0 6
State/local government	4 9	2 1	0.8	14.3
Private donations	0.5	0 9	2.0	0.4
Institutional funds	0 0	0 0	0 1	0.0
Debt financing.. .	0 0	0 0	0 0	0.3
Tax-exempt bonds	0 0	0 0	0 0	0.3
Other debt	0 0	0 0	0 0	0.0
Other sources	0 0	0.0	0 0	0 0

*Findings are limited to projects with estimated total cost at completion of $100,000 or more for R&D related space Project cost and space estimates are prorated to reflect R&D component only

Note Details may not sum to totals because of rounding

Source National Science Foundation, SRS

Table 6-5. Condition of science/engineering research facilities at historically black colleges and universities by discipline: 1988 and 1990

Discipline	Condition of research facilities and year							
	Suitable for use in most scientifically sophisticated research		Effective for most uses, but not most scientifically sophisticated		Requiring limited repair/renovation to be used effectively		Requiring major repair/ renovation to be used effectively	
	1988	1990	1988	1990	1988	1990	1988	1990
	(R&D NASF in thousands)							
Total	399	445	428	643	195	252	76	100
Engineering	79	37	36	83	24	31	12	17
Physical sciences	8	39	102	86	50	45	15	19
Environmental sciences	0	1	2	19	1	6	3	1
Mathematics	2	3	7	16	3	4	1	2
Computer science	25	8	13	11	3	9	2	2
Agricultural sciences	118	201	63	165	56	35	23	32
Biological sciences	41	43	147	178	34	60	9	10
in universities and colleges	35	43	65	80	32	38	9	9
in medical schools	6	0	82	98	2	22	1	1
Medical sciences	112	100	37	51	14	47	8	10
in universities and colleges	2	5	12	18	9	17	8	10
in medical schools	110	95	26	32	5	30	0	0
Psychology	6	5	6	8	2	4	0	2
Social sciences	7	8	13	25	7	8	2	5
Other sciences, n e c	0	1	1	0	2	3	1	0

Note: Details may not sum to totals because of rounding

Source: National Science Foundation, SRS

Table 6-6. Adequacy of the amount of research space at historically black colleges and universities by discipline: 1988 and 1990

Discipline	Number of institutions*		Adequate		Generally adequate		Inadequate**	
	1988	1990	1988	1990	1988	1990	1988	1990
			(percent of institutions)					
Total	29	29	16.5	16.1	53.2	49.1	30.2	34.8
Engineering	13	13	27.3	7.7	54.5	69.2	18.2	23.1
Physical sciences	24	25	9.5	8.0	61.9	56.0	28.6	36.0
Environmental sciences	3	10	0.0	0.0	33.3	60.0	66.7	40.0
Mathematics	14	14	16.7	14.3	58.3	57.1	25.0	28.6
Computer science	16	11	28.6	27.3	35.7	36.4	35.7	36.4
Agricultural sciences	13	14	27.3	35.7	45.5	28.6	27.3	35.7
Biological sciences	28	26	16.0	14.8	52.0	44.4	32.0	40.7
in colleges and universities	27	25	13.0	8.0	52.2	48.0	34.8	44.0
in medical schools	2	2	50.0	100.0	50.0	0.0	0.0	0.0
Medical sciences	9	11	30.0	41.7	70.0	33.3	0.0	25.0
in colleges and universities	8	9	42.9	33.3	57.1	33.3	0.0	33.3
in medical schools	3	3	0.0	66.7	100.0	33.3	0.0	0.0
Psychology	14	13	8.3	15.4	50.0	46.2	41.7	38.5
Social sciences	19	19	5.3	10.5	50.0	47.4	43.8	42.1
Other sciences, n.e.c.	5	3	0.0	0.0	75.0	100.0	25.0	0.0

*Excludes institutions with no R&D space in the discipline and those reporting "Not applicable or not needed."

**Includes responses "Inadequate" and "Nonexistent, but needed."

Note: Details may not sum to totals because of rounding.

Source: National Science Foundation, SRS

Telephone Device for the Deaf

The National Science Foundation (NSF) has Telephonic Device for the Deaf (TDD) capability which enables the individuals with hearing impairment to communicate with the Division of Personnel and Management for information relating to NSF programs, employment, or general information. This number is (202) 357-7492.

Appendix 16

END

U.S. Dept. of Education

Office of Education
Research and
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Date Filmed

March 21,1991